

The Role of Problematic Technology Use for Adolescents: The Importance of Sleep for Wellbeing

by

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Author's Declaration

I declare that this thesis is my own account of my research and contains as its main content work which has not previously been submitted for a degree at any tertiary education institution.

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Lynette Vernon

Abstract

Peer social-networks increase in their salience through adolescence. With access to technology, adolescents extend face-to-face peer interactions to the online environment. Adolescents' heavy engagement in technology, however, can pose risks to their wellbeing. This thesis examines one potential mechanism through which this may occur, vis-a-vis problematic sleep. Two features of adolescents' technology use were measured that related to peer interactions on-line, social-networking and mobile-phone use. Cross-sectional and longitudinal data were drawn from a representative sample of adolescents. Study-1 used cross-sectional data including a new social-networking investment measure, and Study-2 and Study-3 used longitudinal data including students across Years 8 to 11. Study-1 investigated adolescents' problematic social-networking using structural-equation-modeling. A serial mediation pathway was shown in which adolescents' overinvestment in social-networking was associated with increased sleep disturbances and adverse perceptions of sleep quality, which in turn were associated with decreased school satisfaction. These results suggest that minimizing sleep disturbances from problematic social-networking could arguably improve adolescent school experiences. Study-2 examined a mediational process using latent trajectories; problematic social-networking was associated with a trajectory of disturbed sleep, which in turn associated with psychopathology (depressed mood, externalizing). Adolescents who increasingly invested in social-networking also increased in their depressed mood; half of this association was explained by the mediating role of increased sleep disruption. Adolescents who increasingly invested in social-networking also reported increased externalizing behavior (13% via sleep disruption). Again, these findings point to an important role of sleep disruption in adolescent wellbeing. Study-3 tested how adolescents' problematic use of mobile-phones linked to a range of wellbeing indicators: depressed mood, externalizing behavior, self-esteem, and coping. Increases in problematic mobile-phone use predicted later increases in externalizing and subsequent decreases in self-esteem and coping. Importantly, changes in sleep behavior mediated the relation between early changes in problematic mobile-phone use and later increases in depressed mood and externalizing and later declines in self-esteem and coping. These results advocate for monitoring of and education about adolescents' late-night mobile-phone use as well as further attention to pervasive effects of disrupted sleep on adolescent functioning.

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Dedication

To: Mum and Dad (*in spirit*), Bruce, David, Nathan and Christopher for supporting my learning journey. May you all enjoy your technology and sleep!

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Chapter 1 Introduction and Overview

Over the past two decades, communication technologies have become a central part of the adolescents' daily experience. As a result, they have significantly changed the way adolescents interact with one another, their family and wider community. Parents, educators and researchers are unfamiliar with the way today's adolescents use electronic media, and have been challenged to understand the saturation of information from communication technologies (ICTs) into adolescents' lives. Indeed, many adolescents have outpaced the technological skills and knowledge of adults in their lives, and adolescents themselves have created their own technological space, opportunities, and innovative applications. Thus, there is a critical need for research that highlights to educators and parents potential risks to wellbeing and skills and knowledge needed for adolescents to successfully navigate this information-rich, socially interactive environment.

Not only do adolescents spend considerable amounts of time using on-line media, but significant changes also occur in patterns of media use as young people transition through the course of adolescence. During adolescence, youth increasingly engage with their peers and their social organizations increasingly extend well-beyond their families. Peer relations become increasingly salient during the high school years, and typically social connections have been garnered during face-to-face contact in various physical contexts; school, extracurricular activities, or after-school-work, to name a few (Brown & Larson 2009). However, with the introduction of new styles of information and communication technologies adolescents have changed the way they interact with each other and adolescents incorporate new media into their peer networks. Mobile communication devices, in particular, have allowed adolescents to readily link with their peer group, helping them to consolidate close friendships, and to expand social connections (Ling, 2009).

For adolescents, mobile devices especially those that connect to the Internet, have created peer engagement opportunities that don't rely on transport, money, or time together (Livingstone, 2008). Thus, mobile technology has re-defined adolescents' availability so that they can be in 'perpetual contact' interacting with their friends, family and the global community at any time of the day or night (p. Title, Katz & Aakhus, 2002). Although adolescents' availability via mobile devices can provide reassurance for both parents and children, social pressure to be always mobile-available, including from the confines of the bedroom, has also raised a number of issues in relation to adolescent wellbeing.

Parents provide and support technology for their child with the best of intentions, yet there are arguably also risks associated with adolescents' heavy use of technology. For instance, technology in adolescents' bedroom blurs the distinction between homework and the leisure activities ICT's offer, including gaming, downloading music, videos, shopping, and socializing via mobile phones, messaging and social networking (Rideout, Foehr, & Roberts, 2010). Indeed, not only can technology use in the bedroom compete with educational pursuits but a good night's sleep can also be sacrificed as adolescents interact online with their peers (Munezawa et al., 2011). On-line peers and the stimulating environment of ICT can become problematic when their content and/or timing interfere with adolescents' sleep. Whether due to peer communication or to ICT's stimulating environment itself, there is converging evidence showing adolescent ICT access and use from the bedroom interferes with sleep (Becker, Langberg, & Byars, 2015; Zimmerman, 2008).

This thesis focuses on several aspects of information and communication technologies which have been readily embraced in the social life of adolescents, social networking, and mobile phone use. More specifically, this thesis assesses adolescents' use of these technologies in relation to their wellbeing, including sleep. There is a

growing body of research linking problematic online social networking with potentially negative consequences for wellbeing (Kuss & Griffiths, 2011), and psychologists and educators alike have noted negative effects of extensive use of social networking, particularly in terms of frequency of use and amount of emotional investment in social networking. One potential explanation for these negative effects may be that adolescents are using technology in their bedrooms to carry out this social networking, and this may arguably compromise their sleep.

Given robust associations between poor sleep and psychosocial problems for adolescents (Carskadon, 2002, 2011), this thesis investigates whether excessive use of technology could be linked to negative outcomes via poor sleep, and does so across several assessments of technology involvement (social networking sites [SNS] and mobile phones) and different psychological outcomes (school satisfaction, psychopathology, coping, and self-esteem). The first empirical study takes a cross-sectional approach and explores problematic social networking and links to sleep and school experience for adolescents. The second study examines changes in problematic social networking use over time in relation to changing sleep and assesses their relations to psychopathology. The third and final study explores longitudinal links between nighttime mobile phone use and adolescents' subsequent wellbeing, as mediated by changing sleep. In all, these questions are of substantial theoretical and practical importance, and can guide efforts towards adolescents' healthy use of technology especially around bedtime.

1.1 Conceptual Framework

The conceptual framework of this thesis was guided by the critical role sleep plays in the developmental changes that occur during adolescence. Sleep is considered to influence and be influenced by biological, psychosocial, and contextual factors of

adolescents' lives across their development (Becker et al., 2015; Carskadon, 2002, 2011; Gradisar & Short, 2013). For this thesis, aspects of technology, specifically social networking and mobile phone use, were considered as contextual factors that can affect sleep and in turn affect psychosocial functioning related to academic functioning, mental health, and wellbeing. As described in Figure 1.1-1, the conceptual model for the thesis was developed as a framework for testing these links between problematic technology use, in particular for social networking and mobile phone use, and effects on adolescent psychosocial functioning via relations to sleep. Three empirical studies were designed to test these links and aspects of the model associated with each study are further detailed within the model (the numbers adjacent to the links in the conceptual model represent each relevant study).

Technology Contexts → Sleep → Psychosocial Functioning

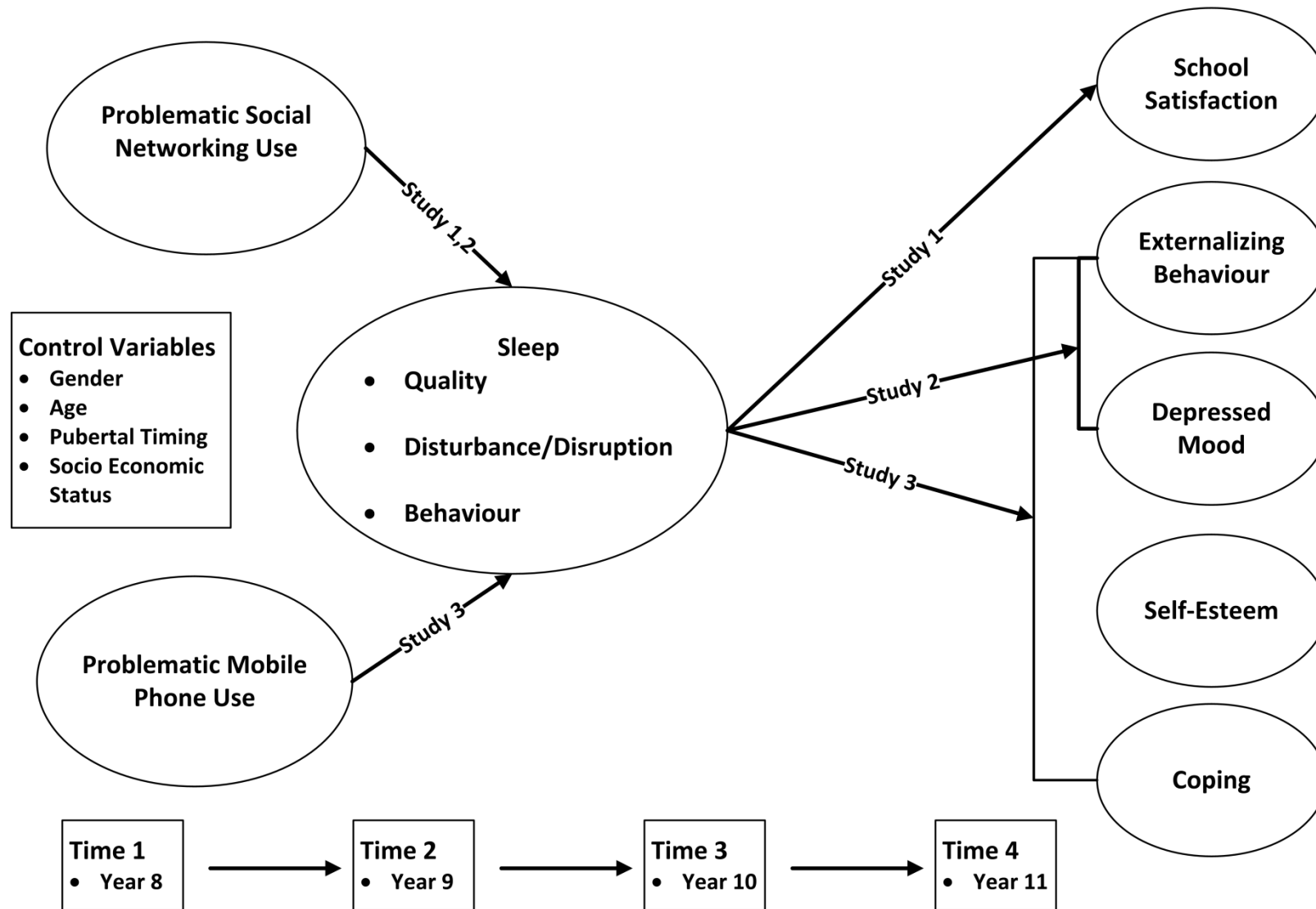


Figure 1-1 Conceptual Model representing the proposed links between technology contexts of use, sleep, and functioning.

1.2 Chapter 3 – Study-1

The first empirical study (Chapter 3) investigates how problematic social networking influences students' school experience through sleep. With the growing popularity of social networking for adolescents, its problematic use has been identified as a cause for growing concern. More specifically, concerns are mounting that students who are highly invested in social networking may be at risk of lower grades, possibly due to interference with their sleep (Calamaro, Mason, & Ratcliffe, 2009). However, the lack of an adequate instrument for measuring problematic social networking has hindered research and understanding to date. Indeed Blomfield-Neira and Barber (2014) suggested future research focus on developing an adolescent 'investment in social media' scale rather than time spent social networking and associations to wellbeing. Consequently, the problematic social networking use scale was constructed (Appendix Chapter 3). This new instrument was specifically developed to measure problematic investment in social networking based on previous behavioral addiction research related to activities such as gambling (Brown, 1987; Young, 1998).

Using this scale developed to measure problematic social networking use, the first major aim of this thesis was: to determine how problematic investment in social networking relates to adolescent sleep patterns and school experience.

Thus, Study-1 in Chapter 3 tests the direct effects between problematic social networking and school satisfaction and mediating or indirect links through sleep quality and sleep disturbances. The results of this multiple mediation model presented in Chapter 3 highlight the importance of a good night's sleep for adolescents in relation to positive experiences at school and indicates that one source of a poor nights' sleep may be problematic use of social networking. This chapter further indicates that a useful next step would be to track changes in problematic social networking and sleep over time, in

order to better inform our understanding of developmental processes related to adolescent use of social networking in relation to their functioning.

1.3 Chapter 4 – Study-2

Following on from Study-1, the second study (Chapter 4) explores adolescent social networking over time in association with sleep perceptions, predicting mental health functioning (depressed mood and externalizing behavior). Although previous cross-sectional research has examined dependency on social networking as a behavioural addiction (Kuss & Griffiths, 2011) and has pointed to its negative effect, including depression (Giota & Kleftharas, 2013; Morahan-Martin, 2005), low self-esteem (Valkenburg, Peter, & Schouten, 2006), and suppression of empathic social skills (Chan, 2014) longitudinal research to date has been limited. Consequently, as a second aim, this thesis sought *to determine if change over time in problematic social networking use was associated with parallel changes in psychopathology (depressed mood and externalizing) and to determine if part of this relation was, explained indirectly, through disrupted sleep.*

Despite growing cross-sectional research in relation to adolescent social network use, few studies have investigated how investment in social networking evolves over time, and no studies have assessed whether this change occurs in tandem with mental health functioning, or whether a related change in sleep might help to account for this relation. Chapter 4 thus examines problematic social networking use, in relation to disrupted sleep and depressed mood, and externalizing behavior.

More specifically, designed as a longitudinal study, this study examined developmental trajectories of problematic social networking use in association with change in depressed mood, and externalizing behavior and described whether disrupted sleep might help to explain these associations. Findings highlighted that the

development of healthy sleep habits during adolescence is of paramount importance for mental health, and one important risk factor for poor sleep is heavy social networking investment. As a result, further research was required to identify technological devices, such as using mobile phones, which could be used by adolescents during the night and thus could subsequently be affecting a range of indicators of their wellbeing.

1.4 Chapter 5 – Study-3

To address this next step, Chapter 5 Study-3 explored use of mobile phones into the night as a predictor of adolescents' subsequent functioning across a broad range of indicators of wellbeing, including self-esteem, coping, depressed mood and problem behavior. Importantly, Study-3 also assessed whether this process was explained, at least in part, via adolescents' sleep behavior. Specifically, the study tested whether developmental trajectories of problematic mobile phone habits predicted subsequent trajectories of wellbeing, and whether these relations could be explained by a change in sleep behavior. This methodology involved lagging the dependent variable latent growth curves for wellbeing by one year so that the origin for the dependent variable was a year before assessment, therefore no possibility of reciprocal causation.

Thus, study findings advance theoretical understanding of problematic mobile phone use -texting/phoning into the night among adolescents, including its changing course over time and its variability within-person.

In addition, this is the first known study to explore adolescents' problematic texting habits across early to mid-adolescence in association with concurrent measures of their sleep behavior. Consequently, Study-3 offers empirical findings of considerable empirical and practical importance.

1.5 Outline

This thesis is comprised of published and submitted manuscripts. Therefore, each empirical chapter is an independent study, consisting of its own abstract, relevant literature review, method section, results section, and discussion. The published and submitted manuscripts are presented as appendices within this thesis. However, each chapter has a preface which outlines the rationale and aims of the study and how each study relates to the overall conceptual model. Chapter appendices are also added within Chapters 3 and 5 as some of these data could not be presented within the word limit of the published manuscripts.

Prior to introduction of the three empirical studies, a review of the literature is presented. Specifically, Chapter 2 presents and reviews information and communication technology use for adolescents as a context that affects psychosocial functioning through sleep, based on the thesis' conceptual model. After the three empirical studies, the overall findings are integrated within a concluding section, Chapter 6. This chapter provides a general discussion and further discusses potential implications of and applications for study findings.

Across all studies, data were drawn from the Youth Activity Participation Study of Western Australia (YAPS-WA). This longitudinal study focused on the role of adolescent activity participation (including technology use) in the accomplishment of a range of developmental tasks (see Chapter 8 Appendix A Wave 4 YAPS-WA surveys and highlighted in grey are the survey questions relevant to this thesis also included in Waves 5, 6 and 7). Data were collected from 27 government and non-government high schools located in regional and metropolitan areas of Western Australia. Data collection commenced in 2007. However, for this thesis, data collection began in Wave 4, which was during the last six months of 2010 and the first six months of 2011. The final wave of data used in this thesis, Wave 7, was collected during the last six months of 2013 and the first six months of 2014. Study 1 included students in year 8 and year 11. The second

and third longitudinal studies recruited and followed students from year 8 in Wave 4 to year 11 in Wave 7.

Chapter 2 Literature Review

Adolescence is a critical transitional stage of development in which peer relationships and associated complex social networks form and grow. Indeed, adolescents devote considerable amounts of time and emotional investment towards keeping in touch with their friends. Whereas in the past, social connectedness outside the family environment mainly occurred through face-to-face contact while at school or participating in structured or unstructured leisure activities (Brown & Larson, 2009) today's adolescents have access to a wide range of technologies, which enable them to extend their face-to-face interactions and go online in order to connect with their peers. These cyber-relationships can develop at anytime of the day or night, without physical boundaries (Griffith, 2012; Young, 1999). Although many adolescents manage to develop such on-line social connections successfully without encountering major psychosocial, cognitive, behavioral or health difficulties, for others, these connections can be associated with increasingly problematic psychosocial functioning.

Certainly, early research has found the ability to develop cyber-relationships and connect online with friends can enhance offline relationships as well as develop social self-concept (Barker, 2009; Blomfield-Neira & Barber, 2014; Ellison, Steinfield, & Lampe, 2007). These cyber-relationships can develop through the use of texting or instant messaging to communicate on a day-to-day basis with friends, or posting on and perusing social networks on social networking sites. However, there can also be costs associated with these highly engaging communication platforms, and it may well be the case that time spent social networking or texting on mobile phones interferes with normative day to day functioning. Indeed adolescents have been enthusiastic in their uptake and engagement in online platforms and problematic media use has been characterized by engagement with media or media devices to levels which become obsessive or unhealthy (Felt & Robb, 2016). Illustratively, around 88% of U.S.

adolescents report texting their friends at least occasionally with 55% texting daily (Lenhart, 2015). Thus engaging in technologies likely influences many other aspects of adolescents' lives, and it is important to address for how considerable investment and time in such online contexts might become problematic and how this impacts adolescents' wellbeing, including sleep.

Technological devices such as mobile phones, screen tablets, and laptop computers, have rapidly become an integral part of adolescents' everyday lives. With mobile convenience, affordability, and easy accessibility, over 90% of U.S. adolescents have access to a device and use these devices to go online daily (Lenhart, 2015). In fact, recent findings from the National *Stress and Wellbeing in Australia Survey* reported that adolescents spend on average 2.7 hours per day connected to social media (Australian Psychological Society [APS], 2015). Likewise, electronic media exposure for U.S. adolescents is reported to average around nine hours a day (including television, music, online gaming, social media, messaging, using the Internet; Rideout, 2015).

Adolescents access social media such as Facebook, Instagram, and Twitter, and this facilitates their ability to keep in touch with family and friends at any time of the day or night (Livingstone, 2008). Facebook is the most popular social media platform and has 71% of U.S. teenagers using their site daily (Lenhart, 2015; Tsitsika et al., 2013). Likewise, a recent census survey of 1399 teenagers in the U.S. found teenagers on average spent one hour and 11 minutes per day using social media (Rideout, 2015). Although almost all of the teenagers surveyed engaged in media use, their profiles of engagement differed. Specifically, those classified as social networkers spent more than three hours per day social networking and only three-quarters of an hour gaming; gamers spend two and a half hours gaming and around 50 minutes social networking (Rideout, 2015). Thus, even adolescents who are not heavily invested in social networking are still dedicating considerable time to this context. Importantly, the

emotional investment which can come from the requirement in adolescence to be socially connected via social media activities likely impacts on their wellbeing, including their ability to attain adequate sleep. For example, recent research in Australia indicates that 53% of teenagers report using social media in the 15 minutes before bed, every day of the week (APS, 2015).

Investigating links between heavy social networking investment and adolescent sleep are important because consequences of a poor nights sleep can flow through to multiple aspects of adolescents' lives. Indeed, evidence is now increasingly supporting a link between technology use around bedtime and various aspects of wellbeing including sleep duration and quality (Bartel, Gradisar, & Williamson, 2015; Cain & Gradisar, 2010; Gradisar & Short, 2013; Hale & Guan, 2015). However most findings linking problematic technology use with poor sleep and other negative aspects of wellbeing is either cross-sectional (Hysing et al., 2015; Muezawa et al., 2011; Oshima et al., 2012; Punamäki, Wallenius, Nygård, Saarni, & Rimpelä, 2007; Suganuma et al., 2007; Tochigi et al., 2012) or relates to specific technological contexts like video gaming and television viewing (Van den Bulk, 2004). To address this gap, this thesis examines adolescents' use of social media and mobile phones over the course of adolescence and how this relates to their overall wellbeing, vis-à-vis sleep.

This chapter reviews the relevant literature within three main sections. The first section highlights the importance of sleep and explores the notion of sleep development within an integrated conceptual framework, including biological, contextual, and psychosocial factors that influence and can be influenced by sleep. Next, links between sleep and various aspects of wellbeing are explored, and the developmental nature of both changing sleep functioning and academic, psychosocial, and mental health functioning are discussed.

Although relations between sleep and wellbeing have been a subject of substantial research, there is now need to explore this link in the context of the variety of electronic media devices that are used within adolescent bedrooms and their potential implications for sleep and associated wellbeing. Thus, the second section of this review incorporates the role of electronic media and examines mobile phone use and social networking in relation to their potential negative impact on sleep. The third section examines these three constructs together, within a single model, and considers the need for further research within this novel framework. The relation between problematic technology use, sleep and wellbeing are tracked over time to determine the directionality of effects and to determine if and when a certain construct is most salient for adolescent development. Finally, aims of the current thesis and how they address relevant gaps in the literature are briefly outlined. In all, these aims seek to assess the impact of the problematic use of mobile phones and social networking on adolescent wellbeing, and the possible role of sleep as indirectly affecting this process.

2.1 Adolescent Sleep

A good night's sleep is essential for health and the developmental requirement of adequate and quality sleep during adolescence has long been recognized as a major developmental task of this period (Carskadon, 2002, 2011; Dahl & Lewin, 2002; Shochat, Cohen-Zion, & Tzischinsky, 2014). Sleep has been conceptualized within this developmental perspective because it influences and is influenced by biological, psychosocial and contextual factors (Becker et al., 2015; Carskadon, 2011). Sleep needs change as we age with the need for sleep declining until around the age of 20 when it stabilises (Carskadon, 2002). From birth we require around 14 to 17 hours of sleep reducing to 9 to 11 hours when in primary school and then further reducing to 8 to 10 hours in adolescence (Hirshkowitz et al., 2015). Because adolescents are rapidly changing and developing as they transition through puberty, they are at heightened risk

for poor sleep and its associated negative consequences. As a result, understanding the role of sleep in relation to development during adolescence, including associated cognitive, behavioral, and emotional difficulties, is of considerable importance. Arguably knowledge can help to inform and improve prevention programs targeting sleep deprivation during adolescence and help to prevent contributions to associated long-term chronic illness during adulthood (Owens, 2014; Wong, Robertson & Dyson, 2015).

Over the last decade, research has focused on sleep duration during adolescence, and it has become clear that sleep duration declines through this developmental period (Carskadon, 2011; Schochat et al., 2014; Short, Gradisar, Lack, Wright, & Dohnt, 2013). For instance, the recommended sleep duration for adolescents is between eight to 10 hours of sleep per night (Hirshkowitz et al., 2015). However, Olds and colleagues, in their meta-analysis of sleep data found that adolescents fall below the recommended eight hour threshold particularly on school nights around the world, including countries across Europe (11 countries), Asia (four countries), and the Pacific Rim (Australia, Canada, and USA) as well as Brazil and Israel (Olds, Blunden, Petkov, & Forchino, 2010). Not only does sleep duration decline with age across adolescence, but it is also associated with later bedtimes (Olds et al., 2010). Specifically, time in bed for adolescents decreases by 14 minutes per school night per year of age. In contrast, studies in biologic regulation of sleep indicate the need for sleep is stable (to increasing) across adolescents' development (Jenni, Achermann, & Carskadon, 2005; Carskadon, 2011). Moreover, research by Gradisar and colleagues indicate that weekday sleep duration may have decreased even further in recent years, with the average now reported at around seven and a half hours sleep for US adolescents (Gradisar et al., 2013) and with the average for Australian adolescents at the lower end of the recommended threshold (8.3 hours; Short, Gradisar, Lack, Wright, & Dohnt, 2013).

With duration of sleep decreasing, it is important to consider other related sleep characteristics that may also be affected, including the quality of sleep, how long it takes to get to sleep and disruptions to a good night's sleep. That is, sleep is a multidimensional construct, rather than just measured as total time asleep, a number of different operationalizations of sleep are permeating recent research, and there is a growing recognition that sleep measures can extend across a number of different domains (Carskadon, 2011). For instance, sleep-wake patterns can be examined as an organizing construct for examining sleep. Sleep problems (not diagnosed sleep disorders, e.g., sleep apnea) can also be conceptualized into a number of measurable factors; such as sleep duration, sleep quality, sleep schedules, sleep onset latency (time it takes to fall asleep), night awakenings, Circadian chronotype, and daytime sleepiness (Cain & Gradisar 2010).

It is also important to consider other operationalizations of sleep because duration does not always show a direct effect on adolescent functioning. Thus some research indicates that a lack of sleep associates with daytime sleepiness, poor academic performance, and depressed mood (Fuligni & Harway, 2006; Wolfson, 2002). However, other work indicates that different operationalizations are more closely linked to adolescent wellbeing. Illustratively, Short and colleagues (2013) investigated sleep duration, sleep quality, and Circadian chronotype in adolescents and found sleep quality and evening chronotype, not duration, associated with poorer grades through the association with depressed mood (Short, Gradisar, Lack, & Wright, 2013). In this thesis, self-report measures of sleep quality, daytime sleepiness and behavioral habits to delay sleep are used to tap into adolescent sleep functioning, given reliance on longitudinal survey data, and good indications that these measures relate to symptoms of psychopathology (Shochat et al., 2014).

2.1.1 Sleep within an Integrated Conceptual Framework

Investigating sleep characteristics within a lifespan perspective is critical, as it has become clear that sleep is at the core of other developmental processes (Dahl & Lewin, 2002). That is, adolescents' sleep is influenced by their developmental stage, and by the associated ongoing changes they experience over the course of their development. Although sleep requirements during adolescence are stable (Carskadon, 2011), research clearly shows that the amount of sleep adolescents obtain is below what is required for normal adjustment (Gradisar et al., 2013).

Lewin and Dahl (1999) constructed an organizing framework to help structure their research into sleep patterns within psychology. Their first theoretical paper postulated that there was a bidirectional relation between sleep and pain (Lewin & Dahl, 1999). That is, being in pain prolongs the onset of sleep and insufficient sleep results in increased worry, stress, and poor pain management setting up a bidirectional relation between biological factors and sleep. Although Lewin and Dahl (1999) postulated that sleep is universally biologically driven across the lifespan, sleep also needs to be investigated in terms of *process, person, context* and *time* (Bronfenbrenner & Morris, 2006). Thus, sleep is part of a greater biopsychosocial regulatory system, and each system can be interrelated across time (Carskadon, 2011).

Building on Carskadon's (2011) review of biologic, psychological and socio-cultural influences on sleep, Becker and colleagues (2015) have proposed a biopsychosocial *and* contextual model of sleep in adolescent development. Here, Becker et al. (2015) highlight previous research which has identified psychosocial and contextual factors that play a key role in adolescent sleep habits. This model further highlights the need for an integrated conceptual framework that includes changes in sleep and changes in contextual, biological and psychosocial factors. Moreover, this

model recognizes reciprocal relationships between these factors and sleep as well as the dynamic role of individual characteristics that influence overall behavioral choices in relation to adolescent sleep. Importantly, time is also included in this conceptual framework (Becker et al., 2015; Bronfenbrenner & Morris, 2006).

In summary and central to the tenets of this thesis, the dynamic interaction within the bidirectional framework of Lewis and Dahl (1999) has been extended by Becker and colleagues to comprise multiple domains of functioning, including contextual and individual psychosocial factors, which interact over time with sleep at its core (p. 241, Becker et al., 2015; p. 644, Carskadon, 2011). Thus, within Becker and colleague's framework, this thesis seeks to understand the process that occurs in relation to change in sleep patterns between and within individuals, aims to characterize different contextual factors that could influence emotional, behavioral and self-regulatory determinants of sleep, and explores the outcomes associated with poor sleep.

Building on Becker and colleagues (2015) updated model, the following section reviews how biological, psychosocial and contextual factors intersect with adolescents' critical sleep needs. The following sections briefly touch on these areas.

2.1.1.1 Biological

Biological influences on adolescent sleep include the onset of puberty, which triggers the delay in the circadian timing system, a change toward evening circadian phase preference and a slower accumulation of homeostatic sleep pressure resulting in an associated later sleep-wake schedule (Carskadon, Acebo, & Jenni, 2004; Jenni, Achermann, & Carskadon, 2005). During adolescence the timing of sleep is said to be the result of the interaction of two separate processes: the sleep-wake homeostatic process (Process S) and the sleep-wake circadian process (Process C; Borbely & Achermann, 1999; Jenni et al., 2005). The homeostatic sleep-wake system is characterised by a homeostatic sleep drive whereby sleep pressure increases the longer

the individual stays awake and decreases during sleep (Carskadon, 2002). Furthermore, as sleep pressure dissipates during sleep the circadian timing system protects sleep during the second half of the night (Carskadon, 2002). During puberty there is a slower accumulation of homeostatic sleep pressure which allows older adolescents to stay awake later and delay the sleep-wake cycle (Jenni et al., 2005). As well, during adolescence, there is also a developmental change in the circadian timing system whereby there is a circadian phase preference in older adolescents for a later bedtime indicating underlying changes in the biological mechanisms regulating sleep. Indeed when dark time is held constant an individual's pubertal stage is positively associated with later circadian timing (Carskadon 2002). When adolescents are allowed to wake up on their own, they have been shown to require approximately nine hours of sleep per night, and they experience a shift in their biological clock to preferring later bedtimes and rise-times (Carskadon, 2002). This shift is biologically based, as adolescents start to secrete melatonin, the chemical which contributes to drowsiness, up to two hours later relative to when they were children (Wolfson, 2002). Attaining adequate sleep becomes problematic as rise times are influenced by school start times and adolescents become sleep deprived with non-negotiable school start times (Carskadon, 2002; Wolfson, 2002). In addition to these biological factors associated with adolescent sleep, contextual and psychosocial factors associated with adolescent technology use can also disrupt this homeostatic balance.

2.1.1.2 Contextual

Contextual factors that impact sleep include homework, employment and extracurricular activities, school start times, neighborhood and community factors as well as electronic media including watching television, video game playing, computer and Internet use, mobile phone use and social networking (Cain & Gradisar, 2010). These factors interact with each other, and with sleep and influence adjustment and

wellbeing of adolescents. Importantly, situational contexts are often transitory in nature. Therefore, it is important to determine the degree to which sleep problems are associated with key contexts at varying time-points, that is whether contexts continue to influence youth as they develop. For example, for some U.S. adolescents, time spent doing homework decreases the amount of sleep obtained on school nights compared to weekends-and so there may be short-term changes in contextual influence. Importantly, this effect is also more salient for older students, pointing to the importance of exploring changing relations between sleep and contexts over time (Fuligni & Hardway, 2006).

Adolescent sleep patterns are also interwoven with broader contextual factors related to community and neighborhood such as parental income and education, both of which contribute to socioeconomic status (SES). Indeed, adolescents from low SES areas are at risk of less sleep because of stressors such as family economic hardship, neighborhood crime and less parental control over screen time likely interfere with healthy sleep (Adam, Snell, & Pendry, 2007; Buckhalt, El-Sheikh, & Keller, 2007; McHale, Kim, Kan, & Updegraff, 2011). Conversely, upwardly mobile families with higher incomes and higher parental education increase academic demands on adolescents, and this can lead to time-consuming homework and extracurricular activities which can compete with sleep time (Knutson & Lauderdale, 2009; McHale et al., 2011). Therefore family SES can be associated with both risk and protective factors related to sleep for adolescents, and so is an important control in sleep-focused research.

2.1.1.3 Psychosocial

Psychosocial factors play an important role in adolescent development, and as a result, they can both influence and be influenced by their sleep (Becker et al., 2015). During adolescence, individuals undergo mental and emotional growth, and healthy development in these areas is facilitated by quality sleep. Among the key psychosocial

factors known to bi-directionally impact sleep includes; family and parent bedtime monitoring, academic functioning and wellbeing, and family, and social relationships.

One key social relationship that is especially salient during adolescence and that may play an increasingly significant role in sleep is those with adolescents' peers. There is a strong desire to make the most of new social relationships, and this is an essential avenue for facilitating healthy identity development (Côté, 2009). Historically, findings from research late last century suggest that peers had little influence on sleep patterns (Carskadon, 2002). However, there is some research to show that increased positive engagement with friends during the day has a positive impact on sleep functioning with increased sleep duration (Fuligni & Hardway, 2006). Moreover, for the current generation of adolescents, many such opportunities for forming and building peer relationships are present online (Valkenburg & Peter, 2011), and this may play a growing role in sleep disruption.

2.2 Sleep and Wellbeing

Problematic sleep can be detrimental to healthy development and wellbeing and adolescents who go to bed later than their peers are less healthy both physically and mentally and less able to cope (Wolfson, 2002; Sadeh & Gruber, 2002). Later bedtimes increase the risk of developing negative health outcomes and poor cognitive performance (Becker et al., 2015; Shochat et al., 2014; McGlinchey & Harvey, 2015). Whether sleep problems are due to bio-regulatory processes (Carskadon, 2002), academic pressures (Lui, Lui, Owens, & Kaplan, 2005), or technology related behavioral choices (Van den Bulk, 2004, 2007), the consequences of poor sleep for adolescents can be cognitive and behavioral problems, poor academic performance and emotion regulation difficulties, and poor self-esteem (Acebo & Carskadon, 2002; Becker et al., 2015; Fredriksen, Rhodes, Reddy, & Way, 2004; Noland, Price, Dake, &

Telljohann, 2009; Shochat et al., 2014; Short, Gradisar, Lack, Wright, & Dohnt, 2013). Although problematic sleep manifests in a range of indicators of physical and mental health, it affects at least five key aspects of adolescent wellbeing which are reviewed below; school satisfaction, internalizing behaviors including depressed mood, self-esteem, coping and externalizing behaviors.

2.2.1 School Satisfaction

Another area in which sleep problems may manifest in poorer adolescent functioning is within the academic realm, especially in relation to their capacity to engage positively in learning and reach their full academic potential. Sleep problems may impact on the emotional appraisal of their satisfaction with their school which then contributes to their overall wellbeing (Huebner & Gilman, 2006; Lewis, Huebner, Malone, Valois, 2011). In fact, insufficient sleep, poor sleep quality, and sleepiness are all associated with learning difficulties and poor school performance (Dewald, Meijer, Oort, Kerkhof, & Bogels, 2010). Students who are tired and sleepy in the class have trouble performing the tasks required to navigate successfully through high school and so feel less satisfied with their school experience (Wolfson & Carskadon, 1998). Adolescents who report inadequate sleep and/or poor sleep quality tend to report lower satisfaction with their school experience and also perform more poorly in school (Short, Gradisar, Lack, & Wright, 2013; Wahlstrom, 2002; Wolfson & Carskadon, 1998, 2003). For instance, one survey of adolescents in the United States found 67% of high school students reported not getting enough sleep, and for this group, 83% reported that insufficient sleep had an impact on their school work (Gradisar, Gardner, & Dohnt, 2011). Overall adolescents who report sleep disturbances, reduced sleep quality, and less sleep have a related less positive attitude toward life in general and tend to be at risk of lower grades (Perkinson-Gloor, Lemola, & Grob, 2013; Titova et al., 2015; Tonetti, Fabbri, Filardi, Martoni & Natale, 2015).

2.2.2 Depressed Mood, Self-Esteem, and Coping

There is growing evidence of the links between sleep problems and mental health functioning with longitudinal research highlighting the associations between poor sleep and factors such as self-esteem and depressed mood (Fredriksen et al. 2004). For example, early studies have reported associations between sleep problems and depressed mood whereby inadequate sleep has linked to depressed mood (Acebo & Carskadon, 2002). These findings were supported using longitudinal analysis by Fredriksen et al. (2004) whereby students who obtained less sleep over time reported increased levels of depressed mood and declines in self-esteem. Using a daily diary methodology, another study identified that when students were stressed during their school day, they reported less sleep and increased levels of depressed mood, anxiety, and tiredness the next day, again without a reciprocal finding (Fulgini & Hardway, 2006). Sarchiapone and colleagues (2014) found that reduced hours of sleep are associated with greater emotional concerns, anxiety, and suicidal ideation, and it is plausible adolescents with less sleep and these severe mental health issues would, in addition, have not only lower self-esteem but also difficulty coping (Sarchiapone et al., 2014). Very few studies have examined links between poor sleep and coping strategies. One recent study to do so examined coping strategies that explicitly support sleep problems and found that greater support coping was associated with greater sleep continuity (El-Sheikh, Kelly, Sadeh, & Buckhalt, 2014).

Although cross-sectional research is useful for highlighting plausible associations, interrelationships between sleep and wellbeing are best explored using longitudinal studies. Especially during adolescence, when sleep is a key developmental task, it is critical to examine how disturbed sleep over time manifests in negative consequences across a number of functional domains. For example, longitudinally, disturbed sleep is linked to internalising problems such as increased depressed mood

(for review see Carney & Moss, 2014), anxiety, and decreased self-esteem (Fredriksen et al., 2004; Lovato & Gradisar, 2014; Roberts, Roberts, & Duong, 2009; Sarchiapone et al., 2014; Winsler, Deutsch, Vorona, Payne, & Szklo-Coxe, 2015). Illustratively, in one longitudinal study, Fredriksen and colleagues (2004) found that adolescents with reduced sleep over time reported higher levels of depressed mood and lower self-esteem, but a reciprocal relationship was not supported, and depressed mood and low self-esteem did not appear to lead to poor sleep. That said, other studies have shown a bidirectional relationship between sleep disturbance and depressed mood (Gregory & Sadeh, 2012; Kelly & El-Sheikh, 2014). One recent longitudinal study of 555 adolescents in the Netherlands found that sleep problems lead to internalizing problems one year later rather than the reverse (Pieters et al., 2015). Thus, research that follows both sleep and wellbeing over time may help to better elucidate directionality of associations between sleep and aspects of mental wellbeing.

2.2.3 Externalizing Behaviors

Not only is poor sleep linked to internalizing problems and lower self-esteem, but early evidence points to the possibility that sleep problems may also be associated with externalizing behaviors as well. For instance, adolescents who report less sleep and with sleep difficulties exhibit increased externalizing behaviors including increased risk-taking (Lin & Yi, 2015; McGlinchey & Harvey, 2015; O'Brien & Mindell, 2005; Pieters et al., 2015). Likewise, longitudinal research conducted by McGlinchey and Harvey (2015) showed that later bedtimes were associated with greater involvement in problem behaviors six years later, including criminal activity, alcohol abuse, and emotional distress. More recently Pieters and colleagues (2015) explored sleep in relation to externalizing behavior among adolescents and found sleep problems predicted increasing externalizing problems over time. Furthermore, a recent systematic review of the interrelationships between sleep and emotion concluded that sleep

deprivation is associated with diminished emotion regulation and this has particular importance for adolescent behavior problems (Beattie, Kyle, Espie, & Biello, 2015). Conceptually, it makes sense that reduced sleep would lead to poor behavioral regulation. Importantly, however, further research is required to better elucidate these links.

2.3 Technology Use and Sleep

The role of technology use in sleep disturbance is a growing concern, and worries about the impact of technology, are all the more salient because there are a number of different types of technology that can interfere with sleep as electronic media moves into children's bedrooms (Roberts, 2000). Early research studies have focussed on the risks associated with television as a key type of media that tended to appear in children's sleep environments (Eggermont & Van den Bulck, 2006; Van den Bulk, 2004). With increased affordability of television sets in the last century, the number of televisions increased per household, and parents began placing televisions in their teenagers' bedrooms. For instance, over two-thirds of U.S. adolescents have a television in their bedrooms (Barr-Anderson, van den Berg, Neumark-Sztainer, & Story, 2008; Rideout et al., 2010).

A body of research has established that the time adolescents devote to watching television screens is linked to poor sleep functioning (Gradisar & Short, 2013; Johnson, Cohen, Kasen, First, & Brook 2004; Van den Bulk, 2004). Further research by Shochat, Flint-Bentler, and Tzischinsky (2010) found that time spent watching television "displaced" time that would normally be spent sleeping, and this had a detrimental association with daytime behavior. With worldwide proliferation of a diverse range of technological devices into households, research changed focus from television to other forms of electronic media to determine if adolescents of today changed their screen habits and how this technology use had an impact on their wellbeing.

Currently there are a number of research studies examining if increased time engaged in the newer types of technology (computers, mobile phones, gaming consoles) as well as television comes at the expense of adolescents getting enough sleep and the impact on wellbeing (Bartel et al., 2015; Cain & Gradisar, 2010; Gradisar & Short, 2013; Hale & Guan, 2015; Zimmerman, 2008). This new research has documented that using technological devices in the bedroom likely interferes with sleep via three possible mechanisms; using media directly “displaces” sleep; bright light suppresses melatonin and interferes with the Circadian Rhythm; or emotional/mental/ physiological arousal from media content makes getting to sleep difficult (Cain & Gradisar, 2010; Hale & Guan, 2015).

Firstly, as with television, using technological devices may lead to shorter sleep duration because their use displaces sleep (for a review see Hale & Guan, 2015; Arora, Broglia, Thomas & Taheri, 2014; Gamble et al., 2014; Garmy, Nyberg, & Jakobsson, 2012; Punamäki et al., 2007). Importantly, use of specific devices has been associated with shortened weekday sleep. For instance, a UK study found that mobile phone use and computer use were the strongest predictors of reduced sleep, relative to other types of device use (Arora et al., 2013).

Because technological devices are used for many different purposes, too, it is also worth considering how different types of activities, and not just different types of devices, impact adolescent sleep. Thus, examining the type of activity the device is used for, in conjunction with the related content, may be useful for elucidating links between the use of electronic media and sleep disruption.

Secondly, electronic devices have light-emitting diodes (LED), which may impact sleep in two ways; bright lights alter Circadian rhythms and can inhibit melatonin secretion. During the pubertal transition, adolescents’ sleep-wake behaviors are impacted by changes in the Circadian timing system (Carskadon, 2002). These

changes delay the timing of sleep onset and, with set rise times to start school, result in insufficient sleep for adolescents (Acebo & Carskadon, 2002). The risk of such sleep difficulties increases when adolescents spend increasingly longer periods in front of electronic screens (Wood, Rea, Plitnick, & Figueiro, 2013). The hormone melatonin, which is necessary for sleep regulation, is suppressed by bright light and may work to keep adolescents alert into the night (Cajochen et al., 2011; Carskadon, 2011). For example, research has also demonstrated that exposure to light can also delay the Circadian rhythm in the evening (Khalsa, Jewett, Cajochen & Czeisler, 2003; Wood et al., 2013).

Thirdly, increased emotional arousal from variety of technological devices can increase sleep onset latency (i.e., the time it takes to fall asleep), and this may also help to explain the role of technology use in adolescent sleep disruption (Gamble et al., 2014; Gradisar & Short, 2013; Hale & Guan, 2015; National Sleep Foundation, 2011; Pieters et al., 2014; Shochat et al., 2010). For example, playing video games with emotionally arousing content before bedtime may have a particularly detrimental effect on sleep for the current generation (Higuchi, Motohashi, Liu, & Maeda, 2005) or stimulating TV content (Van den Bulk, 2000). Zimmerman (2008) suggests the timing of technology use is important in relation to the impact of emotional salience from technology. For adolescents highly invested in social media, if negative feedback is received at night, prior to bedtime or after *lights out* then it is highly likely stimulating negative content elucidates an emotional arousal (for example, envy or anxiety) which impedes sleep onset. It could be suggested that emotional arousal from social networking activities prior to sleep or receiving messages during sleep needs to be considered in association with disturbed sleep. Moreover, fears about missing-out on content may be another form of emotional arousal that disrupts sleep and leads to

shorter sleep duration (APS, 2015; Thomée, Dellve, Härenstam, & Hagberg, 2010; Van den Bulk, 2007).

It may also be the case that for some adolescents, certain types of content associated with electronic media are more emotionally salient than another. For example, for some teenagers, certain types of video gaming may be used as a passive engagement strategy (Gradisar & Short, 2013) and this type of electronic media may be used to “wind down”. However, for others, engaging in electronic media such as social media, for instance, to garner “likes,” may be more emotionally arousing (Sherman, Payton, Hernandez, Greenfield, & Dapretto, 2016). Likewise, using social media to facilitate social interactions with peers, develop friendships and explore identities (Spies-Shapiro & Margolin, 2014) may result in greater difficulty in cognitively settling for sleep (Arora et al., 2014).

Technology that is interactive, such as texting and phoning using mobile phones and SNS use, may arguably be especially disruptive to adolescent sleep. A recent meta-analytic study by Bartel and colleagues (2015) examining risk factors for adolescent sleep found some support for the disruptive role of interactive technology use. Similarly, Hale and Guan (2015) in their review of screen time and sleep indicated that over 90% of the studies found screen time adversely associated with sleep and noted it may not just be screen time, given overlaps and ambiguity that exists between characteristics of technological activity and the type of content the device can host. Likewise, Zimmerman (2008) has postulated that content within the activity on the device may be an especially salient factor in contributing to sleep problems, more so than the type of device itself.

2.3.1 Social Networking and Sleep

Social networking use may be especially disruptive to adolescent sleep because it is a context in which youth spend inordinate amounts of time. Social networking also

has the potential to impact adolescent sleep as its pervasive use often occurs in the privacy of the bedroom (Espinoza & Juvonen, 2011). Indeed, social networking sites started attracting adolescent users in 2004 when opportunities to connect with friends presented, often without parental awareness of the phenomena. Initially applications such as MySpace and subsequently Facebook increased in popularity (Boyd & Ellison, 2007). More recently, a PEW Institute Report (2015) on teenagers social media and technology use, indicated that Facebook, one social networking site platform, had over 70% of those surveyed as Facebook users and those who use this site do so to interact daily with friends, families and interest groups (Lenhart, 2015). Likewise, a recent report by the Australian Psychological Society found that teenagers spent an average of around two hours and forty-five minutes per day connected to any social media with 53% of teenagers checking social media in the 15 minutes before bedtime (APS, 2015).

On social network sites, it is possible for teenagers to *show-off* their friendship networks, either by using a private profile of known friends who are accepted by the individual, or posting to the public where everyone has a knowledge of the social network of the individual (Boyd, & Ellison, 2007). The increased use of social networking sites by teenagers raises a number of issues concerning whether adolescents become reliant on social networking sites to fulfill their emotional needs and/or whether increased time devoted to this activity, often alone in the bedroom, is viewed negatively by family and friends. As adolescents invest in social networking, its use can become problematic. However, research has not yet adequately examined such problematic use of social networking. Instead, research has mainly relied on frequency of use measures, which are limited in their capacity to capture individual differences in importance or investment in social networking among adolescents (Blomfield-Neira & Barber, 2014).

Measuring adolescents' investment in social networking is important because any behavior, which can be used to manipulate emotional arousal including SNS, can

become addictive (Brown, 1987). For example, using Brown's criteria to indicate the development of an addiction, Young (1998) investigated Internet addiction among university students. She found those that met the criteria for dependency on the Internet had poor study habits, poor grades, or failed at university. That said, there is considerable debate over whether Internet addiction is, in fact, a new psychological disorder, whether it can be measured consistently from country to country, or how to appropriately assess its prevalence among respective populations (for review see Felt & Robb, 2016).

Some scholars have attempted to assess internet addiction in relation to specific types of social networking. For example, Andreassen and colleagues adapted technology addiction scales to investigate Facebook addiction in adolescents (Andreassen, Tosheim, Brunberg, & Pallesen, 2011). They found those that met the criteria for Facebook dependency had delayed bedtimes and rise times. Although timely, this scale is limited by its specific reference to a commercially branded site, Facebook, rather than being generic and able to investigate relationship investment across all social networking platforms (Griffiths, 2012). As a result, an existing gap in research to date has been the lack of appropriate capacity to measure problematic social networking investment, more broadly. As one of several aims of this thesis, a construct to measure problematic investment in social networking among adolescents was developed for this research.

One of the reasons it is important to measure problematic social networking investment, is that studies of young adults and adolescents have reported links between frequent use of social networking sites and links with negative weekday sleep duration (Arora et al., 2014; Espinoza & Juvonen, 2011) and increased sleep disturbance, including sleep quality (Levenson, Shensa, Sidani, Colditz, & Primack, 2016; Wolniczak et al., 2013; Xanidis & Brignell, 2016). For example, in a survey of younger

adolescents, Espinoza and Juvonen (2011) found among those students who used social network sites, 37% reported losing sleep because of engaging with social networking. Similarly, Arora et al., (2013) surveyed 738 young adolescents in the United Kingdom aged 11-13 years and found that those who were high-end users of the Internet for social networking before bedtime had reduced sleep duration compared to those who sometimes or never used the Internet to engage in social networking. A follow-up study of frequent young adolescent users of social networking further established that they had almost one hour less sleep than those who were non-users (Arora et al., 2014). Although, these studies of younger adolescents are elucidating, they were all cross-sectional, so it is not possible to determine if social networking dependency contributes to poor sleep or whether poor sleepers engage in social networking or both. Likewise, in addition to young adolescents, other research has investigated social media habits and sleep within young adult populations (Levenson et al., 2016; Wolniczak et al., 2013; Xanidis & Brignell, 2016). However, no research to date has investigated these relations among older adolescents (13-17-years) who are the most prolific users of social networking (Lenhart, 2015). Nor has research addressed these links in any developmental population longitudinally. This thesis addresses both these gaps in the literature, and in two of the three studies tracking changes in social networking and sleep over time across ages 13-17, while also investigating directionality of links among constructs.

As described above, there are several reasons why technology, including social networking engagement, might disrupt adolescent sleep. Specific to social networking, this may be especially likely to displace sleep time and may also have especially heightened physiological arousal, which can influence the underlying biological development of sleep. Most likely, both explanations are valid as social media provides an ability to peruse profiles endlessly into the night, and the interactive nature of the

social networking may also arouse neural pathways, which make winding down to sleep difficult (Woods & Scott, 2016). First, there is increasing evidence linking social media use to shorter sleep duration, which seems to suggest that some of the time spent social networking can displace sleep time (Arora et al., 2014). Second, emotionally, fear of missing out on content may also disturb sleep (Munezawa et al., 2011). Likewise, 60% of Australian teenagers who were users of social media reported experiencing brain *burnout* from constant connectivity to social media (APS, 2015). Moreover, another emotional aspect of social networking investment may be its potential as a source and platform for negative engagement and conflict for many adolescents (68%; Lenhart, Smith, Anderson, Duggan, & Perrin, 2015).

2.3.2 Mobile phone use and Sleep

Some of the concerns about problematic use of social media have arisen due to the prolific uptake of mobile devices, which have dramatically increased adolescents' access to the Internet. Historically in 2004 only 39% of U.S students surveyed owned a mobile phone and this grew to 66% in 2009 (Rideout et al., 2010). Now over 67% of U.S. teenagers own a smartphone (Rideout, 2015), which allows for mobile access to the Internet and social networking sites (65% of U.S. teenagers use social media, up from 7% in 2005; Perrin, 2015). Likewise, over 88% of Australians over the age of 14 years in 2012 had use of a mobile phone, and currently, 80% of young Australian teenagers have access to a smartphone (ACMA, 2013, 2016). As a result, as today's youth progress through adolescence, their mobile phone provides an increasingly important tool for social interaction. Indeed, many teenagers report they cannot live without their phones as they are essential to their social life (Smith & Page, 2015; Ling & Yttri, 2002). The idea here is that the mobile phone is considered by many adolescents to be their own private device, whereby they are able to send and receive messages independent of parental influence, facilitating their development of identity,

autonomy, and self-esteem (Blair & Fletcher, 2011; Erickson, Wisniewski, Xu, Carroll, Rosson, & Perkins, 2015; Livingstone, 2008; Subrahmanyam & Greenfield, 2008). However, this *private device* may also work to disrupt adolescents' sleep development due to the displacement of everyday activities or emotional arousal, and so mobile phone use may facilitate risk, as well as an opportunity.

Problematic mobile phone use and its potential displacement of sleep could have long-term negative impacts on wellbeing. Coupled with the privacy of their bedrooms, teenagers are able to sustain communication well into the night (Arora et al., 2014; Green & Singleton, 2009). Unlike previous generations who would have used a landline situated in a central area in the house more easily monitored by parents, a proliferation of mobile phones means adolescents can privately contact their friends in their bedroom. The portability associated with mobile phones means that adolescents are able to sustain communication at any time of the day or night (Auter, 2007; Ling & Haddon, 2008). A recent study of older adolescents and young adults in India reported that all participants kept their phones either on their bed (91%) or a table near their bed (9%) and only 6% turned their phone to silent as they slept (Gupta, Garg, & Arora, 2015). Thus it is possible that some adolescent sleep problems occur due to texting that occurs at night.

Moreover, mobile phones may also disrupt adolescents' daily activities, and sleep activities in particular, due to the ubiquitous nature of daily texting. Text messaging via mobile phone or short message service (SMS) texting is an important means of communication for adolescents; 91% of adolescent mobile phone owners use text messaging, typically sending or receiving an average of 67 text messages per day, with older teenage girls exchanging on average 83 text messages per day (Lenhart, 2015). As well, adolescents use their mobile phone in daily communication to text (63%) rather than talk (39%), or engage in face-to-face communication outside of

school (35%; Lenhart, 2012). Texting between friends has become a dominant form of communication for social connectedness; when meeting people for the first time, the first item shared is a mobile phone number with the expectation that they will contact and be constantly accessible to exchange messages (Lenhart et al., 2015). This may include texting after hours and into the night.

Another reason that texting and other mobile phone use may be especially likely to disrupt adolescent sleep is that mobile phones enhance connectivity with friends (Ling & Haddon, 2009), and peer relationships are especially important during adolescence (for review see Brown & Larson, 2009). Indeed, prior to the rise in adolescent mobile phone ownership, peer influence was not considered a source of concern for adolescents' sleep (Carskadon, 2002). However, adolescents now text prolifically to maintain their social interactions 24 hours a day, seven days a week, staying in *perpetual contact* (Title, Katz & Aakhus, 2002) and facilitating development of their identity and status within their group (Ling, 2004; Subrahmanyam & Greenfield, 2008). Adolescents may increasingly invest in a mobile presence to maintain their group status and to receive *rewards* (return messages) to show they are being thought of, and included in their intimate group (Grellhesl & Punyanunt-Carter, 2012). This engagement is arguably emotionally arousing, and this may also contribute to plausible sleep disruption associated with adolescent mobile phone use.

In all, among adolescents, parents' ability to regulate mobile phone use declines as importance placed on peer relationships grows (Erikson et al., 2015; Ling 2004), and so enduring poor habits related to mobile phone use around bedtime can develop (Van den Bulck, 2007). Attaining a good night's sleep is simply not a priority for teenagers who increasingly use their mobile phones in the bedroom (Arora et al., 2014; Lemola, Perkinson-Gloor, Brand, Dewald-Kaufmann, & Grob, 2015; Munezawa et al., 2011). Although some evidence suggests that communicating via mobile phone into the night

contributes to poor sleep, more research is needed, particularly in relation to changing mobile phone habits over time, and how this may lead to subsequent changes in sleep and associated wellbeing.

2.4 Problematic Technology Use and Wellbeing

Adolescents' technology use has captured the attention of the media, in part, because of evidence of links to reduced wellbeing with heavy use (Felt & Robb, 2016). The association between problematic use of technology and the multiple dimensions of wellbeing, including depressed mood, self-esteem, coping, problem behavior, and school satisfaction are explored to clarify the relative importance in relation to a technological activity, social networking and a technological device, the mobile phone.

2.4.1 Social Networking – School Satisfaction

There is mounting evidence that social networking can hinder academic performance although most evidence has been collected from college students and young adults (Junco, 2012; Kirschner & Karpinski, 2010). Specifically, Kirschner and Karpinski (2010) reported associations between increased time spent social networking and poor grades, plausibly due to poor time-management. Junco (2012, 2015) found that when college students multitasked with social media, in this case, Facebook, to build social relationships, then their academic performance suffered. One explanation could be that media multitasking can intensify cognitive fatigue, therefore, academic productivity declines (Felt & Robb, 2016). When adolescent academic performance has been investigated in relation to social media, the research suggests a negative relationship between social networking (measured by the amount of time and frequency of checking Facebook) and math grades (Lee, 2014). A more nuanced approach to measuring social media use in Chinese students, by examining not only level of use but also investment in social media found adolescents who were preoccupied with and

overused social media had declines in academic performance (Hanyun & Leung, 2009). Although there is evidence linking adolescent social networking and negative academic performance more research was needed to determine the explanatory mechanisms especially related to fatigue, for this relation.

2.4.2 Social Networking – Psychopathology

There is a growing body of research into the rapid rise in social media uptake by adolescents as well as early evidence that suggests overinvestment in social media can be associated with links to psychopathology (Kuss & Griffiths, 2011; Spies-Shapiro & Margolin, 2014). For instance, the exponential growth in social networking raises a number of issues concerning adolescents' reliance on social media to fulfill their emotional needs and whether increased time and/or emotional salience or investment in social networking, negatively impacts wellbeing. Cross-sectional studies using various methods to measure social media including frequency, time or emotional investment in social media have been linked to negative aspects of wellbeing. For example, problematic use of social networking has been associated with psychological distress and suicidal ideation (Sampasa-Kanyinga & Lewis, 2015), low self-esteem as well as increased rejection for those with low self-esteem (Blomfield-Neira & Barber, 2014; Forest & Wood, 2012; Valkenburg et al., 2006), and depressive symptoms (Błachnio, Przepiórka, & Pantic, 2015; Blomfield-Neira & Barber, 2014). However, Blomfield and Barber found participating in social media can be beneficial for higher social self-concept for some adolescents (Blomfield & Barber, 2014). Recent cross-sectional findings from Woods and Scott (2016) based on social media use of 467 Scottish adolescents found that those who used social media both overall and before bed, as well as being heavily invested in social media, had lower self-esteem and higher levels of anxiety and depression. Emerging longitudinal studies with Korean students indicate

that there is a negative relation between social media activities and self-reported mental health and suicidal ideation, not vice versa (Kim, 2016).

Further, there is also a growing body of evidence to suggest that for some adolescents engaging in social networking can predict increased problem behavior (Mikami, Szewedo, Allen, Evans, & Hare, 2010). Social media can facilitate unfavorable self comparisons (Tandoc, Ferrucci, & Duffy, 2015) as well as host cyber-aggressive behavior (Modecki, Minchin, Harbaugh, Guerra, & Runions, 2014). Research related to cyber bullying suggests that adolescents can continue their negative behaviors between their online social connections and face-to-face communication contexts (Mikami et al., 2010; Modecki, Minchin et al., 2014). Notably, much of the cyber bullying occurs on social media and has been linked to poor mental health, including elevated depressive and externalizing symptoms (Modecki, Barber, & Vernon, 2013; Wang, Nansel, & Iannotti, 2011). Therefore key questions include whether adolescents over investment in social media impacts on adolescents' psychopathology and whether there are mechanisms to explain the links between problematic social networking use and psychopathology.

2.4.3 Mobile Phone Use – Psychopathology

Parallel with the prolific uptake of mobile phones, research directly elucidating the relation of problematic mobile phone use to reduced wellbeing among adolescents is increasing. For example, excessive mobile phone use in Taiwanese adolescents was found to be associated with aggression, low self-esteem, and risky behavior (Yang, Yen, Ko, Cheng & Yen, 2010). Two studies in Japan examining mobile phone use after lights out found high prevalence rates, particularly for younger adolescents, associated with poor mental health (Munezawa et al., 2011; Oshima et al., 2012). A recent study examining the influence of increased cell-phone use, although with college students in America, found that cell phone use and texting were both negatively associated with

academic performance, life satisfaction and positively associated with anxiety (Lepp, Barkley, & Karpinski, 2014). This current research has been cross-sectional. Research examining mobile phone use over time and subsequent psychopathology is limited, and our review of the literature did not identify any studies that track mobile phone use and psychopathology over time.

2.5 Mediating processes

Contemporary adolescents, native to the world of digital technologies, must manage competing demands on their time including engagement in online activities such as social networking and the use of mobile phones. As described earlier, one of the major factors contributing toward chronic sleep loss for adolescents worldwide is electronic media use at night (Owens 2014). To further illustrate, this sleep loss can have health and behavioral consequences including increased depression, psychological stress, problem behaviors, and poor academic performance. Importantly, too, technology use itself is also linked to psychopathology and reduced wellbeing. Thus, these links point to a possible mediating processing in which technology leads to reductions in wellbeing vis a vis disrupted sleep.

Early cross-sectional evidence for this type of mediational process explicates the role of poor sleep as a mediator for the link between excessive mobile phone use and depressive symptoms (Lemola et al., 2015), and anxiety (Adams & Kisler, 2013). However, this research was cross-sectional in nature and involved college students. Further, cross-sectional research using a measure of emotional investment in social media by Woods and Scott (2016) found that lower self-esteem among heavy social media users may be due to poorer sleep. However they controlled for anxiety, depression, and self-esteem attenuating the association of interest, and suggest further research was required to identify underlying mechanisms. Interestingly these researchers also measured nighttime social media use and found those adolescents that

use social media close to bedtime had lower self-esteem and higher levels of anxiety and depression. Notably, too, they also had reduced sleep quality. Again the researchers note a limitation is related to the requirement to examine the interrelations. Accordingly, to broaden our current knowledge longitudinal research is required to examine trajectories of adolescent mobile phone use and social media use over time, with relations to trajectories of sleep, and wellbeing.

This thesis examines problematic social networking and mobile phone use as contributors to sleep problems and how these relate to multiple aspects of adolescent functioning and long-term wellbeing. Studies first focused on links between social networking, sleep, and school satisfaction, followed by associations between social networking, sleep, and psychopathology over time. Finally, mobile phone use was explored in relation to sleep and a range of indicators of wellbeing, including psychopathology, self-esteem, and coping.

2.6 The Current Thesis

Despite a growing body of evidence to indicate various forms of technology are correlated with reductions in wellbeing (depressed mood, externalizing, self-esteem, and coping), the process through which this occurs has not adequately been addressed. Clearly, sleep deprivation can have serious consequences for adolescent wellbeing (Fredriksen et al., 2004; Shochat et al., 2014) and the main tenet of this thesis is that this is one process through which technology may negatively impact adolescent functioning. The significance of social connectedness for peers on social networking sites combined with the means to connect at any time of the day or night using mobile phones means that sleep can often be compromised, with serious negative consequences for wellbeing; the *perfect storm* (Carskadon, 2011, p. 637).

Changes through puberty, social pressures and increasing independence to manage bedtime routines during adolescence characterize later shifts in sleep timing

(Carskadon, 2002). That said, the rapid uptake of new electronic media has increasingly had an impact on adolescent sleep (Gradisar & Short, 2013). In turn, poor sleep impacts on adolescent internalizing and externalizing behaviors and is likely to influence long-term wellbeing as well as influence alertness, self-esteem, coping and school experience (Short, Gradisar, Lack, & Wright, 2013). This possible process is important to highlight, as the literature increasingly examines associations between heavy adolescent technology use and reduced wellbeing. Yet very little research has explored processes through which this association occurs.

A review of the literature identified a number of gaps which the current thesis addresses. A rise in electronic media use and adolescents' desire to stay connected with their peers has led youth to text, phone or use social networking to message into the night as a matter of course. Despite a growing body of research suggesting that using technology into the night results in sleep disruption, we know little about how using technology relates to sleep functioning which in turn affects broad aspects of adolescent wellbeing. This thesis investigates these process focusing on two technology contexts, social networking as a technology activity and mobile phone use as a technological device, and their links to adolescent sleep and wellbeing.

The first aim of the thesis was to determine if adolescent' sleep disruption is a mechanism linking the problematic use of social networking to school satisfaction. As an adequate amount of good quality sleep is required by adolescents to successfully navigate through school. Identifying technological contexts that disrupt connections to school is an important area for research. Although there is an established link between adolescent sleep habits and school performance, and separate research has demonstrated links between problematic social media use and disrupted sleep, and between social media use and reduced academic functioning, research that investigates how problematic social networking relates to problematic adolescent sleep patterns and, in

turn, to a poor school experience, is lacking. Consequently, Study-1 investigates adolescents' sleep disruption as a mechanism linking the problematic use of social networking to school satisfaction.

The second aim of the thesis was to determine whether changes in problematic social networking over time were linked to changes in functioning via disturbed sleep. Based on evidence that problematic online social networking has potential negative consequences for wellbeing (Kuss & Griffiths, 2011) it is essential to further explore links between social networking and psychopathology, and possible explanatory mechanisms. It is argued that when adolescents use electronic media into the night, they will experience sleep disruptions, and this in turn, is associated with an increase in moodiness and externalizing behaviors. Thus, Study-2 used longitudinal data to map changes in investment in social networking and to assess concurrent change in psychopathology, including internalizing and externalizing behaviors. Moreover, it determines whether at least part of these associations can be explained through concurrent change in disturbed sleep.

The third aim of the thesis was to examine whether increased texting/messaging/phoning into the night was associated with subsequent increases in a variety of indicators of wellbeing, including depressed mood and externalizing behavior, and self-esteem, and coping. Again, the probable mediating role of changing sleep behaviors was explored as a plausible mediator. In particular, the final study examined whether early changes in problematic mobile phone use would predict later change in wellbeing using a longitudinal design, as mediated by change in sleep behaviors. With the rise in mobile phone ownership for adolescents, it is of critical importance to explore how mobile phone behaviors (e.g. texting, messaging, and phoning into the night) affect adolescents' functioning. Indeed, *changes* in texting/messaging/phoning into the night should predict changes in later manifestations

of wellbeing. However, no research has yet explored this possibility to date. Moreover, increases in poor sleep behaviors may help to explain these relations, though this has not yet been empirically assessed.

In sum, this thesis generates new insight and builds upon previous research highlighting the problematic use of technology for adolescents who have embraced a digital lifestyle. This thesis examines academic, psychosocial, and mental health risks associated with increased technology use, and highlights the impact of poor sleep on wellbeing over time. Specifically, the thesis parses two especially salient aspects of technology for adolescents and examines their developmental change over time, and in relation to sleep and wellbeing. Notably, too, few studies have examined social networking or mobile phone use over time. As a result, this thesis makes novel contributions across several key areas of the developmental literature and helps to disentangle developmental relations between problematic social media and mobile phone use, sleep, and salient features of adolescent functioning.

2.7 Preface to Chapter 3

Study-1

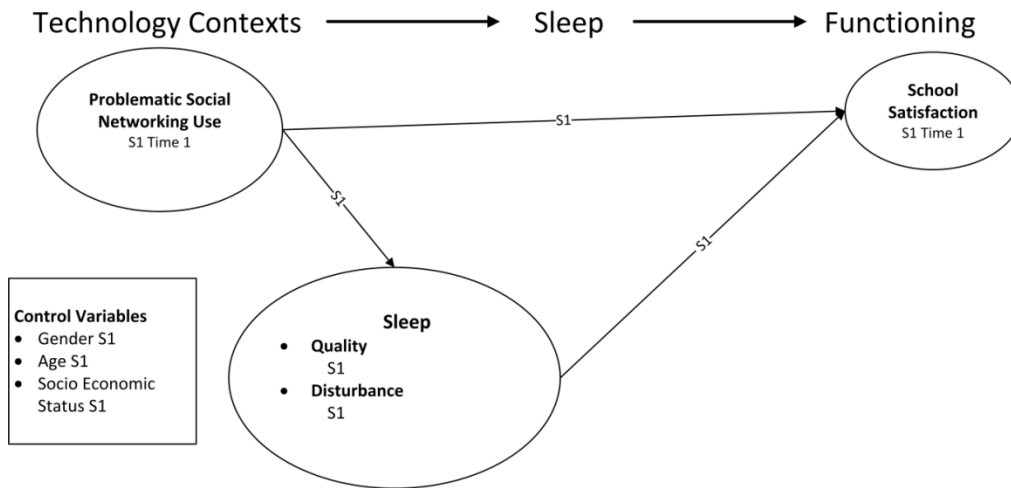


Figure 2-1 The conceptual model tested in Chapter 3 (Study-1).

2.7.1 Aims:

To identify technological contexts which hinder connections to school (see Figure 2.7-1).

- To explore whether problematic investment in social networking relates to adolescent sleep patterns.
- To determine if adolescents sleep disruption is a plausible mechanism linking the problematic use of social networking to school satisfaction.

Teenagers of today spend a large proportion of their time immersed in media, with televisions, computers, gaming consoles, and mobile media housed in their bedrooms. Parents, with the best of intentions, station computers in their teenager's bedrooms so homework can be completed. This practice, however, can be misguided as online devices allow heavy users of social networking to spend more than three hours a day using social media (Rideout, 2015), often at the expense of time normally spent doing homework, reading or engaging in other educational pursuits. This time displaced

by social networking has a detrimental association with school performance (Junco & Cotton, 2011; Rideout, et al., 2010; Sharif & Sargent, 2006). When homework time is finished for the evening and computers are shut down, teenagers can continue to connect with their peers well into the night using online mobile devices (Van den Bulck, 2004, 2007). The identified time devoted to media use (Rideout et al., 2010) not only can displace educational pursuits, it also can compete with sleep, resulting in a trend for adolescents toward insufficient sleep and reduced sleep quality (Giannotti & Cortesi, 2002; Van den Bulck, 2004, 2007).

Assessment of the growing dependency of young people on social networking as a behavioral addiction (see Kuss and Griffiths (2011) for a Literature Review) developed using a variety of measures (Thadani & Cheung, 2011). Study-1 survey items were developed from behavioral addiction studies to investigate social networking behaviors, which manipulate emotional arousal and therefore become problematic (Brown, 1987). These survey items were used in a confirmatory factor analysis to develop a latent construct for problematic use of social networking. As well, latent constructs for sleep disturbance and sleep quality were introduced to examine adolescent sleep habits. Finally, a latent construct for school satisfaction modeled adolescent's school experience.

Overall Study-1 gained insight into the mismatch for adolescents between the developmental need to increase their sleep and the choice and opportunity to engage in social networking. As well the link between problematic use of social networking as a context that affects academic competence was established. Study-1 also validated the mediating role of adolescent sleep quality and sleep disturbances on the effects of problematic use of social networking on an adolescent's school satisfaction. Study-1 affirmed the value of good sleep habits for a positive school experience as poor sleep was an important underlying mechanism linked to problematic social networking.

Chapter 3 Study-1

Adolescent Problematic Social Networking and School Experiences: The Mediating Effects of Sleep Disruptions and Sleep Quality

The following is a modified version of the published co-authored paper, however, it is formatted in accordance with the authors' instructions for submission to the Journal of Cyberpsychology, Behavior and Social Networking. The bibliographic details of the co-authored paper, including all authors, are:

Vernon, L., Barber, B. L., & Modecki, K. L. (2015). Adolescent problematic social networking and school experiences: The mediating effects of sleep disruptions and sleep quality. *Cyberpsychology, Behavior and Social Networking*, 18(7), 386-392. doi:10.1089/cyber.2015.0107

My contribution to the paper involved:

I constructed the survey questions related to problematic Social Networking and Sleep. I collected and prepared the data and formulated the question. I analyzed the data and drafted the manuscript. My co-authors then reviewed the manuscript draft, suggesting edits.

17/10/2016

Lynette Vernon

Date

3.1 Abstract

An important developmental task for adolescents is to become increasingly responsible for their own health behaviors. Establishing healthy sleep routines and controlling media use before bedtime are important for adequate, quality sleep so adolescents are alert during the day and perform well at school. Despite the prevalence of adolescent social media use and the large percentage of computers and mobile phones in adolescents' bedrooms, no studies to date have investigated the link between problematic adolescent investment in social networking, their sleep practices, and associated experiences at school. A sample of 1,886 students in Australia from 12 to 18 years of age completed self-report data on problematic social networking use, sleep disturbances, sleep quality and school satisfaction. Structural equation modeling (SEM) substantiated our serial mediation hypothesis: for adolescents, problematic social networking use significantly increased sleep disturbances, which adversely affected perceptions of sleep quality that, in turn, lowered adolescents' appraisals of their school satisfaction. This significant pattern was largely driven by the indirect effect of sleep disturbances. These findings suggest that adolescents are vulnerable to negative consequences of social networking use. Specifically, problematic social networking is associated with poor school experiences which result from poor sleep habits. Promoting better sleep routines by minimizing sleep disturbances from social media use could improve school experiences for adolescents with enhanced emotional engagement and improved subjective well-being.

3.2 Introduction

Adolescents spend a great deal of time immersed in technology, and for some youth, this can become problematic (Punamäki et al., 2007; Spies-Shapiro & Margolin, 2014). Extensive use of technology, often accessible in the bedroom, raises a number of issues concerning adolescents' reliance on social media to fulfill their emotional needs. In particular, heavy media use can alter sleeping and waking patterns (Punamäki et al., 2007) and thus undermine adolescents' performance at school (Spies-Shapiro & Margolin, 2014). Research investigating whether such excessive use of technology by adolescents has negative implications is growing (Barke, Nyenhuis, & Kröner-Herwig, 2014; Chan, 2014; Chen & Kim, 2013; Nalwa & Anand, 2003; Tsitsika et al., 2014). Studies have documented young people's growing dependency on social networking (Thadani & Cheung 2011), labeling it a behavioral addiction (for a literature review, see Kuss and Griffiths, 2011) which is strongly correlated with other dysfunctional Internet behaviors such as online gambling (Tsitsika et al., 2014). Further, problematic use of social networking has been associated with negative indicators such as depression (Giota & Kleftaras, 2013; Morahan-Martin, 2005), low self-esteem (Valkenburg et al., 2006), and suppression of empathic social skill (Chan, 2014). Because computers and online media devices have been woven into the fabric of our society, it is crucial to understand whether some young people may be vulnerable to problematic social networking use, and so to reduced sleep quality that is so vital for engaging in key aspects of daily life, particularly schooling.

Many parents, encouraged to develop a habitual bedtime routine for their young child, indicate "time for bed" or "lights out" by darkening their child's bedroom, yet this may not continue to signal for adolescents the same imperative to settle into a quality night's sleep. Rather, for some young people, social interactions with peers can occur via communication technology, 24 hours a day, 7 days a week and can interfere

with the ability to get a good night's sleep. Developmentally, adolescents require about 9 hours of sleep per night and inadequate sleep on a regular basis can have adverse effects including decreased motivation (Punamäki et al., 2007; Wolfson & Carskadon, 2003). Time in bed often now includes sending and receiving text messages, posting on or perusing social networking sites, or gaming with on-line "friends", all of which can keep adolescents up well into the night, steadily eroding their sleep. Research has examined sleep patterns and technology use, and found both game playing, and Internet use are negatively related to good sleep patterns (Van den Bulck, 2004). Prevalence of mobile phone use after lights out is also linked to tiredness (Van den Bulck, 2007). Indeed, the hours devoted to media use can compete with sleep, leading to changes in adolescents' sleep habits and sleep time, resulting in a trend toward insufficient sleep and reduced sleep quality (See Cain & Gradisar, 2010, for literature review; Punamäki, et al., 2007; Van den Bulck, 2004, 2007). The more adolescents multitask with a variety of technological devices (texting, talking on the mobile phone, using the Internet, listening to an iPod), the fewer hours they sleep, which increases their daytime sleepiness (Calamaro et al., 2009). As a result, researchers suggest multitasking could put these students at risk for changes in their school performance (Calamaro et al., 2009). Although this has not yet been empirically tested (Calamaro et al., 2009). It may be that those adolescents who heavily invest in social networking become tired during the day and so encounter difficulties trying to meet the cognitive demands of study.

One of the most important tasks for adolescents is to positively engage in school and achieve to the best of their ability (Eccles & Roeser, 2011). Considering the amount of time students spend at school, it is important that their emotional appraisal of their school-related experiences, i.e. their school satisfaction, contributes positively to their subjective well-being (Huebner, 1994; Huebner & Gilman, 2006; Lewis et al., 2011). Students who are tired and sleepy in class have trouble performing tasks related to

academic performance, such as effective time management, and sustaining effort, interest, and attention, therefore they do poorly at school; and tired students feel less satisfied with their school experience (Wolfson & Carskadon, 1998, 2003). Further, the use of social networking sites among college students has been linked to poor academic performance (Junco, 2012; Kirschner & Karpinski, 2010), with social networking use likely interfering with sleep. However, sleep deprivation has not yet been investigated as a negative consequence of social networking use, in relation to poor experiences in high school. Further, there are no studies of adolescents that explore the association between all three components; social networking, sleep habits, and subsequent school experiences.

The current study investigates the possibility of a developmental mismatch between adolescents' need for sufficient, uninterrupted sleep and adequate sleep quality to successfully navigate both school and their desire to socially network online. Identifying contexts (especially on-line) that hinder connections to school is an important and understudied area. Although research has established a link between adolescent sleep habits and academic outcomes, and separate research has demonstrated links between problematic adolescent media use and sleep habits, research is lacking that investigates how problematic investment in social networking relates to adolescent sleep patterns and school experience. We hypothesize that sleep disturbances and perceived sleep quality will play a serial mediating or explanatory role in the association between problematic use of social networking and school satisfaction.

3.3 Method

3.3.1.1 Participants

Data come from the Youth Activity Participation Study of Western Australia (Blomfield-Neira, & Barber, 2014; Modecki et al., 2013). Participants included 1,886 students (59.2% female) from thirty-two high schools (68% Metropolitan, 32%

Regional). The mean age of the participants was 15 years ($SD = 1.41$ years), and youth ranged from 12 to 18 years of age. Of the sample, 71.4% of participants were Caucasian, 8.7% Asian, 1.9% Aboriginal or Torres Strait Islanders and 18% other. Socioeconomic status (SES) was measured at school level for survey schools (Blomfield & Barber, 2011) and obtained from the Australian Curriculum Assessment and Reporting Authority (ACARA), which computes the Index of Community Socio-Educational Advantage (ICSEA; Australian Curriculum, Assessment and Reporting Authority [ACARA], 2015). Schools are placed on a numerical scale that describes their comparative socio-economic advantage, and survey schools ranged between two standard deviations above and below the state mean on the ICSEA (ACARA, 2015; Blomfield & Barber, 2011).

3.3.1.2 Materials and Procedure

Data for this study were collected in 2010 and 2011. During a 45-minute classroom session participants entered responses onto laptops, or alternatively completed a paper and pencil version of the survey. Ethics approval to conduct research was obtained from the university Human Research Ethics Committee, the Education Department, and the Catholic Education Office. Study participation required active informed parent and student consent.

3.3.1.3 Measures

Problematic Social Networking Use was a latent construct that measured the degree to which adolescents' use of Social Networking Sites affected their wellbeing. The construct consisted of four observed indicators (see Table 3-1). Possible responses ranged from 0 = *no social networking profile*; 1 = *completely disagree* to 5 = *completely agree*. These items were adapted from Young's (1998) Internet Addiction Scale to reflect emotionally problematic use of social networking.

Sleep Quality and *Sleep Disturbance* were latent constructs measuring adolescents' perceptions about sleep behaviors during the previous two weeks (see Table 3-1). Responses for all sleep indicators ranged from 1= *never*; 2= *once*; 3= *twice*; 4 = *several times*; 5 = *every day/night*. These items were adapted from the School Sleep Habits Survey (Wolfson & Carskadon, 2003, 1998).

School Satisfaction was a latent variable measuring adolescents' perceptions of how satisfied they were with their school experience (see Table 3-1). Responses on all indicators ranged from 1 (*not at all true for me*) to 5 (*very true for me*). These items were adapted from the Multidimensional Students' Life Satisfaction Scale (MSLSS; Huebner, 1994). We controlled for relevant covariates including gender (0 = *female*, 1= *male*), SES and age; both SES and age were mean centered.

Table 3-1 Latent Constructs with Model Fit Indices

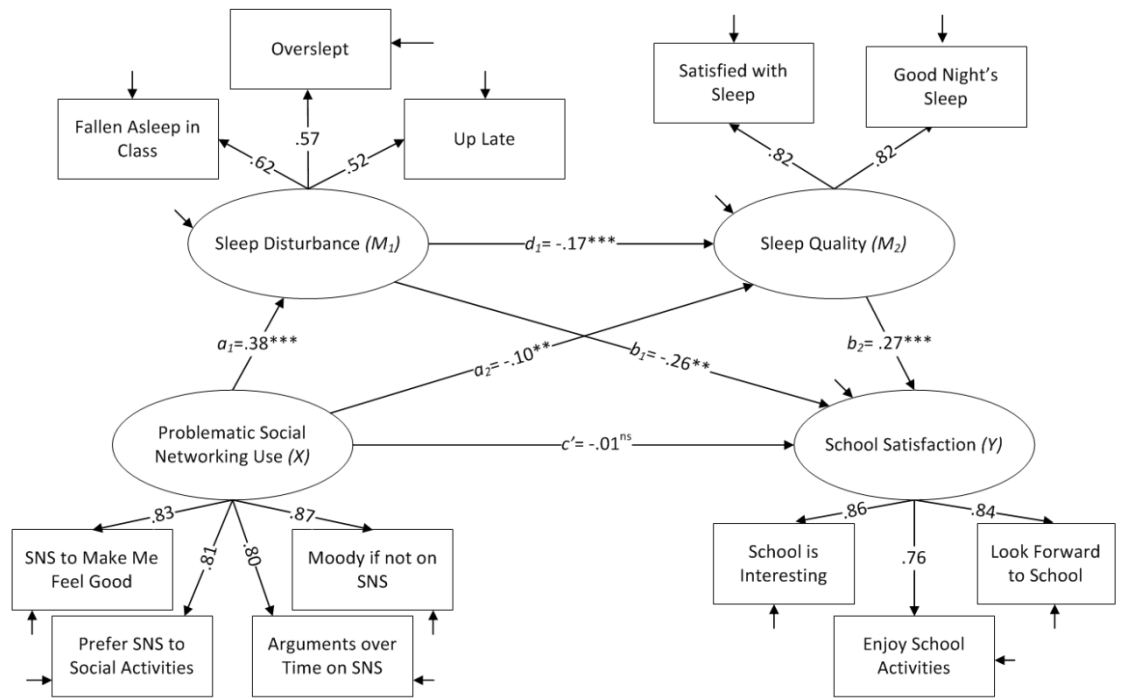
Problematic Social Networking Use
I use social networking as a way of making me feel good.
I get into arguments with other people about the amount of time I spend on social networking.
I prefer to spend time on social networking rather than attend social activities/events.
If I can't access social networking I feel moody and irritable.
$\chi^2_{(2, n=1883)} = 4.943, p = .085, CFI = .998, RMSEA (90\% CI) = .028 (0.000-0.061)$
Sleep Disturbance
How often have you arrived late to class because you overslept.
How often have you fallen asleep in morning class.
How often have you stayed up until at least 3am.
Sleep Quality
How often have you felt satisfied with your sleep.
How often have you had a good night's sleep.
$\chi^2_{(4, n=1863)} = 7.197, p = .126, CFI = .997, RMSEA (90\% CI) = .021 (0.000-0.045)$
School Satisfaction (not identified)
School is interesting.
I enjoy school activities.
I look forward to going to school.
Measurement Model
$\chi^2_{(48, n=1882)} = 103.271, p = .000, CFI = .991, RMSEA (90\% CI) = .025 (0.018-0.031)$

3.3.1.4 Analysis

Covariance structure analysis, using the statistical software package *Mplus7.1* (Muthén & Muthén, 1998-2012), analyzed the measurement models using maximum likelihood estimation with robust standard errors (MLR; Yuan & Bentler, 2000). Bias-corrected (BC) bootstrap confidence intervals were used to generate an estimate for each indirect effect along with a 95% confidence interval to examine the significance and strength of a particular mediator in the multiple mediated model (Cheung & Lau, 2008; Williams & MacKinnon, 2008). This approach adjusts for non-normality and uses

data from cases where the information is available to obtain estimates with missing data (Yuan & Bentler, 2000).

We first performed a confirmatory factor analysis (CFA) to ensure that the measurement model was an appropriate fit, overall. Each of the latent constructs representing the conceptual variables for problematic social networking use, sleep disturbance, sleep quality, and school satisfaction were simultaneously estimated in the measurement model. We also divided the sample into two groups based on age ($\text{Age} < 14.62=0$), and gender (female=0), and estimated a multiple group measurement model. Chi-squared difference tests determined whether the items we used to measure our latent constructs adequately measured the underlying conceptual variables for each of the two age groups and gender (Cheung & Lau, 2008; Lau & Cheung, 2012; Muthén & Muthén, 1998-2012; Preacher & Hayes, 2008; Williams & MacKinnon, 2008; Yuan & Bentler, 2000). Next, using Multiple Indicators, Multiple Causes (MIMIC) modelling (Kline, 2011; Schumacker & Lomax, 2010), the observed variables, gender, age and SES were used to predict the unobserved latent variables in the overall sample; problematic social networking use, sleep quality, sleep disturbance, and school satisfaction. Finally, we hypothesized a serial mediation model (Taylor, MacKinnon, & Tein, 2008), whereby problematic social networking increased sleep disturbance, which in turn decreased sleep quality and, in turn, reduced students' satisfaction with their school. We used the product of coefficients approach (Cheung & Lau, 2008; Lau & Cheung, 2012; Preacher & Hayes, 2008; Williams & MacKinnon, 2008), calculating the indirect effects by multiplying the path coefficients that link problematic social networking (X) to school satisfaction (Y) through the mediators, sleep disturbances (M_1) and sleep quality (M_2) as shown in Figure 3.3-1.



- χ^2 (d.f.=75) = 348.32 ($p = .000$), RMSEA = .044, CFI = .97, TLI = .96, SRMR = .035
- Standardized Factor Loadings – all significant at .001
- *significant at .05; ** significant at .01; *** significant at .001; ^{ns} – non significant

Figure 3-1 Research model and test results.

3.4 Results

Descriptive data (means, standard deviations) for gender, SES, age, the four latent variables Problematic Social Networking, Sleep Disturbance, Sleep Quality, and School Satisfaction, along with correlations among the variables, are presented in Table

3-2

Table 3-2
Correlations and Descriptive Statistics

Variables	1	2	3	4	5	6
1. Problematic SOCIAL NETWORKING	–					
2. Sleep Disturbances	.38***	–				
3. Sleep Quality	-.17***	-.20***	–			
4. School Satisfaction	-.16***	-.33***	.33***	–		
5. Gender ^a	-.08***	.14***	.13***	-.06*	–	
6. Age ^b	.13***	.06	-.09***	.00	.00	–
7. Socioeconomic Status ^c	.01	-.15***	.08*	.24***	-.04	.15***
<i>M</i>	1.36	1.46	3.50	3.18		
<i>SD</i>	.98	.65	.99	.97		
Range	0-5	1-5	1-5	1-5		

Note. ^aGender: 0 = female, 1 = male. ^bAge: Mean centered. ^cSocioeconomic status: Mean centered. * $p < .05$. ** $p < .01$. ***

The measurement model, demonstrated good fit $\chi^2(48) = 103.271, p = .000$, CFI=.991, RMSEA (90% CI) =.025 (0.018-0.031). Incremental fit indices were used to test for measurement invariance for age and gender (Cheung & Lau, 2012; Cheung & Rensvold, 2002; Muthén & Muthén, 1998-2012; Steenkamp & Baumgartner, 1998). Although weak factorial invariance was supported meaning the different gender and age groups employed the same conceptual framework to answer the survey items (Cheung & Lau, 2012), scalar invariance was not achieved for either age or gender. Therefore both were included as predictors for the mediators, thus removing any secondary influences related to the association between the latent variables (Kline, 2011; Schumacker & Lomax, 2010). MIMIC modeling investigated direct and interaction effects of covariates, age, gender, and SES, with good fit $\chi^2(104) = 332.17, p < .001$, CFI=.972, RMSEA (90% CI) =.033 (0.029-0.038). Further information related to the measurement models is available from the author (See Appendix 3.7, Figure 3.7-1). Finally a structural model was estimated to examine the direct and indirect relations between the latent variables of interest and the background variables for gender, age and

SES (Cheung & Lau, 2008; Cheung & Rensvold, 2002; Kline, 2011; Lau & Cheung, 2012; Preacher & Hayes, 2008; Schumacker & Lomax, 2010; Steenkamp, & Baumgartner, 1998; Taylor, MacKinnon, & Tein, 2008; Williams & MacKinnon, 2008).

3.4.1.1 Sleep Quality and Sleep Disturbances as Serial Mediators

A focal question of the study was whether problematic social networking use influenced students' school satisfaction by adversely affecting their sleep. This hypothesis was modeled and tested by setting direct paths from problematic social networking to sleep disturbances, sleep quality and school satisfaction, as well as a serial mediation pathway through sleep disturbances and sleep quality to school satisfaction (see Figure 3.3-1) while statistically controlling for gender, age, and SES (not depicted in Figure 3.3-1). The data fit the model well, $\chi^2(75) = 348.319, p = .000$, CFI = .971, RMSEA (90% CI) = .044 (.039 -.049).

Results are presented in Figure 3.3-1 and Table 3.4-3 and indicate a significant indirect path, such that participants with problematic social networking behavior experienced sleep disturbance which in turn was associated with a perception of poor quality sleep and a stronger dissatisfaction with their schooling. A bias-corrected bootstrap confidence interval for the total indirect effect, $(a_1 b_1 + a_2 b_2 + a_1 d_1 b_2 = -0.128; CI = -0.167 \text{ to } -0.093)$ indicated a significant effect between problematic social networking, sleep quality, sleep disturbance and school satisfaction. There was no evidence that problematic social networking influenced school satisfaction independent of its effect on sleep disturbance and on sleep quality ($c' = -.012, p = .666$). Examination of the single mediator paths compared to the serial mediation showed problematic social networking use had a stronger influence on school satisfaction through sleep disturbance in isolation ($a_2 b_2 - a_1 b_2 d_1 = -0.064; CI = 0.110 \text{ to } -.028$) than through the serial mediation which also included sleep quality.

Table 3.4-3

Path Coefficients, Indirect Effects And 95% Bias-Corrected Bootstrapped Confidence Intervals Corresponding To The Three-Path Mediation Model

<i>Antecedent</i>	<i>Consequent</i>								
	<i>M₁ (Sleep Disruptions)</i>			<i>M₂ (Sleep Quality)</i>			<i>Y (School Satisfaction)</i>		
	<i>Estimate</i>	<i>95% BC Bootstrap CI</i>		<i>Estimate</i>	<i>95% BC Bootstrap CI</i>		<i>Estimate</i>	<i>95% BC Bootstrap CI</i>	
		<i>Lower</i>	<i>Upper</i>		<i>Lower</i>	<i>Upper</i>		<i>Lower</i>	<i>Upper</i>
Total Effect						\hat{c}	-0.139	-0.185	-0.087
Direct effect						\hat{c}'	-0.012	-0.060	0.049
X (SNS)	\hat{a}_1	0.161	0.124	0.207	\hat{a}_2	-0.081	-0.127	-0.018	
<i>M₁ (Disruption)</i>					\hat{d}_1	-0.310	-0.528	-0.139	
<i>M₂ (Quality)</i>									\hat{b}_2
C ₁ (GENDER)		0.147	0.091	0.203		0.266	0.018	0.366	
C ₂ (AGE)		0.014	-0.005	0.036		-0.048	-0.077	-0.013	
C ₃ (SES)		-0.001	-0.001	0.000		0.001	0.000	0.001	
Indirect Effects									
$a_1 b_1$		-0.088	-0.129	-0.058					
$a_2 b_2$		-0.024	-0.042	-0.006					
$a_1 d_1 b_2$		-0.015	-0.026	-0.008					
Total Indirect		-0.128	-0.167	-0.093					
$\# a_1 b_1 - a_2 b_2$		-0.064	-0.110	-0.028					
$\# a_1 b_1 - a_1 b_2 d_1$		-0.073	-0.112	-0.043					
$\# a_2 b_2 - a_1 b_2 d_1$		-0.009	-0.031	0.014					

Note: Models include covariates gender, age, SES; age and SES centered at means. [^] The coefficients for $a_2 b_1 b_2 c' d_1$ refer to the paths in Figure 3.3-1 [#] Comparison of multiplicative paths and bootstrap CI's

3.5 Discussion

The purpose of this study was to examine the role of sleep in the association between problematic social networking use and students' satisfaction with schooling. A serial mediation model confirmed that sleep disturbances and sleep quality mediated the association. Students reporting high levels of problematic social networking use reported more sleep disturbance problems which in turn were associated with lower sleep quality, resulting in lower school satisfaction. Notably, sleep disturbance exerted a stronger influence on school satisfaction than did sleep quality. This makes sense as the indicators of disturbance – staying up until at least 3 a.m., arriving late to school because of oversleeping, and falling asleep in morning class – impair every aspect of the school experience. When tired students try to engage in school activities, their resulting emotional evaluative response toward their school satisfaction will be low compared to students who routinely get a good night's sleep.

Consistent with our predictions, we found that poor sleep habits were an important underlying mechanism that helped explain why students with problematic social networking use reported low school satisfaction. When youth use their social networking at appropriate times of the day, and not into the night, they are less likely to experience sleep disturbance and so report better sleep quality which in turn is associated with an evaluative response that their school experience was positively contributing to their subjective well-being (Lewis et al., 2011). This finding is congruent with previous research, which shows that the protective effects of a good night's sleep improve academic performance (Dahl, 2005; Dewald et al., 2010; James, Kristjánsson, & Sigfúsdóttir, 2011; Wolfson & Carskadon, 1998, 2003).

One of the factors that contributes to problematic social networking use for adolescents included using social media as a way of making them feel good (Table 3.1) so if students have a poor experience at school they may tend to increase social media

use to improve feelings of well-being. This over-use may then further disturb their sleep, and lead to lower satisfaction with their school the next day. This finding affirms the value of good sleep habits for adolescents' subjective sense of well-being as they undertake their student role.

Several limitations need to be considered when interpreting the results of the present study. First, we cannot make causal inferences from these cross-sectional data. Studies using longitudinal data could provide further evidence for the effects found in this study particularly related to following the trajectories of students to examine associations over time. Second, data were based on students' retrospective self-reported measures of their sleep habits. Although previous research has shown that retrospective self-report measures of sleep quality as collected in this study do not contain strong bias (Wolfson, Carskadon, Acebo, et al., 2003), future studies may benefit from using technology to capture real-time sleep patterns.

Despite these limitations, this research has practical implications. Our results suggest that parents should consider limiting adolescents' access to mobile technology (computers and mobile phones) in the bedroom to reduce the risk of poor sleep habits and associated poor school experience. Students who are identified as problematic users of social networking have associated problems with their sleep, suggesting they continue to use social media after bedtime or lights out (Van den Bulck, 2007). Given the fact that a positive school experience is associated with strong academic achievement (Lewis et al., 2011; Huebner & Gilman, 2006), parents will likely wish to maximize their child's emotional engagement in school (Dahl, 2005; Dewald et al., 2010; Green et al., 2012; James et al., 2011) by making sure they have undisturbed, quality sleep. Well-rested students find school both enjoyable and interesting.

Our findings could also inform school curriculum and pedagogy. Illustratively, high schools could include course content detailing positive sleep habits, and could

provide opportunities for students to develop and monitor their own individualized sleep schedules. Students could examine their sleep habits with an associated behavioral analysis of their social networking practices (i.e. monitoring bedtimes, checking for excessive use of social networking sites past bedtime, and feelings when using social networking), and reporting their tiredness and related emotional evaluation of their daytime school experiences. When provided with information about the importance of regular sleep patterns, adolescents will arguably be better equipped to make healthy lifestyle choices. At a minimum, such knowledge may facilitate students' acceptance of the potentially fraught job of parents in monitoring night-time technology use.

3.6 Acknowledgments

The Youth Activity Participation Study of Western Australia (YAPS-WA) has been supported through three grants under Australian Research Council's Discovery Projects funding scheme: DP0774125 and DP1095791 to Bonnie Barber and Jacquelynn Eccles, and DP130104670 to Bonnie Barber, Kathryn Modecki, and Jacquelynn Eccles. We would like to thank the high school principals, their staff, and the students who participated in the YAPSWA study. We are also grateful to everyone in the YAPSWA team.

3.7 Appendix 3.7

3.7.1 Postscript to Chapter 3

In Chapter 3, the results of the measurement model were not included in the peer reviewed journal and so are included as a postscript to the article.

Data Analyses

In the first step, we performed a confirmatory factor analysis (CFA) in order to show that the measurement model was an appropriate fit for the overall sample. Each of the latent constructs representing the conceptual variables for problematic SNS, sleep quality, sleep disturbance, and school satisfaction were simultaneously estimated in the measurement model (Figure 3.2). In the second step, we set up multiple group models for the purpose of testing for measurement invariance (Table 3.4). We divided the sample into two groups of adolescents based on their reported age at wave 4 (Age < 14.62=0), and groups based on gender (female=0), and estimated a multiple group measurement model. The Chi-square difference test was determined using scaling correction factors for MLR (Muthén & Muthén, 2013). This allowed us to determine whether the items we used to measure our latent constructs for the overall sample adequately measured the underlying conceptual variables for each of the two age groups and for gender.

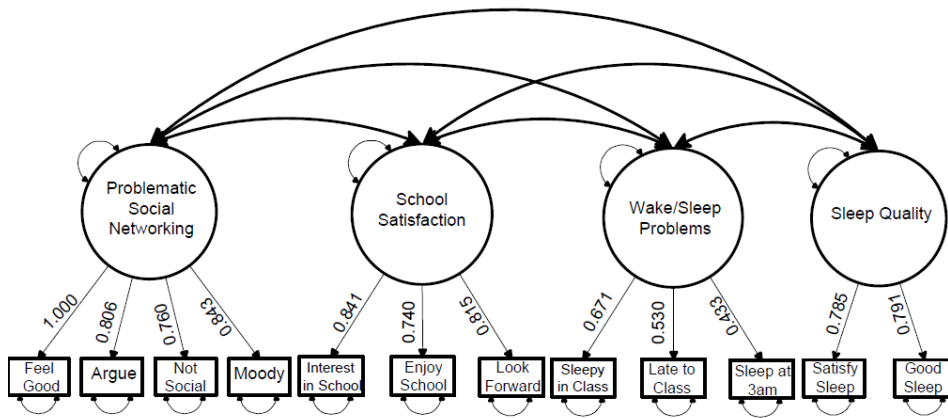


Figure 3-2 Measurement model, Unstandardized estimates.

Table 3.4. Fit Indices Testing Factorial Invariance of the Latent Variables; Problematic Social Networking Use, Sleep Quality, Sleep-wake Problems, And School Satisfaction Across Gender And Age ($\underline{1}$, >14.62 ; $0 \leq 14.6$; $n = 1882$)

	χ^2	<i>df</i>	<i>p</i>	CFI	Δ CFI	TLI	Δ TLI	RMSEA	(90%CI)
Configural	265.60	192	0.00	.989		.984		.029	(.024-.037)
Metric	303.74	216	0.00	.986	.003	.983	.001	.029	(.021-.037)
Scalar	436.99	240	0.00	.969	.017	.966	.017	.042	(.035-.048)
Metric vs Configural	37.12	24	.043						
Scalar vs Configural	166.23	48	0.0						
Scalar vs Metric	155.70	24	0.0						

Note: *df* = degrees of freedom; CFI = comparative fit index; TLI = Tucker-Lewis Index; RMSEA = root mean square error of approximation; 90% CI = 90% confidence interval.

3.8 Preface to Chapter 4

3.8.1 Study-2

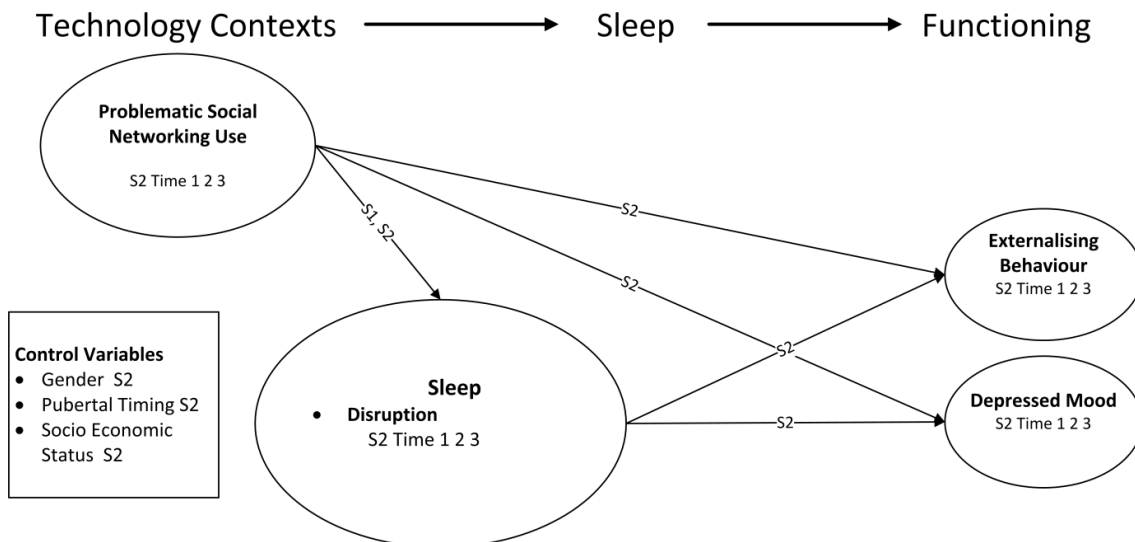


Figure 3.8-2 The Conceptual Model tested in Chapter 4 (Study-2)

3.8.2 Aims:

To identify technological contexts (problematic social networking) and associated psychopathology (see Figure 3.8-2).

- To use latent growth curve modeling to examine if changes in problematic social networking use, and changes in manifestations of psychopathology (depressed mood and externalizing behaviors) for adolescents are related to one another
- To use parallel process modeling to examine changes in social networking use and disturbed sleep, to then explain the links to changes in depressed mood and externalizing behaviors.
- To test the putative mediating process and examine change in problematic social networking investment and disrupted sleep, in relation to change in depressed mood and externalizing behavior.

Study-1 was a snapshot in time and indicated that adolescents problematic social networking was related to sleep and school satisfaction. Specifically, the results showed that higher levels of problematic social networking were linked to lower school satisfaction via high levels of sleep disruption. This finding supported the importance of a good night's sleep for cognitive and emotional processing to aid learning and achievement (Dahl & Lewin, 2002; Zimmerman, 2008). There is little up-to-date information in the literature which examines the place of sleep in the lives of adolescents and its integration with aspects of technology which influence teenagers.

There is increasing interest in the risks of increased technology use for adolescents with a recent report finding which reported adolescents use, on average, around nine hours of entertainment media per day (Rideout, 2015). There is a growing practice whereby students have at any time of the day or night access to the Internet via digital technology, whether by smartphone, tablet or computer and all devices can be accessed in their bedrooms (Calamaro et al., 2009). Therefore, there is a competing tussle between sleep time and technology use (Van den Bulck, 2004, 2007). Study-2 investigates the development of problematic social networking use, disrupted sleep, depressed mood, and externalizing behaviors; all potential risks faced by students as they traverse through adolescence. This study investigates how these risks are related, and how disrupted sleep, in particular, changes in tandem with these risks over time.

To examine developmental trajectories, latent growth curve models for problematic social networking, depressed mood, externalizing behavior and sleep disturbances over ages 13-15 were estimated, followed by estimation of parallel process models, including covariates gender, socio-economic status, and pubertal timing. The findings in Study-2 suggest that increasing problematic social networking use was associated with increasing levels of depressed mood and externalizing behavior with increasing sleep disturbance as the explanatory mechanism. Study-2 is one of the first

studies involving early adolescents to associate problematic social networking use with sleep disruptions and psychopathology. Promoting responsible use of social media by reducing use and rescheduling away from bedtimes is vital for undisturbed sleep and positive wellbeing.

Chapter 4 Study-2

Tracking Effects of Problematic Social Networking on Adolescent

Psychopathology:

The Mediating Role of Sleep Disruptions

The following is a modified version of the published co-authored paper, however, it is formatted in accordance with the authors' instructions for submission to the Journal of Clinical Child & Adolescent Psychology. The bibliographic details of the co-authored paper, including all authors, are:

Vernon, L., Modecki, K.L., & Barber, B.L. (2017). Tracking effects of problematic social networking on adolescent psychopathology: The mediating role of sleep disruptions. *Journal of Clinical Child & Adolescent Psychology*, 46(2), 269-283. doi.org/10.1080/15374416.2016.1188702

My contribution to the paper involved:

I constructed the survey questions related to problematic Social Networking and Sleep. I collected and prepared the data and formulated the question. I analyzed the data and drafted the manuscript. My co-authors then reviewed the manuscript draft, suggesting edits.

17/10/2016

Lynette Vernon

Date

4.1 ABSTRACT

Concerns are growing about adolescents' problematic social networking and possible links to depressed mood and externalizing behavior. Yet there remains little understanding of underlying processes that may account for these associations, including the mediating role of sleep disruption. Objective: This study tests this putative mediating process and examines change in problematic social networking investment and disrupted sleep, in relation to change in depressed mood and externalizing behavior. Method: A sample of 874 students (41% male; 57.2% Caucasian; baseline mean age=14.4 years) from 27 high schools were surveyed. Participants' problematic social networking, sleep disruption, and psychopathology (depressed mood, externalizing behaviors) were measured annually over 3 years. Longitudinal mediation was tested using latent trajectories of problematic social networking use, sleep disruption, and psychopathology. Results: Both problematic social networking and sleep disruption underwent positive linear growth over time. Adolescents who increasingly invested in social networking reported increased depressed mood, with around 53% of this association explained by the indirect effect of increased sleep disruptions. Further, adolescents who increasingly invested in social networking also reported increased externalizing behavior; some of this relation was explained (13%) via increased sleep disruptions. However, an alternative model in which increased externalizing was associated with increased social networking, mediated by sleep disruptions, indicated a reciprocal relation of similar magnitude. Conclusion: It is important for parents, teachers, and psychologists to minimize the negative effects of social networking on adolescents' psychopathology. Interventions should potentially target promoting healthy sleep habits through reductions in social networking investment and rescheduling usage away from bedtime.

4.2 Introduction

Recognition of the importance of quality sleep in healthy adolescent development has led to increased concerns about technology, and the role it could play in disrupting bedtime behaviors (Cain & Gradisar, 2010; Carskadon, 2011; Gradisar & Short, 2013; Suganuma et al., 2007; Van den Bulck, 2004, 2007; Zimmerman, 2008). Electronic media has become an integral part of adolescent lives with a recent report finding adolescents use an average of nine hours of entertainment media per day, with just over one hour of that time, on average, devoted to social media (Rideout, 2015). At nighttime, adolescents' engagement with electronic media can affect their sleep duration and quality, which can subsequently lead to problematic daytime functioning (Cain & Gradisar, 2010; King, Delfabbro, Zwaans, & Kaptsis, 2013; Vernon, Barber, Modecki, 2015). Indeed, risk of sleep disruption increases when youth are exposed to more than two hours of bright light from screens, due to the suppression of melatonin, a sleep-promoting hormone (Wood et al., 2013). Although an increasing number of longitudinal studies have advanced our understanding of the importance of sleep and consequences of sleep deprivation (Buckhalt, El-Sheikh, Keller, & Kelly, 2009; Fredriksen et al., 2004) and further studies have examined relations between electronic media use and sleep (Hale & Guan, 2015), few studies have examined specific media activities together with the consequences of sleep deprivation (Arora et al., 2014; Lemola et al., 2015). Thus, gaps remain in our understanding of the extent to which investment in social media couples with sleep disruption to affect youth psychopathology, including depressed mood and externalizing behaviors. This longitudinal study addresses these gaps by employing a series of latent growth curves which allow for examination of individual change over time, as well as individual differences in trajectories, and also models the mediational process of technology - sleep disruption - psychopathology (Cheong, MacKinnon, & Khoo, 2003).

4.2.1 Sleep Development

Most adolescents require just over nine hours of sleep per night but also prefer later bedtimes and rise-times due to a shift in their biological clock (Carskadon, 2002; Hirshkowitz, et al., 2015). To some extent, this developmental change is biologically based, and circadian changes are correlated with pubertal stages (Tate, Richardson, & Carskadon, 2004). Adolescents' preference for later bedtimes can become problematic when their schedules are dictated by external forces, such as on school nights when they must rise early, resulting in consistently fewer than nine hours of sleep (Acebo & Carskadon, 2002; Kelley, Lockley, Foster, & Kelley, 2015; Warner, Murray & Meyer, 2008). In addition to biological and environmental factors regulating adolescents' sleep, behaviors performed close to bedtime can potentially disturb their "wind-down" process and affect quality and amount of sleep. For example, in National Sleep Foundation's (NSF) *2011 Sleep in America Poll*, 72% of youth reported using mobile phones in the hour before bed and there were similar rates for other electronic media devices (NSF, 2011). Further, media that was more interactive was associated with greater difficulty falling asleep. In all, reported school day total sleep time averaged seven and a half hours, which is well below the recommended 8 -10 hour requirement for teenagers (Hirshkowitz, et al., 2015). Globally, similar patterns of reduced sleep duration and quality for adolescents using electronic media before bedtime have been reported (for review see Bartel et al., 2015; Fredriksen et al., 2004; King et al., 2013; Lemola et al., 2015; Suganuma et al., 2007; Van den Bulck, 2004, 2007). Given the importance of adolescent sleep, and the role of electronic media use in its disruption, a development framework is required to assess how changes in sleep behaviors and electronic media are functionally linked to adolescent wellbeing.

4.2.2 Sleep and Psychopathology

There is a growing consensus that healthy development of sleep behaviors during adolescence contributes to improved cognitive performance and wellbeing, preventing later mental health problems and other manifestations of psychopathology (McCracken, 2002; Sadeh, Gruber, & Raviv 2002; Talbot, McGlinchey, Kaplan, Dahl, & Harvey, 2010; Wolfson & Carskadon, 1998; Zimmerman, 2008). Extensive research into negative outcomes associated with poor-quality and insufficient sleep finds links to internalizing emotional difficulties such as mood disturbances and externalizing difficulties such as conduct and behavior problems (Dahl & Lewin, 2002; Fuligni & Hardway, 2006; Lemola et al., 2015; Talbot et al., 2010). For example, adolescents with adequate, good quality sleep report lower levels of depressed mood and less tiredness during the day compared to adolescents with poor sleep habits (Acebo & Carskadon, 2002; Fuligni & Hardway, 2006; Wolfson & Carskadon, 1998). As well, adolescents who have inadequate sleep on a regular basis report adverse effects, including sleepiness during the day, irritability and low tolerance levels, less control of emotions and exaggerated affect, all of which can lead to increases in negative mood and risk-taking (Carskadon, 2002, 2011; Talbot et al., 2010). Indeed Dahl and Lewin (2002) report that too little sleep can impair adolescents' ability to do two important things at once, such as thinking and curbing emotions. As a result, tired adolescents are unable to regulate mood and negative emotions. Importantly, one major driver of such tiredness among adolescents may be their heavy use of technology, including computers, laptops and mobile devices with Internet access. In this case, the *content* on these devices, including emotionally arousing posts on social networking sites (SNSs), and the *location* and *timing* of use before and after bedtime are especially salient (Zimmerman, 2008). In spite of the significance of these factors in relation to adolescent sleep, few studies have examined the developmental course of sleep and psychopathology over

time and none, to our knowledge, have considered the role of social networking investment as precursor to this relation.

4.2.3 How Does Social Networking Use Affect Sleep And Psychopathology?

Adolescents use social media for shared interactions with their peers and to gather collectively online. Unfortunately, however, the pull of SNSs can readily encroach upon adolescents' sleep. In previous generations, social interactions took place in person or over landline telephones. Yet today, adolescents have access to technology with real-time contact 24 hours a day, 7 days a week (Calamaro et al., 2009). As a result, social media use, including posting on or perusing SNSs, messaging, and instant updating of profile status can facilitate (or strain) social relationships in ways never experienced by previous generations (Spies-Shapiro & Margolin, 2014). For instance, recent data from the Pew Research Centre shows that 76% of adolescents use social media, and 71% say they use Facebook (a major SNS platform) as their main form of social media contact (Lenhart, 2015). In addition to continuous access to social media during the day, an increasing number of adolescents also access SNSs via the Internet in their bedrooms at night (33% of 8-18-year-olds; Rideout et al., 2010) via a variety of sources (computer, tablet, and mobile/smart-phone).

Because of access to technology in their bedrooms, lights out for many adolescents may not signal an intention to settle down to a quality night's sleep (Exelmans & Van den Bulck, 2015; Munezawa et al., 2011). Research on the technology-mediated activities of adolescents describes a high prevalence of mobile phone use after lights out and subsequent tiredness the following day (Eggermont & Van den Bulck, 2006; Van den Bulck, 2007; Munezawa et al., 2011). Further, because of recent increased capability of smart phones to readily access the Internet and SNSs, concerns about the impact of technology after lights out on healthy adolescent

development are exacerbated (Nalwa & Anand, 2003). Illustratively, some research in this area has focused on the impact of SNS on sleep, and finds that excessive use of social networking, classified as addiction to social networking, directly leads to later bedtimes and poor quality sleep among college students (Andreassen et al., 2012; Wolniczak et al., 2013).

In addition to displacing sleep time, engaging with technology can have consequences for adolescent wellbeing, including manifestations of psychopathology. In fact, there is a growing body of research pointing to the benefits and risks that result from the rapid rise in social media use by adolescents (See Kuss, & Griffiths, 2011 for review). For example, the dramatic increase in social networking has been accompanied by adolescents' growing use of social media to foster connections to others and fulfil emotional needs. But whether heavy investment in SNSs negatively impacts wellbeing is not well understood. In one study investigating gambling addictions, researchers argued that any behavior which stimulates emotional arousal can become addictive (Brown, 1987). Following on from this conclusion, Young (1998) developed an Internet addiction scale to examine Internet behaviors of university students. She found that students who met the criteria for dependency on the Internet became more emotionally aroused and reported more negative wellbeing compared to non-dependent students. More recently, scales have been developed to investigate addiction to social networking (Andraessen et al., 2012; Kuss & Griffiths, 2011; Wolniczak et al., 2013) with emerging evidence for excessive use of social networking being related to relationship problems. Little is known, however, about adolescent investment in SNS and associated manifestations of psychopathology.

One of the reasons SNS use tends to increase and thus be potentially problematic, is that it can be highly rewarding. SNSs provide a cyber-place where people can connect with their friendship networks (Griffiths, 2013) and gain rewards for

participation in activities such as posting or messaging through “likes” and “comments.” A number of studies suggest that there may be benefits to using SNSs to engage with friends and to develop social self-concept (Barker, 2009, Blomfield-Neira & Barber, 2014) and to build social connections and support, especially for those who are lonely (Ellison, Steinfield, & Lampe, 2007, 2011; Lee, Noh, & Koo, 2013; Liu & Yu, 2013). Such positive engagement can motivate users to invest heavily in SNSs.

Yet there may be costs associated with this highly appealing arena of participation, particularly in relation to adolescent mental health. A growing body of evidence suggests that for some adolescents SNS use can undermine wellbeing (Valkenburg et al., 2006), predicting higher levels of depressed mood (Blomfield-Neira & Barber 2014; Steers, Wickham, & Acitelli, 2014) and increased behavior problems (Mikami et al., 2010). The emotional salience of social media may account, in part, for these effects, for two primary reasons: 1) unfavorable social comparisons with exacerbated feelings of worthlessness and 2) aggression victimization when online.

Discrepancies between adolescents’ comparison group and appraisals of self can lead to internalizing and externalizing problems, especially if these comparisons undermine confidence in youths’ relative abilities or attributes. For example, adolescents who compare themselves to others on social media report feelings of envy and higher levels of depression (Tandoc et al., 2015). Similarly, Facebook social comparisons account for links between intensity of social networking (time spent, or number of times viewing) and depression (Steers et al., 2014). Given that the heaviest Internet users in adolescence may be those with lower self-concept (Israelashvili, Kim, & Bukobza, 2012), this ubiquitous platform for social comparison may be undermining mental health and wellbeing, particularly for more vulnerable adolescents. More needs to be understood about the consequences of personal dependence, or overinvestment in

SNSs, in the development of symptoms of internalizing, especially with respect to the causal order of the investment-depressed mood link.

In addition to facilitating unfavorable self-driven comparisons, electronic media can also be a venue for cyber-aggression (Modecki, Minchin et al., 2014). In fact, research suggests that adolescents manifest cross-situational stability in their interpersonal interactions, with continuity in adverse behaviors between their computer-mediated and face-to-face communication contexts (Mikami et al., 2010; Modecki, Minchin et al., 2014). Adolescents' heavy use of the Internet is linked to poor coping and negative interpersonal relationships (Milani, Osualdella, & Di Blasio, 2009). Involvement in cyber-aggression, either as a perpetrator or victim, has also been linked to poor mental health, including elevated depressive and externalizing symptoms (Modecki et al., 2013; Wang et al., 2011). Moreover, adolescent bullying is associated with sleep difficulties (Hunter, Durkin, Boyle, Booth & Rasmussen, 2014). One recent study of 19,436 school students in Japan reports bullying is significantly linked to irregular bedtimes (Tochigi et al., 2012). In particular, using a mobile for e-mail exchanges and calling after lights-out leads to emotional arousal and facilitates bullying. Notably, much of this bullying occurs on social media, but we know little about the developmental course of the links between SNS use and externalizing behaviors, and the possible mediating role of sleep disruption.

We posit that a process unfolds for many teens, in which heavy SNS use leads to poor sleep. That is SNS use has a displacement effect on sleep time, coupled with increased arousal and negative affect for teens, just before bedtime. For adolescents who are highly invested in social media, upsetting negative feedback received at night, prior to bedtime or after "lights out," likely activates emotional arousal (e.g. envy, anxiety) and hampers sleep onset (Tandoc et al., 2015). Indeed, emotional arousal before bed has been researched extensively (Beattie et al., 2015; Kahn, Sheppes, & Sadeh, 2013) and,

in the context of viewing adult or violent media, has been linked to difficulties in falling asleep for children and adolescents (Eggermont & Van den Bulck, 2006; Munezawa et al., 2011; Van den Bulck, 2000). We suggest that similar emotional arousal from social networking activities prior to sleep may be an important factor in adolescents' sleep disruption. As a result, disturbed sleep could be a possible mechanism for the links between participating in social networking and negative wellbeing.

Despite growing interest in and research on adolescents' social networking experiences, there is little evidence of how investment in SNSs evolves over time or how this relates to changes in adolescent sleep, which could mediate links between SNS use and psychopathology. Because the development of healthy sleep habits is of paramount importance during adolescence (Shochat et al., 2014), identifying contexts that affect sleep competence, and subsequent outcomes associated with poor sleep, are important and understudied areas of research.

4.2.4 The Current Study

Recent findings document the negative impact of disrupted sleep on adolescent functioning (Carskadon, 2011). Further, a key feature in adolescents' lives is social networking, and for some youth, problematic SNS investment leads to poor quality sleep and daytime sleepiness (Wolniczak et al., 2013). Despite preliminary evidence of links between problematic social networking and poor sleep, and despite heavy interest in the impact of poor sleep on adolescent psychopathology, no research has yet examined these relations simultaneously. Nor has research to date examined whether *change* in these aspects of adolescent lives are linked, as opposed to examining single snapshots of each construct at one point in time. Here, we hypothesize that increased investment in social networking is associated with sleep disruptions which in turn may be associated with increases in both depressed mood and externalizing behavior. Thus, our analyses address two major questions: Are *changes* in problematic SNS use and

changes in manifestations of psychopathology (i.e. depressed mood and externalizing behaviors) related to one another? Further, do increases in sleep disruptions mediate the relation between increased problematic social networking and increased psychopathology?

4.3 METHODS

4.3.1 Participants

Data were drawn from a longitudinal study on adolescent activity participation (Youth Activity Participation Study; YAPS), including areas of wellbeing such as health correlates related to sleep, and constructs related to technology use (see Blomfield-Neira & Barber, 2014; Vernon et al., 2015, for descriptions of the study). The sample comprised 874 high school students (41% male, baseline mean age (Grade 9) = 14.4years) from metropolitan and regional areas across Western Australia. Of the sample, 57.2% were Caucasian, 7.2% Asian, 1.6% Aboriginal or Torres Strait Islander, 23.3% other (e.g., Middle Eastern, African, Indian, and Maori), and 10.6% did not nominate ethnicity. School level SES was obtained from Australian Curriculum, Assessment and Reporting Authority (ACARA, 2015), which computes the yearly Index of Community Socio-Educational Advantage (ICSEA) for schools. The ICSEA is calculated using Australian Bureau of Statistics data and draws on education, occupation, income, ethnicity, and location of student household (ACARA, 2015). Schools were placed on a numerical scale that described their comparative socio-economic advantage; 14 of the 27 schools were at or below the median with 48.3% of the students in these low SES schools.

In Year 9, 85% of the students had a social networking profile, with 74% having access to the Internet in their bedrooms. This grew to 92% having an SNS profile in Year 11, of whom 92% had access to the Internet in their bedroom. As well, Year 9

students averaged 8.24 hours ($SD = 1.02$) of sleep on weeknights, with 32% indicating they go to bed after 10pm. Hours of sleep declined the following year to 8.11 hours ($SD = 1.05$) with 46% indicating they go to bed after 10pm. We did not collect sleep hour data in Year 11.

4.3.2 Procedures

Ethical approval was obtained from the University Human Research Ethics Committee, the Education Department and Catholic Education Office. Study participation required active, informed student and parent consent. Students were recruited from 27 high schools (16 government, 11 non-government), selected from schools across Western Australian and were surveyed annually for three years from 2011. Students were informed that the survey was voluntary, confidential and no information would be released to their teachers, school, or parents. The survey was administered using iPads via intranet over a 45-minute session. Alternatively, a paper survey could be administered at the school's request.

4.3.3 Measures

Scale internal consistency estimates are presented in Table 4-1.

Problematic SNS use. The problematic use of social networking scale consisted of the mean score for four items measured across three waves. These items were adapted from Young's (1998) Internet Addiction Scale and used in previous research (adapted from Vernon et al., 2015). Items measured the degree to which adolescents invest emotionally in social networking and included "I prefer to spend time on Facebook/MySpace/Bebo rather than attend social activities/events"; "I use Facebook/MySpace/Bebo as a way of making me feel good"; "I get into arguments with other people about the amount of time I spend on Facebook/MySpace/Bebo". Possible responses ranged from 0= "no SNS profile," to 1= "completely disagree" and 5= "completely agree." In these data, the baseline problematic SNS scale was negatively

correlated with amount of sleep ($r = -.22, p < .05$), and positively associated with later times to bed ($r = .29, p < .05$).

Sleep Disruptions. Sleep items were adapted from the School Sleep Habits Survey (Wolfson & Carskadon, 1998; Wolfson & Carskadon, 2003). Based on theory where sleep imbalance impairs cognitive-emotional regulation (Dahl & Lewin, 2002), measures for perceived quality of sleep and daytime sleepiness were assessed using exploratory factor analysis (EFA) with geomin rotation, to determine the factorial structure of the eight sleep items included in our survey. A three-factor solution fit the data well; however, one factor was discounted due to cross loadings. Therefore, a two-factor solution, which also fit the data well, was explored; one related to the affective domain and the other to the behavioral domain. The affective domain, used in the current analyses, tapped how students felt about their sleep. We chose the affective domain for this study because we theorized that adolescents who used SNS's into the night would report feeling less satisfied with their sleep. That is, youth who heavily invested in SNS use would ruminate over SNS content at night and experience difficulties getting to sleep and feelings of tiredness during the day. Therefore, the resulting affective scale tapped perceptions about sleep affect during the previous 2 weeks, and included: How often have you: "felt tired or sleepy during the day"; "had an extremely hard time falling asleep"; "had a good night's sleep (reversed)"; "felt satisfied with your sleep" (reversed). Responses for all sleep indicators were 1= "never," 2= "once," 3= "twice," 4= "several times," and 5= "every day/night".

Depressed mood. Depressed mood was measured using the mean of five items designed to tap emotional well-being, originally from the longitudinal Michigan Study of Adolescent Life Transitions (MSALT). Scale items have been published in prior research (e.g. Barber, Eccles, & Stone, 2001; Durkin & Barber, 2003) and in our sample, validity of the full scale has also been supported (Modecki et al., 2013). In these

data, the baseline scale was negatively correlated with self-esteem ($r = -.51, p < .05$), and social self-concept ($r = -.32, p < .05$). Items included “How often do you feel there is nothing nice you can look forward to?”; “How often do you feel unhappy, sad or depressed?” Responses ranged from 1= “never,” to 6= “daily.”

Externalizing behavior. Externalizing behavior consisted of the mean of seven items drawn from Fredricks and Eccles (2006) which tapped delinquency and aggressive behaviors. Previous research shows this measure is a valid indicator of status offenses, aggression, and delinquency. Although previous use of the scale has sometimes included substance abuse (Modecki et al., 2013) this was not included as substance use and sleep should be considered separately (Acebo & Carskadon, 2002). The items were measured on an eight-point scale from (1) = None to (8) = 31 or more times and include: “In the past 6 months how often have you skipped school without parent permission?”; “have you gotten in a physical fight with another person?” and “have you taken something from a store without paying for it?”

Covariates. Relevant covariates were controlled for including gender (0= “female,” 1= “male”), socioeconomic status (SES; 0= “equal to or below median,” 1= “above median”) and an adapted measure of pubertal timing (Dubas, Graber, & Petersen, 1991). Pubertal timing was assessed in Year 9 with the item “Teenagers’ bodies change a lot as they grow up; this is referred to as your physical development. Compared to other people your age do you think your physical development has started?” with responses from (1) much later to (5) much earlier. Previously published studies demonstrate validity of the measure (Modecki, Barber, & Eccles, 2014).

4.3.4 Analytic Procedure

Analyses were conducted using latent growth modeling (LGM) in *Mplus 7.2* (Muthén & Muthén, 1998-2012). Latent changes in the independent variable (problematic social networking use), dependent variables (either depressed mood or externalizing behavior) and the mediating variable (sleep disruption) were modeled (Cheong et al., 2003; MacKinnon, 2008; von Soest & Hagtvet, 2011). Previous research demonstrates use of LGM to estimate longitudinal mediation effects (see Littlefield, Sher, & Wood, 2010 for a comprehensive review of the procedure and von Soest & Hagtvet, 2011 for a framework for analysis). For all models, we used full information maximum likelihood (FIML) procedure, in order to use all available data from each participant (Yuan & Bentler, 2000). Bias-corrected bootstrapping was used to determine the mediated (i.e. indirect) effects using 95% asymmetric confidence intervals to adjust for non-normality of data. Unstandardized parameter point estimates with 95% asymmetric confidence intervals were reported for significance (MacKinnon, 2008; Muthén, 2007).

For all study variables (problematic SNS use, sleep disruption, depressed mood, and externalizing behavior) unconditional (with no covariates) univariate growth curve models were run individually. Next, conditional parallel process models were run to examine the direct effects between early levels of the constructs (intercepts) and change in each of the constructs (slopes), with gender, pubertal timing, and SES entered as covariates. This was followed by the conditional, multiple mediation parallel process models for each psychopathology indicator, as illustrated in Figure 4.3-1. For instance, for depressed mood, the steps of the analyses were as follows: First, the direct effects between intercepts and slopes of problematic SNS use (the independent variable) with sleep disruption (the mediator), were modeled; then links between problematic SNS use with depressed mood (the dependent variable) were modeled; followed by modeling the

direct effects between sleep disruption, and the intercept and slopes of depressed mood. Finally, the multiple mediation models for problematic SNS use, sleep disruption, and depressed mood were run (Figure 4.3-1). The psychopathology intercept and psychopathology slope represent the LGM of the respective psychopathology constructs (i.e. depressed mood or externalizing behavior). Intercept factors represent the initial level (Year 9 at school, age roughly 14.5) for each construct, and slope factors represent change in the constructs from year 9 to year 11.

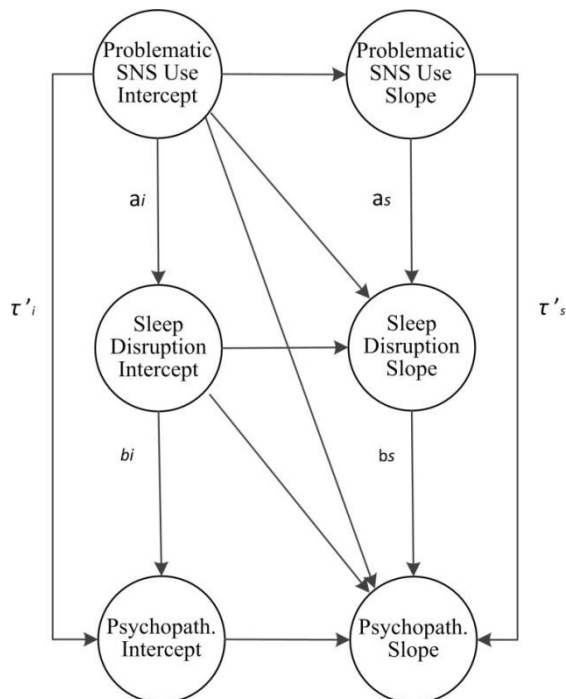


Figure 4-1 Latent growth curve mediation model. Psychopathology modeled separately for depressed mood and externalizing behavior. Covariate paths for gender, SES and pubertal maturation not included in the model. Direct effect of initial level (Year 9) of problematic SNS use on initial level of psychopathology = τ'_i . Indirect effect of initial level of problematic SNS use on initial level of sleep disruptions on initial level of psychopathology = $a_i b_i$. Total effect of initial level of problematic SNS use on initial level of psychopathology = $\tau'_i + a_i b_i$. Direct effect of changes in problematic SNS use on change in psychopathology = τ'_s . Indirect effect of change in problematic SNS use on changes in sleep disruptions on changes in psychopathology = $a_s b_s$. Total effect of change in problematic SNS use on change in psychopathology = $\tau'_s + a_s b_s$.

Because the temporal order of mediational models should be informed by strong theory, the order for the model was created “a priori,” (Cheong et al., 2003). Thus, the relation of baseline levels of problematic SNS use (intercept) was modeled to predict baseline measures of sleep disruption. However, there is some early evidence that poor sleep can contribute to increased media use among adults (Tavernier & Willoughby, 2014) and as a more rigorous check of our theory, the reversed models were also tested. For our theorized model, Figure 4.3-1 indicates the directional paths, with the slopes controlled for their intercept (von Soest & Hagtvvet, 2011). Bias-corrected bootstrap confidence intervals (CI) were computed for indirect effects (the products of coefficients approach; Preacher & Hayes, 2008) by multiplying the path coefficient that links problematic SNS use intercept to depressed mood or externalizing behavior intercept through the mediator intercept of sleep disruption. Similarly, examination of the coefficients for the mediational processes for the associated slopes determined if changes in sleep schedules was the correct mechanism to account for changes in the associations between problematic SNS use and psychopathology.

4.4 RESULTS

Table 4-1 displays correlations, means, standard deviations, and scale reliabilities among problematic SNS use, sleep disruption, and psychopathology constructs over the 3 time periods with covariates gender, SES, and pubertal maturation.

4.4.1 Univariate Growth Models

Overall the univariate model estimates of the growth trajectories for problematic SNS use, sleep disruptions, depressed mood, and externalizing behavior all provided good fit to the data (i.e. Comparative Fit Index [CFI] $>.95$; Root Mean Square Error of Approximation [RMSEA] and Standardized Root Mean Square Residual [SRMR] $<.08$;

Hu & Bentler, 1999). Slope parameters indicated that, overall, individuals increased in problematic SNS use, sleep disruptions, depressed mood, and externalizing behaviors from Year 9 to Year 11. The intercept and slope factor for each study variable exhibited significant variability (all $ps < .05$), suggesting variability initially and in the rate of change across participants.

4.4.2 Parallel Process Models

Next, conditional parallel process models were estimated. These models were run as a precursor to examining the potential mediating role of sleep disruptions in the relation between problematic SNS use and psychopathology. Initially, total effects (without the mediator) between SNS use and psychopathology were determined by examining the relation between the LGM for problematic SNS use and LGMs for each psychopathology construct in two separate parallel process models. In these models, directional paths between intercepts and slopes (i.e. controlling the slope for its intercept) also enable clarification of mediational processes in the final model (von Soest & Hagtvet, 2011). Results for all parallel process models are presented in Table 4-1 and show good fit (i.e. CFI $> .95$; RMSEA and SRMR $< .08$; Hu & Bentler, 1999). Direct effects for the intercept-to-intercept and slope-to-slope models for problematic SNS use and psychopathology constructs were all statistically significant. Students with higher baseline levels of problematic SNS use also tended to have higher initial levels of depressed mood and externalizing behavior. Furthermore, changes in problematic SNS use were associated with changes in both depressed mood and externalizing behavior.

Table 4-1

Correlations, Means, Standard Deviations, Cronbach's Alpha Coefficients of Youth Characteristics - Problematic Social Networking Use, Sleep Disruptions, Depressed Mood, Externalizing Behavior, Gender, Socioeconomic Status and Puberty Maturation.

Variable List			1	2	3	4	5	6	7	8	9	10	11	12
1.	Problematic SNS Use	(T0)	1											
2.	Problematic SNS Use	(T1)	.65**	1										
3.	Problematic SNS Use	(T2)	.47**	.52**	1									
4.	Sleep Disruption	(T0)	.35**	.25**	.16**	1								
5.	Sleep Disruption	(T1)	.34**	.29**	.22**	.63**	1							
6.	Sleep Disruption	(T2)	.26**	.22**	.18**	.48**	.59**	1						
7.	Depressed Mood	(T0)	.31**	.26**	.21**	.46**	.42**	.32**	1					
8.	Depressed Mood	(T1)	.31**	.33**	.20**	.33**	.46**	.38**	.54**	1				
9.	Depressed Mood	(T2)	.24**	.25**	.24**	.36**	.40**	.50**	.51**	.60**	1			
10.	Externalizing Behavior	(T0)	.37**	.20**	.20**	.24**	.20**	.15**	.24**	.19**	.19**	1		
11.	Externalizing Behavior	(T1)	.29**	.32**	.21**	.16**	.21**	.21**	.18**	.23**	.23**	.55**	1	
12.	Externalizing Behavior	(T2)	.22**	.24**	.28**	.11**	.19**	.14**	.21**	.22**	.18**	.45**	.57**	1
13.	Gender		-.10**	-.12**	-.07*	-.17**	-.23**	-.18**	-.23**	-.28**	-.20**	.04	.09**	.13**
14.	SES High-Low		-.04	.00	.03	-.02	-.04	-.05	-.07	-.05	-.07	-.10**	-.08*	-.07
15.	Puberty Maturation	(T0)	-.01	.04	.07	.01	.00	.01	.01	.07	.03	.10**	.06	.13**
	<i>M</i>		1.98	2.04	2.08	2.76	2.86	3.02	2.59	2.74	2.84	1.39	1.42	1.47
	<i>SD</i>		1.22	1.17	1.09	.85	.86	.87	1.06	1.14	1.15	.67	.73	.63
	α		.91	.90	.89	.76	.76	.75	.80	.83	.83	.81	.79	.79

Note. For Gender Girls' ($n = 515$) values coded as 0 and Boys' ($n = 359$) values coded as 1; For Socioeconomic Status (SES) Lower SESs' ($n = 422$) values coded as 0 and Higher SESs' ($n = 452$) values coded as 1; Problematic SNS Use Range 0 - 5; Sleep Disruptions Range 1 - 5; Depressed Mood Range 1 - 6; Externalizing Behavior Range 1 - 8. T = Time. * $p < .05$ ** $p < .01$

Further, to examine the relations between the independent variable (SNS use) and the mediator variable (sleep), we combined the LGM for problematic SNS use with the LGM for sleep disruptions, again controlling slope of the construct for its intercept. As seen in Table 4-2, the intercept and slope of problematic SNS use was positively associated with the intercept and slope of the mediator variable, sleep disruptions. That is, students with high initial levels of problematic SNS use tended to also have higher initial levels of sleep disruptions; and as students' growth in problematic SNS use from year 9 to year 11 increased so too did their sleep disruption. Finally, the mediator and dependent variables for psychopathology were run in two separate parallel process models, one for depressed mood and the other for externalizing behavior. Again these models specified directional paths between intercepts and slopes and values are reported in Table 4-2. In these models, the more frequent the sleep disruptions, the more depressed mood and externalizing behaviors reported in year 9. Further, changes in sleep disruptions were positively associated with changes in depressed mood and externalizing behavior.

Table 4-2

Parallel Process Latent Growth Models of Depressed Mood and Externalizing Behaviors with Problematic SNS Use and Sleep Disruptions

	B	95% CI	β
Problematic SNS use and depressed mood parallel process model			
Problematic SNS Use Intercept \longrightarrow Depressed Mood Intercept	0.32	0.24-0.40	.43*
Problematic SNS Use Slope \longrightarrow Depressed Mood Slope	0.35	0.12-0.72	.51*
Sleep disruptions and depressed mood parallel process model			
Sleep Disruptions Intercept \longrightarrow Depressed Mood Intercept	0.75	0.63-0.88	.67*
Sleep Disruptions slope \longrightarrow Depressed Mood Slope	0.95	0.68-1.51	.85*
Problematic SNS use and externalizing behavior parallel process model			
Problematic SNS Use Intercept \longrightarrow Externalizing Behavior Intercept	0.23	0.18-0.28	.51*
Problematic SNS Use Slope \longrightarrow Externalizing Behavior Slope	0.28	0.11-0.65	.48*
Sleep disruptions and externalizing behavior parallel process model			
Sleep Disruptions Intercept \longrightarrow Externalizing Behavior Intercept	0.27	0.20-0.35	.39*
Sleep Disruptions slope \longrightarrow Externalizing Behavior Slope	0.25	0.10-0.56	.26*
Problematic SNS use and sleep disruptions parallel process model			
Problematic SNS Use Intercept \longrightarrow Sleep Disruptions Intercept	0.27	0.21-0.33	.41*
Problematic SNS Use Slope \longrightarrow Sleep Disruptions slope	0.19	0.07-0.37	.30*

Note. $n=807$. All variables are controlled for gender, socioeconomic status and pubertal maturation.

* $p < .05$.

4.4.3 Mediation Models

Finally, multiple mediation models were estimated to determine if the effect of investment in SNS on the intercept and slope of each psychopathology variable (depressed mood and externalizing behavior) was due to early levels and change in the mediator (sleep disruption). The results of the two parallel process models are presented in Figure 4.4-2

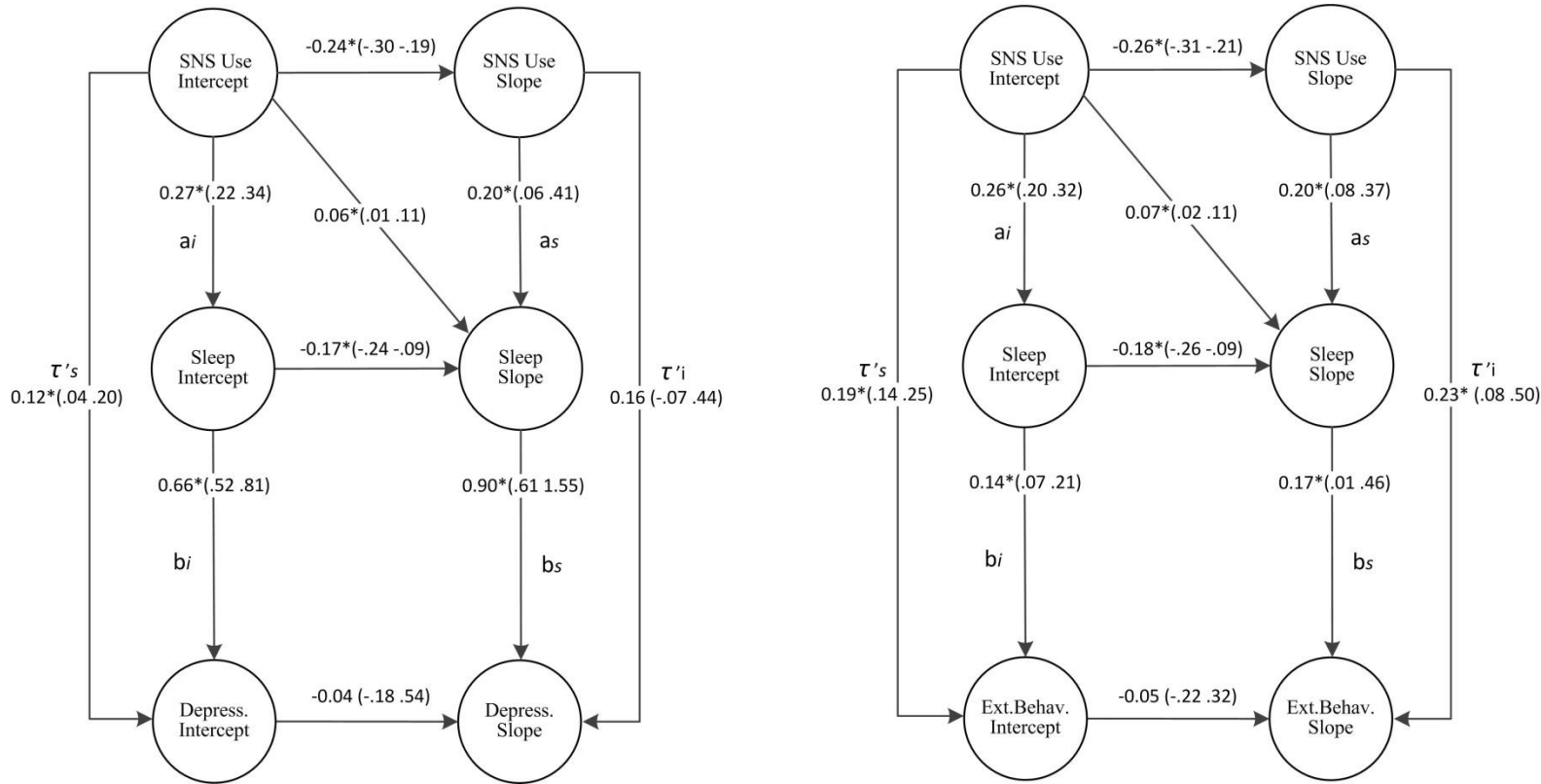


Figure 4.4-2 Latent growth curve mediation models (n=807) for problematic Social Networking use, sleep disruptions, depressed mood, and externalizing behavior with unstandardized parameter estimates. The 95% Bias corrected Bootstrap confidence interval is displayed in parentheses. All variables were controlled for Gender, SES and Pubertal Maturation but are not displayed for clarity purposes as were 2 insignificant paths to dependent variable. Direct effects intercepts = $\tau' i$. Indirect effect intercepts = $a_i b_i$. Total effect intercepts = $\tau' i + a_i b_i$. Direct effect Slopes = $\tau' s$. Indirect effect Slopes = $a_s b_s$. Total effect Slopes = $\tau' s + a_s b_s$. SNS use = Problematic Social Networking Use; Sleep = Sleep Disruptions; Depress = Depressed Mood; Ext. Behav. = Externalizing Behavior. * $p < .05$.

4.4.4 Depressed Mood

Sleep disruptions intercept partially mediated the relation between initial levels of problematic SNS use and depressed mood with good fit $\chi^2(30) = 83.98, p < .000$, CFI = .979, RMSEA (90% CI) = .047 (0.035, 0.059), SRMR = .023. The indirect effect (IE) of problematic SNS use intercept on depressed mood intercept through sleep disruptions intercept was significant as tested by asymmetric CI method (IE = 0.181, 95% CI = 0.132, 0.244). Furthermore, although the direct relation between intercept of problematic SNS use and intercept of depressed mood remained statistically significant ($\beta = .167, p < .05$) the magnitude was lower than the total effects between the two constructs ($\beta = .413, p < .05$), suggesting partial mediation. The effect size ratio (indirect effect/total effect; MacKinnon, 2008) was 0.60, indicating that 60% of the intercept association between problematic SNS and depressed mood was explained by the indirect effect through sleep disruption intercept. Of principal interest, change in sleep disruptions mediated the association between change in problematic SNS use and change in depressed mood (IE = 0.181, 95% CI = 0.049, 0.433) with the direct effects no longer significant in this model. The effect size ratio was 0.53 so around 53% of the original slope relation was explained by the indirect effect through sleep disruption slope. Three other multiple mediation pathways were significant (for clarity these pathways are not included in Figure 4.4-2).

4.4.5 Externalizing Behavior

Sleep disruptions intercept partially mediated the relation between initial levels of problematic SNS use and externalizing behavior with good fit $\chi^2(30) = 76.46, p < .000$, CFI = .979, RMSEA (90% CI) = .044 (0.032, 0.056), SRMR = .024. The indirect effect of problematic SNS use intercept on externalizing behavior intercept through sleep disruptions intercept was significant (IE = 0.037, 95% CI = 0.019, 0.060). The

direct relation between intercept problematic SNS use and externalizing behavior although reduced, remained statistically significant, suggesting partial mediation. The effect size ratio was 0.17 so only around 17% of the intercept relation between problematic SNS and externalizing behavior was explained by the indirect effect through sleep disruption. Change in sleep disruptions partially mediated the effect of change in problematic SNS use on change in externalizing behavior (IE = 0.034, 95% CI = 0.006, 0.131), with the direct effects ($\beta = .407, p < .05$) remaining significant and of similar magnitude to the total effects ($\beta = .468, p < .05$). The effect of the mediator variable (sleep disruption slope) on the outcome of externalizing behavior was small with the effect size ratio being 0.13, indicating only 13% of the original slope relation between problematic SNS use and externalizing behavior was explained by the indirect effect through sleep disruption slope. Three other multiple mediation pathways were significant and for clarity, these pathways are not included in Figure 4.4-2 (see note in Figure 4.4-2 caption).

4.4.6 Alternative Models

To determine if demonstrated directional effects worked in the opposite direction, alternative models were tested. That is, rather than change in problematic SNSs use predicting change in sleep disruption and in turn predicting changes of depressed mood or externalizing behavior, manifestations of psychopathology may be responsible for growth in sleep disruptions and problematic SNSs use. In fact, there is evidence of bidirectional relations between sleep and mood disorders (Carney & Moss, 2014). Examination of the alternative models allowed us to make relative evaluations of fit as well as examine the significance of the indirect effects for intercept and slope.

The alternative models and results, in which problematic SNS use was the outcome variable, sleep was the mediator, and either depressed mood or externalizing behaviors was the predictor, are presented in Figure 4.4-3. Gender, SES, and pubertal

timing were also included as covariates to these models. The alternative models were estimated and fit the data well: depressed mood, $\chi^2(30) = 81.20, p < .000, RMSEA = .046$; externalizing behavior, $\chi^2(30) = 76.78, p < .000, RMSEA = .044$. When considering the model whereby depressed mood predicted sleep disruption, which in turn predicted problematic SNS use, only the indirect effects through the intercepts were significant (IE = 0.251, 95% CI = 0.134, 0.400). The effect size was lower than the original model (0.44), indicating only 44% of the original intercept relation between depressed mood and problematic SNS use was being explained by the indirect effect through the intercept of sleep disruptions. As previously noted, the indirect effects through the intercepts and slopes for the original model were significant and greater in magnitude so, although there is a reciprocal relation through initial levels (intercepts), the trajectory for depressed mood was influenced by the trajectory of sleep, rather than vice versa.

However, this was not the case for externalizing behavior. In the alternative model for externalizing, the reciprocal relation was evident for both initial levels (intercepts) and trajectories (slopes). The indirect effects for the intercepts (IE = 0.206, 95% CI = 0.126, 0.315) and for the slopes (IE = 0.064, 95% CI = 0.012, 0.223) were both significant. The effect size ratio was similar in magnitude to the original model's association for both intercept (0.19) and slope (0.13).

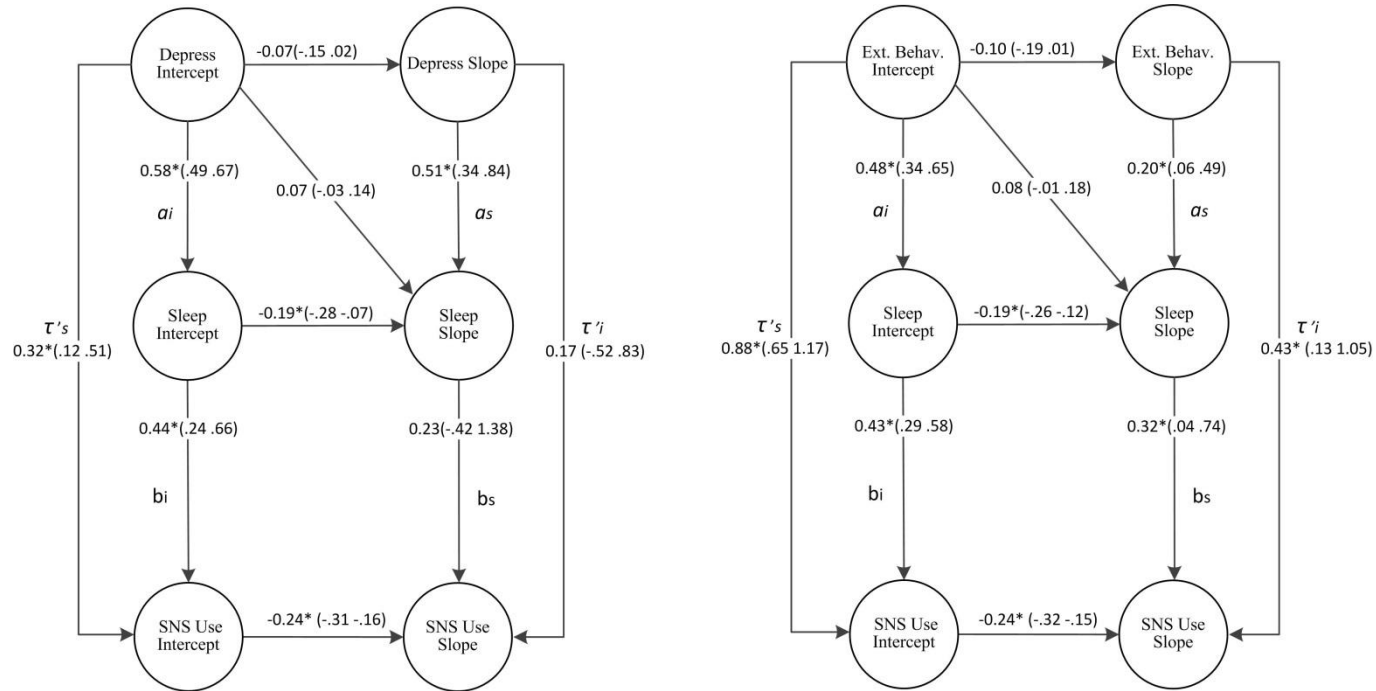


Figure 4.4-3 Alternative Model for latent growth curve mediation models ($n = 807$) for depressed mood and externalizing behavior, sleep disruptions, problematic Social Networking use with unstandardized parameter estimates. The 95% Bias corrected Bootstrap confidence interval is displayed in parentheses. All variables were controlled for Gender, SES, and Pubertal Maturation but are not displayed for clarity purposes, as were 2 insignificant paths to dependent variable. Direct effects intercepts = τ'_i . Indirect effect intercepts = $a_i b_i$. Total effect intercepts = $\tau'_i + a_i b_i$. Direct effect Slopes = τ'_s . Indirect effect Slopes = $a_s b_s$. Total effect Slopes = $\tau'_s + a_s b_s$. SNS use = Problematic Social Networking Use; Sleep = Sleep Disruptions; Depress = Depressed Mood; Ext. Behav. = Externalizing Behavior. * $p < .05$.

4.5 DISCUSSION

The goal of this study was to examine links between adolescents' social networking use and psychopathology across three years of high school and to assess whether changes in disturbed sleep explained this relation. We hypothesized that adolescents who invested heavily in social media would have increased sleep disruption, leading to increased psychopathology in the form of elevated depressed mood and problem behavior. Although research has previously established links between adolescent sleep and wellbeing, and between SNS use and sleep, no study has assessed all three together, over time, to consider their developmental course and variability within-person. Across three years of high school, on average, youth increased their investment in SNSs, reported increased sleep disruptions and increased levels of internalizing and externalizing symptoms. Importantly, our findings indicated that increasingly problematic SNS use predicted increases in sleep disruption, which in turn lead to increases in psychopathology. Thus, one way to help promote and maintain healthy sleep habits during adolescence is to help youth restrict their unhealthy use of SNS. As a result of improved sleep, youth may be buffered against increases in symptoms of psychopathology associated with too-heavy investment in SNS.

We were particularly interested in understanding whether adolescents' increasing sleep disruption was a plausible mechanism linking increases in their problematic SNS use to escalations in psychopathology over time. Notably, this relation existed only in our hypothesized direction for depressed mood; increasingly problematic SNS use predicted sleep disruption, which in turn was associated with increasing depressed mood. A considerable amount, just over half, of the original relation between change in SNS use and change in depressed mood was explained by change in sleep disruption. Thus unhealthy SNS use appears to be especially salient to manifestations of internalizing, and programs to prevent depression during adolescence could consider

including messages to reduce SNS use and encouraging youth to reschedule time online to well before bedtime.

Our mediating model for externalizing was slightly less clear-cut. Increasing problematic SNS use predicted more sleep disruptions, which in turn was associated with increasing externalizing behaviors, *and vice-versa*. Thus, for externalizing behavior, relations seem to run in *both* directions; problematic SNS use lead to externalizing and vice-versa, both mediated by sleep disruption. Further, the role of sleep as an operating mechanism in links between problematic SNS use and externalizing behavior was relatively smaller in comparison to models with depressed mood. Thus, although there was a significant indirect effect through sleep disruption, a significant direct effect still remained so that changes in problematic SNS use predicted changes in externalizing behaviors, even when the associated change in sleep disruption was controlled, and vice versa. Such tight links between SNS use and externalizing could be interpreted as consistent with previous evidence that social networking is just a new way of displaying the same patterns of behaviors (Mikami et al., 2010; Modecki, Minchin et al., 2014). Thus, those who already have developing delinquent tendencies or aggressive behaviors may use social networking to manifest socially inept interactions. Furthermore, heavy use of social networking to facilitate aggressive behaviors arguably also interferes with sleep, leading to cyclical escalations of externalizing behaviors and poor quality sleep (Tochigi et al., 2012).

Interestingly, although young people's immersion in technology is a growing concern for parents, teachers, psychologists, and policy-makers generally the focus of those concerns is on the direct impact of strong emotional investment in technology on youths' psychological well-being. Relatively less attention has been paid to the displacing effect of heavy technology investment on key aspects of adolescents' routine, including sleep. However, an emerging body of evidence suggests that social

networking is indeed associated with poor sleep quality (Wolniczak et al., 2013) and sleep displacement (Andreassen et al., 2012). Here, our findings echo this notion and highlight that much of SNSs' role in the development of internalizing and externalizing symptoms may be attributed to sleep disruption.

Indeed, sleep disruption is a key concern for adolescents. Our research assessed sleep disruption, including how satisfied students were with their sleep, whether they had difficulty getting to sleep and felt tired and sleepy during the day. As a group, adolescents reported increases in these aspects of disturbed sleep across the high school years. These increases in sleep disruption were precipitated by increased engagement in social networking which is consistent with more general findings that adolescents who use interactive media before bed are at risk of poor sleep (Gradisar & Short, 2013). The implications of this link between increases in SNS investment and sleep disruptions is that youth may need to be screened-for and monitored-about investment in, and use of, social networking. In particular, our results indicate that early (age 14) SNS investment is predictive of subsequent increases in problematic sleep so that young adolescents who are heavy SNS users may especially benefit from intervention. In general, educating youth about the benefits of reducing and rescheduling their use of SNS's as well as discussing its impact on sleep and subsequent psychopathology could be a useful addition to prevention programming.

Educating youth about ways to protect their sleep is important because disturbed sleep is linked to increases in psychopathology symptoms. Consistent with our prediction, adolescents who experienced higher levels of sleep disruption at the beginning of ninth grade also exhibited higher levels of depressed mood and externalizing behaviors. Further, we found that as sleep disruptions increased over time so did symptoms of psychopathology. Our finding of parallel increases in depressive symptoms and poor sleep is consistent with previous research (Fredriksen et al., 2004).

However, our results indicating parallel increases between externalizing symptoms and poor sleep is novel, and points to the importance of sleep for maintenance of psychological resources such as self-control and coping (Modecki, Zimmer-Gembeck, & Guerra, in press).

4.5.1 Study Limitations and Future Directions

This study is unique as it uses latent growth curve modeling to examine growth trajectories over time in sleep disruptions, investment in social networking, depressed mood, and externalizing behaviors. Although using LGM to examine longitudinal mediation is superior to cross-sectional studies, the causal interpretations must be viewed with caution (Cheong et al., 2003). The proposed pathways between intercepts and slopes are correlational, and constructs were concurrently measured. However causal conclusions regarding the associations can be based on strong theory (Cheong et al., 2003), and for this study, the temporal relation between heavy SNS use and sleep disruptions suggests they are contemporaneously linked; heavy use of SNSs displaces sleep. In terms of the relation between sleep and the indicators of psychopathology, previous research using LGM has suggested a link from sleep to depressive symptoms (Fredriksen et al., 2004) and this rationale was used to test our mediational pathway for depressed mood. However, strong theory and research were less evident for predictions about the externalizing behavior pathway, and our results testing both causal directions suggest the pathway for externalizing behavior is worthy of further investigation.

Future research should lag growth processes, perhaps using two-phase piecewise modeling in which earlier growth processes are modeled simultaneously with later growth process. In this case, change in the mediator would precede the change in the outcome, providing information about the direction for mediational hypotheses (Cheong et al., 2003). However, this suggestion requires more waves of data than we had available. Despite these limitations, we have improved the interpretability of the model

by controlling the dependent variable's slope for its intercept so that the mediation analysis is not confounded by initial differences between individuals in the dependent variable (von Soest & Hagtvet, 2011).

Although this study used multiple items for each construct, we were not able to ascertain whether sleep quality, night time problems or daytime sleepiness was the driver of symptoms of psychopathology. Further, the data were self-reported, and future research would benefit from collecting other measures around sleep duration, daytime functioning, and engagement online. Sleep and mood diaries (Short, Gradisar, Lack, Wright, & Chatburn, 2013) used in tandem with real-time monitoring of SNS activities would offer a substantial advance to our understanding; allowing for the consideration of both between-person comparisons of heavily invested and less invested SNS users, and within-person differences in sleep displacement or disruption on nights when more time is spent on SNSs. Previous research suggests pathological dependence on the Internet results in loss of sleep and excessive daytime fatigue (Nalwa & Anand, 2003). As our investment in SNS scale taps a subjective sense of dependency on SNSs (e.g. feeling out of touch when have not logged on, getting into arguments about time spent on SNS), we have made an assumption that those who are heavily invested in social networking are likely to be carrying out the activity not only during the day, but also in the evening, (just before bed and possibly continuing after lights out) both of which disrupt adolescents' sleep. Verification of this temporal aspect of the association is needed.

We note, however, that problematic investment in SNSs as we have defined it transcends solely temporal classification, and reflects a psychological dependency, albeit linked to a felt need for constant access to respond and interact at any time of the day or night. This SNS constancy requirement can lead to arguments with family and friends about the time spent social networking. Sleep becomes a casualty, not only

because time spent social networking displaces sleep, but also because personal dependency on SNSs (feeling moody and irritable if cannot access SNSs) increases emotional arousal, and delays sleep onset (Eggermont & Van den Bulck, 2006). Research into the emotional valence of social media interactions during daytime compared to those at night may also inform about useful boundaries for healthy use of social media.

4.6 Conclusion

Sleep needs change over the course of adolescence and identification of psychosocial and behavioral risk factors for impaired sleep offer a first step for promoting healthier adolescent development. This study has made two important contributions to the research into adolescent sleep and psychopathology. First, our study suggests that for some adolescents, heavy investment in, and problematic use of social networking is reflective of psychological dependency. This dependency on social networking manifests in adolescents searching for affirmative posts and making social comparisons as a way to feel good about themselves. The time and effort adolescents devote to maintaining a socially acceptable online presence may come at the cost of a good night's sleep. The second important contribution of the study is that disturbed sleep has implications for psychopathology. Adolescents with increased sleep disruptions are at risk of developing depressed mood and engaging in externalizing behaviors during high school. These findings suggest that in order to guide healthy development, schools, teachers, and parents may need to focus on the role of adolescent sleep disruption, with heavy investment in social networking as a precursor. Educational guidelines to reduce social networking investment and reschedule use away from bedtimes could help to ensure sleep is not a casualty of healthy development. In all, promoting healthy sleep hygiene among adolescents should positively impact their long-term wellbeing.

4.7 Acknowledgments

We would like to thank the high school principals, their staff, and the students who participated in the YAPS-WA study. We are grateful to everyone in the YAPS-WA team, with special thanks to Corey Blomfield-Neira, Bree Abbott, Catherine Drane, and Stuart Watson for their intellectual input, vital support and contributions to data collection over the years.

4.8 Funding

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4.9 Preface to Chapter Five

4.9.1 Study-3

Technology Contexts → Sleep → Functioning

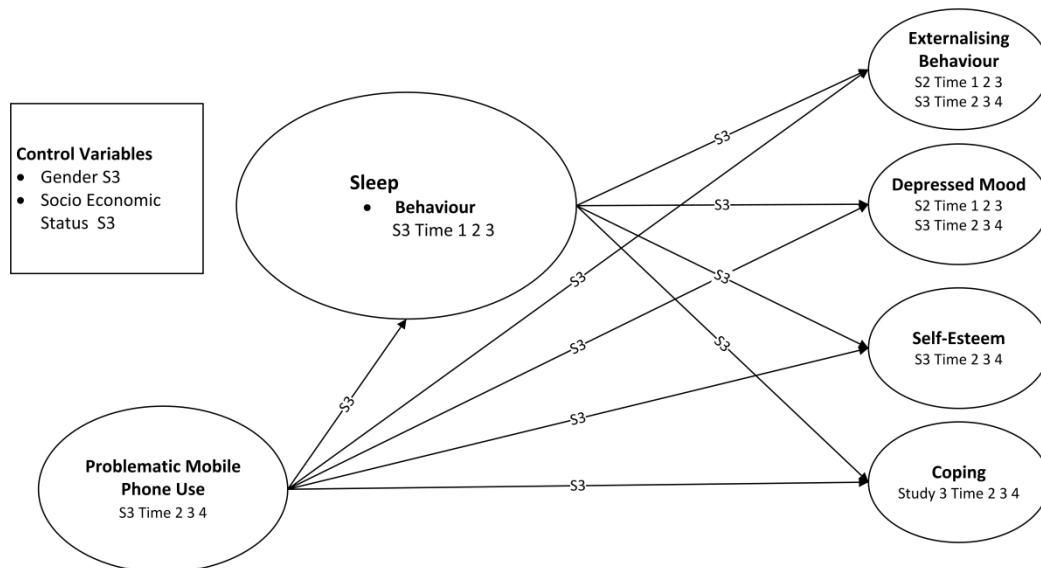


Figure 4.9-3 The conceptual model tested in Chapter 5 (Study-3).

4.9.2 Aims:

To identify technological contexts (mobile phone use) and associated wellbeing (see Figure 4.9-3).

- *To use latent growth curve modeling to describe the developmental trajectories of problematic mobile phone use, sleep and wellbeing (externalizing behavior, depressed mood, self-esteem and coping) for adolescents*
- *To use parallel process modeling to examine changes in problematic mobile phone use and disturbed sleep, to explain the links to changes in wellbeing.*
- *To test the putative mediating process and examine change in problematic mobile phone use and disrupted sleep, in relation to subsequent change in wellbeing.*

Study-2 validated the mediating role of adolescent sleep disruptions on the relations between early problematic use of social networking and later growth in depressed mood or externalizing behavior. Considering the links in the mediational model, the first link, investing in social networking, (having to log on daily, feeling moody and irritable if not on social media, and using social networking to feel good) lead to increased sleep disruptions. Sleep disruption (having a hard time getting to sleep, feeling less satisfied with sleep and feeling sleepy in the day) then lead to feeling depressed and moody, like things were piling up, or being unable to regulate emotions such as getting into physical fights. The longitudinal growth curve analysis used in Study-2 demonstrated that changes in sleep appear to be a highly plausible mechanism linking the growth processes of problematic SNS use (increasing) and depressed mood (increasing) or externalizing behaviors (increasing). Study-2 also suggests that changes in SNS use, sleep and depressed mood or externalizing should be considered from a developmental framework whereby the constructs are functionally linked. Study-1 found tired students don't have a positive school experience. Study-2 elicits that tired students can feel unhappy about the way things are going for themselves or that they are too tired to regulate their behavior and can lash out at others. Both studies suggest integrating social networking as well as establishing a place for sleep is an important developmental task for adolescents to ensure academic functioning and wellbeing. These findings support the argument that sleep and emotions are closely linked (Beattie et al., 2015) and technological integration with growing social roles can influence the place of sleep in adolescent lives (Bartel et al., 2015).

The sleep environments, adolescent bedrooms, hold many media formats; televisions, computers linked to the internet, gaming consoles and mobile phones. Study-3 tests the final section of the model and extends the previous studies by investigating the role of mobile technology around bedtime and how this impacts on

adolescent' wellbeing. A rise in smartphone ownership (Lenhart, 2015) and adolescents' desire to stay connected with their peers has led youth to text into the night (Van den Bulck, 2007). In fact, researchers have described texting as a "life phase" medium, because texting increases rapidly across early adolescence, before declining in the late teen years (Ling & Haddon, 2008). This habit can also be problematic, however, and late night texting links to poor functioning (Lemola et al., 2015). Despite a growing body of research suggesting that texting into the night results in sleep disruption (Tochigi, 2012; Van den Bulk, 2007) and reductions in wellbeing (Lemola, et al., 2015) we know little about how texting into the night and its related disrupted sleep affect broad aspects of adolescent well-being. Notionally, texting into the night could affect adolescents' functioning across a range of indicators of wellbeing, including self-esteem, coping, depressed mood and externalizing behavior, and arguably the process by which this occurs is through adolescents' disrupted sleep. In Study-3 we investigate these hypothesized mediational processes using parallel process latent growth curve modeling (Cheong et al., 2003). Specifically, we describe whether associations between developmental trajectories of texting habits and subsequent trajectories of well-being are mediated by the developmental change in disrupted sleep. Study-3 extends the findings from Study-2 by considering specific mobile phone behavior around bedtime. Study-3 advances our theoretical understanding of links between problematic mobile phone use, sleep, and development of adolescent functioning.

Chapter 5 Study-3

Mobile Phones in the Bedroom: Trajectories of Sleep Habits and Subsequent Adolescent Psychosocial Development.

The following is a modified version for the manuscript accepted for publication for a special edition of Child Development – Contemporary Mobile Technology and Child and Adolescent Development co-authored paper (see page 235 of this thesis), and, it is formatted in accordance with the authors' instructions for submission to the journal, Child Development. The bibliographic details of the co-authored paper, including all authors, are:

Vernon, L., Modecki, K.L., & Barber, B.L. (Accepted for Publication). Mobile phones in the bedroom: Trajectories of sleep habits and subsequent adolescent psychosocial development. *Child Development*.

My contribution to the paper involved:

I constructed the survey questions related to problematic mobile phone use and sleep. I collected and prepared the data and formulated the question. I analyzed the data and drafted the manuscript. My co-authors then reviewed the manuscript draft, suggesting edits.

7/12/2016

Lynette Vernon

Date

5.1 Abstract

Mobile phones are an essential part of adolescent life, leading them to text, phone, or message into the night. Longitudinal latent growth models were used to examine relations between changes in adolescent night-time mobile phone use, changes in sleep behavior and changes in wellbeing: depressed mood, externalizing behavior, self-esteem and coping, for 1101 students (43% male) from 13-to-16-years-old. Both night-time mobile phone use and poor sleep behavior underwent positive linear growth over time. Increased night-time mobile phone use was directly associated with increased externalizing and decreased self-esteem and coping. Changes in sleep behavior mediated the relation between early changes in night-time mobile phone use and later increases in depressed mood and externalizing behavior and later declines in self-esteem and coping.

5.2 Introduction

Mobile phones are an essential tool for youths' social interaction. Many adolescents report phones are indispensable to their social life and that they "can't live without their phones" (Lenhart, Smith, Anderson, Duggan & Perrin, 2015; Ling & Haddon, 2008). Internationally around 80% of youth have access to a mobile phone, which they chiefly use to message their peers or to call their close friends (Australian Communications and Media Authority, 2015; Lenhart et al., 2015). The ubiquitous nature of mobile phones allows for one-on-one communication, and also instantaneous mass communication, enabling adolescents to reach a diverse range of peers from close friends to distant acquaintances (Ling & Haddon, 2008). As a result, adolescents consider the mobile phone as their own "private" device whereby they are able to send and receive messages autonomous of parental influence, cultivating their identity, autonomy, and self-esteem (Erickson, Wisniewski, Xu, Carroll, Rosson, & Perkins, 2015). Although mobile phones and other devices provide opportunities for positive interactions and development, the lack of physical boundaries associated with their use means that adolescents are able to sustain communication at almost any time of day or

night (Ling & Haddon, 2008). Thus one challenge in adolescent use of mobile phones may be disruption to daily activities – and sleep activities in particular. Consequent displacement of sleep and its potential long term negative impact on wellbeing is thus an important area of inquiry for understanding adolescents’ night-time mobile phone use (Kalak, Lemola, Brand, Holsboer-Trachsler, & Grob, 2014).

Adolescents are drawn to mobile phones because they enhance connectivity with their friends (Ling & Haddon, 2008) during a time when peer relationships take on increasing importance (Lam, McHale & Crouter, 2014). Adolescents text or phone to facilitate face-to-face contact, then continue using their phones to maintain their social interactions 24 hours a day, 7 days a week, staying in “perpetual contact” (Katz & Aakhus, 2002, p.1). Frequent and continual messaging gives adolescents a sense of unity within their peer group, provides a sense of belonging, and reaffirms their group status (Ling & Haddon, 2008). Although mobile phone use facilitates adolescents’ maintenance of a strong social presence, calls and messaging take time. For example, teenagers report spending around an hour and a half a day engaged in sending and receiving texts (Rideout, Foehr, & Roberts, 2010). This time spent on mobile phones can displace adolescents’ other essential activities, including sleep (Van den Bulk, 2007). As well as sleep displacement, Cain and Gradisar (2010) theorized two other possible mechanisms for sleep disruption from mobile phone use: impact on circadian physiology, through melatonin suppression, due to exposure to bright light from screens (Cajochen et al., 2011); and sleep disturbance due to the content of messages received pre-bedtime increasing cognitive and emotional arousal (Oshima et al., 2012; Vernon, Modecki, & Barber, 2016). Indeed, studies assessing both melatonin and emotional context of messages point to these possibilities. Here, we focus on the complimentary possibility that after-hours time on mobile phones displaces time that would otherwise be spent asleep. Whatever the underlying mechanism, if poor mobile phone use habits

around bedtime develop and become entrenched, sleep can become a casualty, as adolescents increasingly access their mobile phones in their bedrooms (Lemola, Perkinson-Gloor, Brand, Dewald-Kaufmann, & Grob, 2015; Van den Bulk, 2007).

Adequate sleep for adolescents, between 8-10 hours per night, is an essential requirement for healthy psychosocial adjustment (Hirshkowitz et al., 2015). Thus, delays to bedtimes put adolescents at increased risk for developing negative health outcomes (Becker, Langberg, & Byars, 2015; McGlinchey & Harvey, 2015; Shochat, Cohen-Zion, & Tzischinsky, 2014). In particular, for adolescents, disturbed sleep over time has been associated with increases in depressed mood and decreased self-esteem (Lovato & Gradisar, 2014; Roberts, Roberts, & Duong, 2009) as well as increased externalizing behaviors (McGlinchey & Harvey, 2015). Thus, communicating via mobile phones “into the night” likely contributes to sleep problems, which in turn, may lead to increases in a wide range of psychosocial problems—from mental health symptoms to poor coping and self-esteem. Indeed, a body of research has documented negative consequences of excessive use of other electronic media (Hale & Guan, 2015; Vernon, Barber, & Modecki, 2015; Vernon et al., 2016) and we argue these negative effects may be due, in part, to technology’s potential for replacing other tasks necessary for healthy development, such as sleep.

Some cross-sectional evidence supports this thesis (Bartel, Gradisar & Williamson, 2015). For instance, Van den Bulck (2007) examined the prevalence of mobile phone use after lights-out and demonstrated a concurrent link to higher levels of tiredness. Other studies also point to the possibility that one process by which “too much” technology could lead to problems in wellbeing, is through diminished sleep. For instance, research with Asian adolescents finds excessive mobile phone use is associated with sleep difficulties, daytime tiredness, and poor mental health (Oshima et al., 2012; Yang, Yen, Ko, Cheng & Yen, 2010). Finally, some cross-sectional evidence

suggests that excessive mobile phone use may be linked to higher levels of depressive symptoms through sleep disturbance (Lemola et al., 2015), but longitudinal data are needed to better disentangle developmental processes.

Despite a growing body of evidence that adolescents use various forms of technology, including their mobile phones, during the night (Van den Bulk, 2007) and despite early evidence that too much technology use can be associated with disturbed sleep (Hale & Guan, 2015) and psychosocial maladjustment (Shochat et al., 2014), no research has yet unraveled whether night-time mobile phone use leads to increasing problems via sleep disruption. Here, we examine changes in mobile phone use over three years of high school in total, and examine subsequent changes in wellbeing (depressed mood, externalizing, self-esteem, and coping) beginning one year later. Importantly, we hypothesize that changing sleep behavior may be one important pathway by which adolescents' increasingly unencumbered phone use (when they would otherwise be sleeping) leads to subsequent increases in psychosocial maladjustment.

5.2.1 The Present Study

Few studies have explored the longitudinal effect of communicating by mobile phone into the night on adolescents' sleep habits and wellbeing. Notionally, texting, messaging, and phoning into the night could affect adolescents' functioning across a range of indicators of wellbeing, including depressed mood, externalizing behavior, self-esteem, and coping, and arguably one process by which this occurs is through adolescents' poor sleep habits. Despite preliminary evidence of links between communicating into the night and poor sleep (Hale & Guan, 2015) and despite heavy interest in the impact of poor sleep on wellbeing (Kalak et al., 2014); no research has yet examined these relations simultaneously. Nor has research examined whether early change in these aspects of adolescent lives predict later change in wellbeing. Here, we

hypothesize that increased night-time mobile phone use across the high school years would be associated with increasingly poor sleep habits which in turn would be associated with subsequent increases in depressed mood and externalizing behavior, and declines in self-esteem and coping. Thus, our analyses addressed two major questions: are changes in night-time mobile phone use and changes in later manifestations of wellbeing related to one another? Further, do increases in poor sleep habits mediate this relation, between developmental increases in night-time mobile phone use and indicators of wellbeing?

5.3 Method

Data were drawn from an ongoing longitudinal study on adolescent activity participation (See, Blomfield & Barber, 2014; Vernon et al., 2015; 2016 for study descriptions). These studies have previously explored other aspects of technology (social networking) in relation to other sleep dimensions, vis-à-vis correlations, and no work has explored mobile phone use. The 29 participating schools (17 public schools) were from regional (14 schools) and metropolitan areas across Western Australia. The current study focused on self-report data for students who completed the survey during four consecutive years, starting in Year 8 in high school, from 2010 to 2013. All students were surveyed at least twice with 80.8% participating in 3 or more waves of data collection. Parameters were estimated in the presence of missing data, using the full information maximum likelihood (FIML) procedure (Yuan & Bentler, 2000).

5.3.1 Participants

The sample comprised 1101 students (43% male, baseline mean age = 13.5; 44% lower SES) who began Year 8 in high school. Over half of the students identified as Caucasian (56.9%), with 7.1% Asian, 2% Aboriginal or Torres Strait Islander, 21.9% other (e.g., Middle Eastern, African, Indian, and Maori) and 11.9% did not nominate

ethnicity. In Year 8, 86.3% of the students had a mobile phone, and this increased to 93% in Year 11, with 92% of those mobile phones having internet access. For students who owned a mobile phone in Year 8 only 36% reported that they never sent or received text messages and, or phone calls after lights out on school nights, declining to 32% in Year 9, 29% in Year 10 and 22% in Year 11.

5.3.2 Procedures

Ethical approval was obtained from the University Human Research Ethics Committee, the Education Department and Catholic Education Office. Study participation required active, informed student and parent consent. Students were informed that the survey was voluntary and confidential. The research team visited schools during class-time and administered the survey using 30 laptops or iPads via an intranet in a 45-minute session. Alternatively, a paper survey was administered at the school's request.

5.3.3 Measures

Night-time mobile phone use. Students were asked if they had a mobile phone and if they answered yes they were then asked; "At what time of the night do you usually send or receive messages and/or phone calls?" The students ticked all boxes that apply and were given the options: *Never text or phone after lights out; Immediately after lights out; 10-11pm; 11pm - 12am; 12 - 1am; 1 - 2am; 2 - 6am; At any time of the night.* The timeslots from 10pm to 12am were collapsed to one category and classified as using the mobile phone before midnight. The responses from 12am to 6am were collapsed and classified as using the mobile phone after midnight. The students' latest use of their mobile phone into the night determined their mobile phone habit classification. The final 6 point scale had responses ranging from 0 = *No mobile phone,*

1 = *Never text or phone after lights out*, 2 = *Immediately after lights out*, 3 = *Before midnight*, 4 = *After midnight* and, 5 = *At any time of the night*.

Sleep behavior. This scale consisted of the mean of eight items drawn from the School Sleep Habits Survey (Wolfson & Carskadon, 1998). The sleep scale tapped perceptions about sleep quality and behavior during the previous 2 weeks, and included: “How often have you needed more than one reminder to get up in the morning.” Responses for all sleep items were 1 = *never*, 2 = *once*, 3 = *twice*, 4 = *several times*, and 5 = *every day/night*. Because sleep behavior could also be influenced by adolescents’ bedtime, we controlled for bedtime at each wave by including it as a time-varying covariate, as described further below. Thus, growth curve parameters for the sleep behaviour models represent the estimated trajectories of sleep behaviour, controlling for underlying change in bedtime.

Depressed mood. This scale was based on the mean of five items designed to tap emotional wellbeing, originally from the Michigan Study of Adolescent Life Transitions. Scale items have been published extensively in prior research (e.g., Durkin & Barber, 2002) and validity of the full scale has also been supported (Modecki, Barber, & Vernon, 2013). In these data, the Year 8 scale was positively correlated with low self-esteem ($r = .51, p < .05$). Items included: “How often do you; feel there is nothing nice you can look forward to; Feel unhappy, sad or depressed?” Responses ranged from 1 = *never*, to 6 = *daily*.

Externalizing behavior. This scale was comprised of the mean of seven items which tapped delinquency and aggressive behaviors. Previous research shows this measure is a valid indicator of status offenses, aggression, and delinquency (Modecki et al., 2013). The items were measured on an eight-point scale from 1 = *none* to 8 = *31 or more times* and include: “In the past 6 months how often have you gotten in a physical fight with another person?”

Self-esteem. This scale was based on the mean for three items; used in previous research where the validity of the scale has been ascertained (Blomfield & Barber, 2014). Items were measured on a six-point scale from 1 = *never* to 6 = *daily* and include: “How often do you feel satisfied with who you are?” The items were reverse coded with higher scores representing low self-esteem.

Coping. This was measured with one item drawn from the vulnerability facet of the NEO Personality Inventory-Revised (Costa & McCrae, 1992) used to determine general susceptibility to stress through coping. The item used was; “How often do you feel that you are capable of coping with most of your problems?” Responses ranged from 1 = *never*, to 6 = *daily*. The item was reverse coded with higher scores representing poor ability to cope. In these data, the Year 8 poor coping ability was positively correlated with low self-esteem ($r = .60, p < .05$) and depressed mood ($r = .30, p < .05$).

Covariates. Relevant time invariant covariates were controlled for including gender (0 = *female*, 1 = *male*), and socioeconomic status (SES; 0 = *below median*, 1 = *above median*). School level SES (17 schools were below median) was obtained from a standardized report which draws on education, occupation, income, ethnicity, and location of students (See, Vernon et al., 2015 for further details on standardization). A time varying covariate, weekday bedtime, was included as a predictor of each repeated measure of sleep behavior. Bedtime was a self-report measure asking: “What time do you usually go to bed on school days?” The item was measured in 15 minute intervals starting 1 = *before 9pm*; 2 = *9.00 - 9.15pm*; 3 = *9.16 - 9.30pm*; 4 = *9.31 - 9.45pm*; 5 = *9.46 - 10pm*; 6 = *10.01- 10.15pm*...26 = *after 3am*. Because estimation problems can result when model variables are on vastly different metrics, the bedtime variable was rescaled using the proportion of maximum scoring method, a monotonic transformation

in which the distribution of variables is retained (Little, 2013). The resulting scale range was from 0 to 1, where 0 = *before 9pm* and 1 = *after 3am*.

5.3.4 Analysis Plan

Analyses were conducted using latent growth modeling (LGM) in Mplus 7.4 (Muthén & Muthén, 2012). Latent changes in the independent variable (X; night-time mobile use), dependent variables (Y; depressed mood, externalizing behavior, self-esteem, and coping) and the mediating variable (M; sleep behavior) were modeled (MacKinnon, 2008). Use of LGM to estimate longitudinal mediation has been established in the literature (Littlefield, Sher, & Wood, 2010). Because ideally mediation models include temporal precedence and preclude reciprocal causation, here we lag the dependent variable latent growth curves for wellbeing by one year so that the origin for the dependent variable falls one year before assessment (Preacher, 2010). Thus, the X and M scores precede the Y scores temporally (e.g., by one year). The ratio of indirect effect to absolute value of total effect was used to determine how much of the original relation is explained by indirect effects (MacKinnon, 2008).

For all study variables, a series of unconditional (with no covariates) univariate growth curve models were run individually to determine the best fitting model of change in individual constructs. Next, a series of conditional parallel process models were run to examine the direct effects between early levels of the constructs (intercepts) and change in each of the constructs (slopes), with gender, and SES entered as time-invariant covariates. As described above, for sleep behavior, all models controlled for time-varying effects of bedtime. This was followed by conditional, multiple mediation parallel process models for each dependent variable, as illustrated in Figure 1. For instance, for externalizing, the steps of analyses were: First direct effects between intercepts and slopes of X (night-time mobile use) with M (sleep, net of bedtime) were modeled; then links between X (night-time mobile use) with Y (externalising with one

year time lag) were modeled; followed by modeling direct effects between M (sleep, net of bedtime), and the intercept and slopes of Y (externalizing plus one year). Finally, the multiple mediation models for X (night-time mobile use), M (sleep, net of bedtime) and Y (externalizing plus one year) were run (Figure 1). Intercept factors represent the initial level (X and M = Year 8, age 13.5 years; Y = Year 9 age 14.5 years) for each construct, and slope factors represent change from year 8 to year 10 for X and M and from year 9 to year 11 for Y.

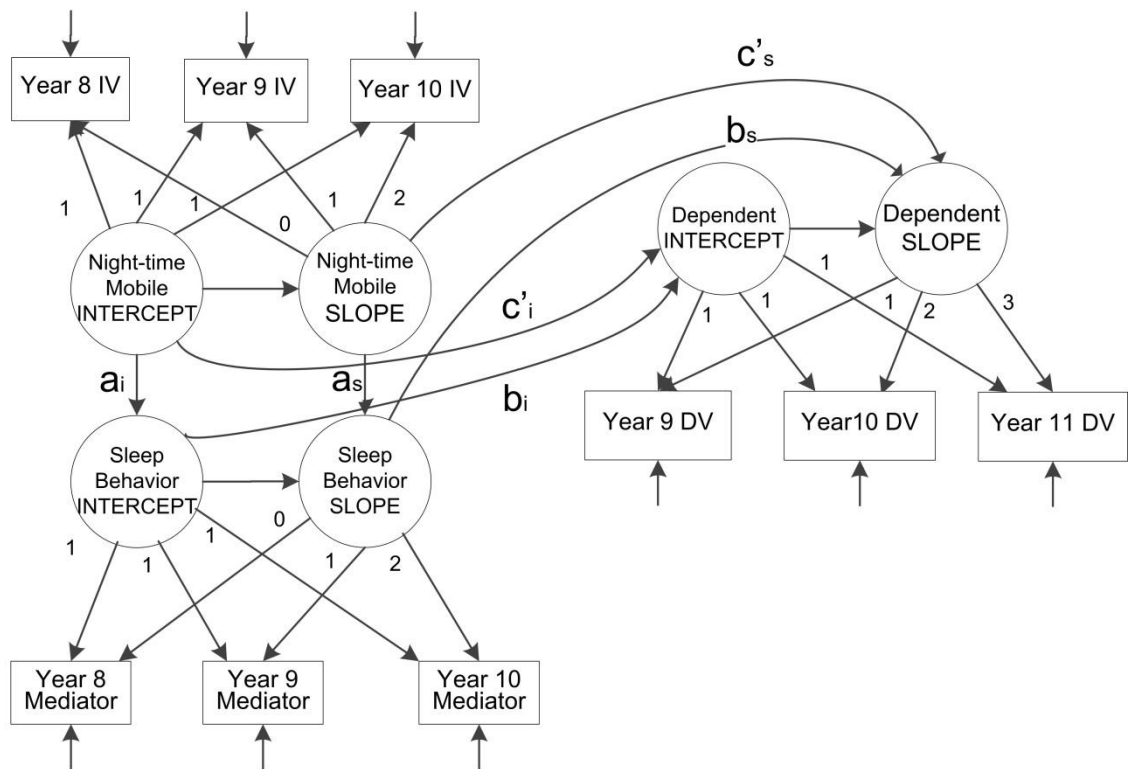


Figure 1 Longitudinal multiple mediation model with control for intercepts; IV = Independent Variable; DV = Dependent variable lagged for 1 year; i=intercept; s=slope; a=coefficient for IV → Mediator; b=coefficient for Mediator → DV; C'=direct effect from IV → DV; Paths for covariates and from IV intercept → Mediator slope and Mediator intercept → DV slope not shown to simplify figure (MacKinnon, 2008, p. 212).

Figure 5-1 Longitudinal multiple mediation model

Night-time mobile use and sleep behavior were contemporaneously linked. Therefore the order for the X and M variables was created “a priori,” and measured concurrently with the independent variable X and mediator M linked to the dependent variable Y in a subsequent wave of measurement (Cheong, MacKinnon, & Khoo, 2003; MacKinnon, 2008). Thus, the relation of baseline levels of night-time mobile use

(intercept) was modeled to associate with baseline measures of sleep behavior (intercept) and later measures of wellbeing. For our theorized model, Figure 1 indicates the directional paths, with the slopes controlled for their intercept. Bias-corrected bootstrap confidence intervals (CI) were computed for indirect effects (the products of coefficients approach; Preacher & Hayes, 2008) for the associated intercepts and slopes to determine if changes in sleep behavior was the correct mechanism to account for changes in the associations between night-time mobile use and wellbeing.

5.4 Results

5.4.1 Descriptive Analysis

Table 1 provides descriptive data and scale reliabilities. Correlations among night-time mobile use, sleep behavior, and wellbeing over the three time periods with covariates gender, SES and bedtime are available as supplementary data as well as mobile phone ownership by SES (Appendix Table 1 and 2). The pattern of associations between the predictors (night-time mobile use and sleep behavior) indicated significant correlations in the expected direction; night-time phone use positively associated with poor sleep behavior, depressed mood, externalizing, low self-esteem, and poor coping ability.

Table 5-1 Mean, Standard Deviations of Youth Characteristics

Table 1

Means, Standard Deviations of Youth Characteristics

		Time				Range	α Range
		1	2	3	4		
Night-time Mobile Use	<i>M</i>	2.10	2.21	2.35		0-5	1 item
	<i>SD</i>	1.72	1.69	1.67			
Sleep Behavior	<i>M</i>	2.17	2.28	2.33		1-5	.67-.74
	<i>SD</i>	0.59	0.64	0.65			
Depressed Mood	<i>M</i>		2.62	2.73	2.84	1-6	.75-.79
	<i>SD</i>		1.08	1.14	1.15		
Externalizing Behavior	<i>M</i>		1.43	1.43	1.42	1-8	.78-.81
	<i>SD</i>		0.75	0.73	0.63		
Self-esteem ^R	<i>M</i>		2.82	2.96	3.06	1-6	.88-.89
	<i>SD</i>		1.13	1.17	1.16		
Coping ^R	<i>M</i>		2.74	2.73	2.89	1-6	1 item
	<i>SD</i>		1.25	1.21	1.22		

Note: Night-time Mobile Use refers to sending or receiving text messages or phone calls after bedtime, with responses ranging from 0= No Mobile Phone, 1= Never text or phone after lights out, 2= Immediately after lights out, 3= Before midnight, 4= After midnight and 5= At any time of the night.

^R Items reverse coded, higher values indicate poorer effects. Time 1 = Baseline, Time 2 = 1 year, Time 3 = 2 years from baseline, Time 4 = 3 years from baseline.

5.4.2 Univariate Growth Models

Overall the univariate model estimates of the growth trajectories for all LGM provided good fit to the data (i.e., Comparative Fit Index [CFI] > .95; Root Mean Square Error of Approximation [RMSEA] and Standardized Root Mean Square Residual [SRMR] < .08; Hu & Bentler, 1999). See Appendix 2 for further details regarding the univariate models.

5.4.3 Parallel Process Models

Next, a series of conditional parallel process models, controlling for time-invariant covariates gender and SES, were estimated. These models were run as a precursor to examining the potential mediating role of poor sleep behavior in the relation between night-time mobile use and indicators of wellbeing. Results for all parallel process models are presented in Table 2 and each model shows acceptable fit (i.e., CFI > .90; RMSEA and SRMR < .10; Hu & Bentler, 1999). To examine the relations between the independent variable (night-time mobile use) and the mediator variable (sleep behavior, net of bedtime), we combined the latent growth models for

these two variables controlling for gender and SES. The intercept and slope of night-time mobile phone use were positively associated with the intercept and slope of the sleep mediator (net of bedtime; Table 2). That is, students with high initial levels of night-time mobile phone use tended to have higher initial levels of poor sleep behavior; as students' growth in night-time mobile phone use increased from grade 8 to grade 10, so too did their poor sleep behavior.

Night-time mobile phone use and wellbeing. Next, the direct effects between night-time mobile phone use and wellbeing variables were determined (Table 2). Initial levels of night-time mobile phone use were significantly and positively related to initial levels of all wellbeing indicators except for poor coping ability. That is, students in Year 8 who reported higher levels of night-time mobile phone use also reported higher levels of depressed mood and externalizing and lower self-esteem one year later. The slope of problematic mobile phone use significantly and positively predicted the slopes of externalising, low self-esteem, and poor coping ability, such that students who reported a rise over time in night-time mobile phone use reported a subsequent associated rise in externalising, low self-esteem, and poor ability to cope over time. Changes in night-time mobile phone use were not significantly associated with subsequent changes in depressed mood.

Sleep behavior and wellbeing. The mediator (sleep behavior, net of bedtime) and dependent variables for wellbeing were run in separate parallel process models, with directional paths between intercepts and slopes and values also reported in Table 2. In these models, higher baseline levels of poor sleep behaviors in Year 8, were associated with poorer wellbeing in Year 9. Further, increases in poor sleep behaviors from Year 8 to Year 10 were significantly and positively associated with rises in depressed mood, externalizing, low self-esteem, and poor coping ability from Year 9 to Year 11.

Table 5-2 Direct Effect Coefficients for Respective Parallel Process Latent Growth Models

Table 2

Direct Effect Coefficients for Respective Parallel Process Latent Growth Models for Associations Between Wellbeing with Night-time Mobile Phone Use or Sleep Behavior

	B	95% CI	β
Night-time mobile use and depressed mood parallel process model			
Night-time mobile use Intercept → Depressed Mood Intercept	0.16	0.02,0.31	.17
Night-time mobile use Slope → Depressed Mood Slope	0.08 ^{ns}	-0.06,0.27	.12
Sleep behavior and depressed mood parallel process model			
Sleep behavior Intercept → Depressed Mood Intercept	1.34	1.07,1.68	.62
Sleep behavior slope → Depressed Mood Slope	1.92	0.92,8.27	.64
Night-time mobile use and externalizing behavior parallel process model			
Night-time mobile use Intercept → Externalizing behavior Intercept	0.27	0.16,0.43	.33
Night-time mobile use Slope → Externalizing behavior Slope	0.21	0.01,1.61	.16
Sleep behavior and externalizing behavior parallel process model			
Sleep behavior Intercept → Externalizing behavior Intercept	0.76	0.57,0.97	.49
Sleep behavior slope → Externalizing behavior Slope	0.50	0.24,1.46	.34
Night-time mobile use and self-esteem reversed parallel process model			
Night-time mobile use Intercept → Self-esteem reversed Intercept	0.17	0.05,0.31	.17
Night-time mobile use Slope → Self-esteem reversed Slope	0.12	0.01,0.35	.15
Sleep behavior and self-esteem reversed parallel process model			
Sleep behavior Intercept → Self-esteem reversed Intercept	1.12	0.85,1.41	.45
Sleep behavior slope → Self-esteem reversed Slope	1.07	0.63,3.05	.38
Night-time mobile use and coping reversed parallel process model			
Night-time mobile use Intercept → Coping reversed Intercept	0.13 ^{ns}	-0.03,0.28	.16
Night-time mobile use Slope → Coping reversed Slope	0.14	0.03,0.34	.20
Sleep behavior and coping reversed parallel process model			
Sleep behavior Intercept → Coping reversed Intercept	1.18	0.84,1.53	.47
Sleep behavior slope → Coping reversed Slope	1.32	0.74,5.64	.44
Night-time mobile use and sleep behavior parallel process model			
Night-time mobile use Intercept → Sleep behavior Intercept	0.13	0.09,0.17	.35
Night-time mobile use Slope → Sleep behavior Slope	0.13	0.05,0.37	.39

Note. $N=1101$. Night-time Mobile Use refers to sending or receiving text messages or phone calls after bedtime, with responses ranging from 0= No Mobile Phone, 1= Never text or phone after lights out, 2= Immediately after lights out, 3= Before midnight, 4= After midnight and, 5= At any time of the night. All variables are controlled for gender, and socioeconomic status; for models with sleep behavior bedtime was entered as a time-varying covariate for sleep behavior. CI = Confidence intervals; 95% CI = if the 95% CI interval contains 0 then estimate is non-significant at .05 level. ^{ns} = non significant.

5.4.4 Mediation Models

Finally, multiple mediation models were estimated to determine if the effect of night-time mobile phone use on the intercept and slope of each wellbeing variable (depressed mood, externalizing, self-esteem, and coping) was due to earlier levels and change in the mediator (sleep behavior, net of the effect of adolescent bedtime), while

controlling for gender and SES. The indirect and direct effects for these models along with model fit indices are presented in Table 3. All models had acceptable fit (i.e., CFI > .91; RMSEA < .07 and SRMR < .10; Hu & Bentler, 1999).

5.4.5 Indirect Effect - Intercepts

The indirect effect (IE) was significant for association between the intercept of night-time mobile phone use and intercepts of later wellbeing (depressed mood, externalizing, low self-esteem, and poor coping) through baseline levels of poor sleep (Table 3). Furthermore, the direct effects for this mediation model were non-significant except for externalizing. For externalizing, the magnitude was reduced compared to the total effect between the two constructs ($\beta = .44, p < .05$); however the direct relation between night-time mobile phone use and externalizing remained statistically significant ($\beta = .29, p < .05$). Overall, these models indicate that initial high levels of night-time mobile phone use is associated with high levels of poor sleep behavior, which in turn is associated, one year later, with higher levels of depressed mood, externalizing, low self-esteem, and poor coping ability. The proportion of mediated effect (indirect effect/total effect; MacKinnon, 2008) indicates that sleep behavior in Year 8 explained a small (externalising, 33%) to large (self-esteem, 91%) indirect effect for the relation between levels of night-time mobile phone use and subsequent levels of wellbeing (see Table 3).

5.4.6 Indirect Effects - Slopes

Change in sleep behavior mediated the effect of change in night-time mobile phone use on subsequent change in all wellbeing slopes, and the direct effects were no longer significant in the respective models (Table 3). Increasing night-time mobile phone use from years 8 to 10 lead to increases in (poor) wellbeing trajectories, and this effect was significantly mediated via growth in poor sleep behaviors (for path coefficients information contact first author). The indirect to total effect size ratio for

slopes indicated that a small (externalising, 33%) to large (depressed mood, 73%) proportion of the original relation between changes in night-time mobile phone use and changes in wellbeing was explained by the indirect effect through changes in sleep behavior net of the effect of adolescent bedtime.

Table 5-3 Model Fit and Bootstrapped Mediation Effect Estimates for Respective Parallel process latent Growth Curve Mediation Models.

Table 3

Model Fit and Bootstrapped Mediation Effect Estimates for Respective Parallel Process Latent Growth Curve Mediation Models

Dependent Variable	Model Fit			Test of Indirect Effects								Test of Direct Effects		Effect Size			
				Intercept Night-time Mobile Use → Intercept Sleep → Intercept DV				Slope Night-time Mobile Use → Slope Sleep → Slope DV				Intercept Night-time Mobile Use → Intercept DV	Slope Night-time Mobile Use → Slope DV	Indirect/Total Effects			
				95% CI				95% CI				B (95% CI)		B (95% CI)		Pathway	
				B	LL	UL	β	B	LL	UL	β					Intercept	Slope
Depressed Mood	.913	.066	.092	0.18	0.12	0.27	.24	0.29	0.10	1.75	.44	-0.05 ^{ns} (-0.19,0.06)		-0.10 ^{ns} (-1.46, 0.09)		.77 ^a	.73 ^a
Externalising	.924	.068	.099	0.09	0.05	0.13	.14	0.08	0.01	1.34	.12	0.17 (0.08, 0.27)		0.16 ^{ns} (-0.02, 1.65)		.33	.33
Self Esteem ^R	.927	.068	.097	0.15	0.09	0.22	.16	0.13	0.04	0.73	.15	-0.01 ^{ns} (-0.13, 0.10)		0.13 ^{ns} (-0.21, 0.64)		.91 ^a	.50
Coping ^R	.920	.066	.089	0.15	0.09	0.24	.18	0.16	0.06	1.07	.19	-0.03 ^{ns} (-0.18 0.11)		0.11 ^{ns} (-0.39, 0.55)		.83 ^a	.60

Note. Night-time Mobile Use refers to sending or receiving text messages or phone calls after bedtime, with responses ranging from 0= No Mobile Phone, 1= Never text or phone after lights out, 2= Immediately after lights out, 3= Before midnight, 4= After midnight and 5= At any time of the night. ^R denotes scale reversed for mediation analysis, higher scores indicate poorer outcomes. ^a denotes absolute values for direct effects used to determine absolute total effects. All variables controlled for gender, and socioeconomic status. Bedtime entered as a time-varying covariate for sleep behavior. DV = Dependent Variable. CI = Confidence intervals. Bootstraps = 5000. 95% CI = if the 95% CI interval contains 0 then estimate is non-significant at .05 level. ns = non significant.

5.5 Discussion

The present study provides important insight into one of the pathways by which night-time mobile use can lead to increases in psychosocial maladjustment and declines in wellbeing among adolescents. We hypothesized that adolescents, who increasingly used their mobile phones into the night to text, message, and phone their peers, would increasingly engage in poor sleep behavior, which in turn would predict future declines in wellbeing, specifically, declines in self-esteem and coping ability and increases in depressed mood and externalizing behaviors. Our findings indeed demonstrate that change in sleep behaviour, over and above adolescent bedtime, is one mechanism linking increased night-time mobile phone use to declines in a range of wellbeing indicators. Although there are of course many benefits to mobile technology use, these findings provide cogent evidence of adolescents' need for electronic curfews, in order to assist with healthy development during the high school years. Previously research has established links between late-night phone use and sleep (Van den Bulck, 2007) and between sleep and wellbeing (Kalak et al., 2014; Shochat et al., 2014; McGlinchey & Harvey, 2015), but this is the first study to assess all three together, mapping their developmental course and variability within-person across adolescence. Here, we delineated a key pathway, in which growth in night-time mobile phone use predicted subsequent trajectories of psychosocial maladjustment over time, via growth in poor sleep.

We first mapped developmental change in night-time mobile phone use across three years of high school, which revealed several noteworthy findings. First, few teenagers indicated that they never use their phone after lights out, as found in other studies (Oshima et al., 2012; Van den Bulk, 2007). Further, on average night-time mobile phone use increased and there were significant individual differences in both

early levels and change in use over three years. Those adolescents who reported lower levels of night-time phone use in eighth grade had steeper increases in use over time. Furthermore, on average, girls and lower SES adolescents reported higher levels of night-time use in eighth grade; thus, programs focused on healthy use of technology may be especially helpful in early adolescence for these youth. At the same time, parents and educational policy-makers should bear in mind that reminding adolescents about advantageous versus problematic use of their mobile technology and continued monitoring of adolescents' late-night use may be especially important as youth progress through high school.

We next paired developmental trajectories of night-time phone use across years 8-10 with four different lagged indicators of wellbeing, across years 9-11. These results highlighted direct links between night-time engagement with mobile phones and subsequent wellbeing during adolescence. Specifically, we found that increasing night-time mobile phone use was associated with subsequent increases in externalizing and decreases in self-esteem and coping ability. Interestingly, though, change in night-time mobile phone use was not significantly associated with change in depressed mood. Adolescents' relationships with their peers can fluctuate, as can the social makeup of their peer groups, and these changes are tied to psychosocial wellbeing (Lam et al., 2014). It may be that depressed adolescents withdraw from their peers and associated late-night mobile phone use, so that one-to-one socializing on mobile phones is less directly linked to depressive symptoms. Rather, it may be that night-time uses of other types of technology (e.g., social networking) are more closely tied to depression, with a pathway through poor sleep (Lemola et al., 2015; Vernon et al., 2016).

Our primary study aim was to examine one mechanism through which late-night mobile phone use could set off a detrimental cascade of effects, ultimately resulting in declines in adolescent health. Specifically, we hypothesized that heavy mobile phone

use becomes a problem when it overtakes essential aspects of adolescent's life – in this case, displacing sleep time and subsequently limiting ability to efficiently cope with the developmental demands of adolescent life-including tamping down behavioral impulses, up-regulating low mood, keeping a positive self-view and coping with any range of challenges or problems faced on a daily basis (Modecki, Zimmer-Gembeck, & Guerra, in press). Consistent with our prediction, we found that as night-time mobile phone use increased over time so did poor sleep behaviors. In turn, sleep behavior performed as a statistical mediator and subsequently predicted declines in wellbeing across all four indicators, (Lemola et al., 2015). Our findings also suggest that a direct, predictive role of changing night-time phone use on development of externalizing remained, beyond the (partially) mediating effects of sleep. These findings are particularly noteworthy in that they also controlled for the time-varying effects of changing adolescent bed-times. Consequently, the mediating role of change in sleep behaviors is above and beyond the propensity for adolescents to increasingly delay their bedtimes over the course of high school (Wolfson & Carskadon, 1998).

In all, study findings indicate that teachers and parents should educate teens about night-time mobile phone use and, in tandem, monitor teenagers for signs of daytime tiredness. These efforts may help to counter developmentally-normative increases in depressed mood and externalizing, and declines in self-esteem and coping ability. Teachers, school psychologists, and researchers should consider delivery of health programs to educate youth about ways to use mobile phones that not only promote positive development, but also diminish risks for problematic night-time use. For example, teenagers could consider physically removing mobile phones from the bedroom to reduce disturbance once bedtime has commenced (Van den Bulck, 2007). For parents, digital curfews may be an important first step towards development of healthy mobile phone habits. However, as adolescents become more autonomous in

their sleep routines over the high school years, interventions may need to “meet them where they sleep.” Perhaps using the mobile phone itself as a sleep diagnostic tool (using a sleep tracking app, for example) to arm young people with enough information to bolster their motivation to improve their sleep habits.

This study is particularly noteworthy in its use of longitudinal data - spanning a total of four years - to map within-person trajectories of change in night-time mobile phone use and in systematically examining a range of indicators of healthy adolescent development (externalizing, depressed mood, self-esteem, and coping). However, it is limited by its reliance on self-report measures, including single items for mobile phone use and coping. Future studies would benefit from an instrument validation study to enhance the psychometric quality of the measurement of night-time mobile phone use; this could be achieved through the use of call or text logs for phones. As well, actigraphy with sleep diaries capturing real-time sleep patterns would validate self-reports for sleep behavior and reported bedtime (Short, Gradisar, Lack, Wright, & Chatburn, 2013). Further, although LGM to examine longitudinal mediation offers advantages over “snap shot” cross-sectional studies, causal conclusions cannot be inferred (Cheong et al., 2003). Finally, future research would also benefit from assessing type of mobile phone (e.g., Smartphone) and the specific ways in which youth are engaging with these. Our own future work will examine these types of questions to better characterize risks and opportunities that are afforded by adolescents’ near-constant access to and use of mobile phones.

Although mobile phones have a role in improving adolescents’ health and psychosocial wellbeing, this study shows there are some risks associated with their heavy use, particularly when after-hours engagement displaces adolescents’ sleep. Adding to a growing body of evidence to suggest adolescents increasingly use their mobile phones around bedtime, our study shows that extensive late-night mobile phone

use can be associated with development of sleep problems and subsequent increases in psychosocial maladjustment and declines in adjustment.

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5.8 Appendix 5.1 Study-3 Mobile phones in the bedroom: Trajectories of sleep habits and subsequent adolescent psychosocial development.

Table 5-4 Appendix 1 Table 1.

Appendix 1 Table 1

Zero-Order Correlations, Means, Standard Deviations of Youth Characteristics

Variable		1	2	3	4	5	6	7	8	9	10	11	M	SD	α
1. Gender															
2. SES Higher-Lower		-.03													
3. Bedtime	(T0)	.05	-.16										.11	.13	
4. Bedtime	(T1)	.02	-.08	.49									.16	.15	
5. Bedtime	(T2)	.06	-.05	.39	.59								.21	.16	
6. Night-time Mobile Use	(T0)	-.12	-.08	.21	.20	.12							2.10	1.72	
7. Night-time Mobile Use	(T1)	-.11	-.06	.23	.29	.24							2.21	1.69	
8. Night-time Mobile Use	(T2)	-.16	-.01	.18	.27	.25							2.35	1.67	
9. Sleep Behavior	(T0)	-.03	-.03	.23	.28	.25	.23	.22	.16				2.17	0.59	.67
10. Sleep Behavior	(T1)	-.06	-.05	.19	.39	.33	.17	.27	.21				2.28	0.64	.74
11. Sleep Behavior	(T2)	-.10	-.06	.15	.29	.37	.16	.24	.26				2.33	0.65	.74
12. Depressed Mood	(T1)	-.21	-.07	.15	.23	.18	.12	.13	.16	.32	.47	.32	2.62	1.08	.75
13. Depressed Mood	(T2)	-.28	-.03	.10	.20	.18	.12	.17	.19	.27	.32	.43	2.73	1.14	.80
14. Depressed Mood	(T3)	-.20	-.04	.08	.11	.16	.10	.15	.16	.23	.33	.42	2.84	1.15	.79
15. Externalizing Behavior	(T1)	.08	-.10	.18	.37	.27	.17	.28	.24	.32	.38	.29	1.43	0.75	.81
16. Externalizing Behavior	(T2)	.10	-.06	.13	.24	.26	.16	.29	.25	.25	.28	.38	1.43	0.73	.79
17. Externalizing Behavior	(T3)	.13	-.03	.18	.20	.20	.10	.19	.21	.16	.20	.30	1.42	0.63	.78
18. Self-esteem ^R	(T1)	-.15	-.13	.17	.23	.19	.12	.16	.15	.31	.41	.32	2.82	1.13	.88
19. Self-esteem ^R	(T2)	-.21	-.08	.18	.22	.22	.12	.22	.21	.30	.35	.43	2.96	1.17	.88
20. Self-esteem ^R	(T3)	-.17	-.10	.14	.15	.19	.12	.18	.22	.23	.34	.42	3.06	1.16	.89
21. Coping ^R	(T1)	-.08	-.10	.07	.21	.16	.04	.12	.10	.26	.38	.30	2.74	1.25	
22. Coping ^R	(T2)	-.13	-.10	.16	.15	.14	.12	.16	.17	.24	.28	.38	2.73	1.21	
23. Coping ^R	(T3)	-.11	-.09	.09	.13	.12	.02	.13	.17	.20	.28	.37	2.89	1.22	

Note. Covariates: Gender Girls' (n = 629) values coded as 0 and Boys' (n = 472) values coded as 1; For Socioeconomic Status (SES) Lower SES (n = 512) values coded as 0 and Higher SES (n = 589) values coded as 1. Bedtime time-varying covariate was measured in 15 minute intervals starting 1= before 9pm; 2= 9 - 9.15pm; 3= 9.16 - 9.30pm; 4= 9.31 - 9.45pm; 5= 9.46 - 10pm; 6= 10.01 - 10.15pm....26= after 3am and transformed using Proportion of Maximum scoring (POMS; Little 2013) for range 0 - 1 whereby 0 = bedtime before 9pm and 1 = bedtime after 3am.

^R Items reverse coded, higher values indicate poorer effects; Range- Night-time Mobile Use 0 - 5 (1 item); Sleep Behavior 1 - 5; Depressed Mood 1 - 6; Externalizing Behavior 1 - 8; Self-esteem^R 1 - 6; Coping^R 1 - 6 (1 item).

Absolute values of correlations greater than $r = .06$ are significant at the .05 level.

Table 5-5 Appendix 1 Table 2.

Appendix 1 Table 2

Mobile Phone Ownership for Socioeconomic Status

SES	Percentage with Mobile Phone Access		
	Time 1	Time 2	Time 3
Low	80	83.2	85.9
High	90.6	90.9	94.1

Note: Smartphone ownership for teenagers (14-17 years) in Australia in June 2015 was 80% (Australian Communications and Media Authority, 2015).

Appendix 2 - Mobile phones in the bedroom: Trajectories of sleep habits and subsequent adolescent psychosocial development

5.8.1 Univariate Growth Models

Overall the univariate model estimates of the growth trajectories for all LGM provided good fit to the data (i.e., Comparative Fit Index [CFI] > .95; Root Mean Square Error of Approximation [RMSEA] and Standardized Root Mean Square Residual [SRMR] < .08; Hu & Bentler, 1999).

Night-time mobile phone use. A significant positive mean for the slope factor ($\mu = .13, p < .05$) indicated that overall youth reported increases in night-time mobile phone use over time. A significant variance component in both the intercept ($\psi = 1.28, p < .05$) and the slope ($\psi = .29, p < .05$) indicated that there were significant individual differences in both the initial levels and growth in adolescent night-time mobile phone use over time. A significant negative correlation between the intercept and slope factors ($r = -.31, p < .05$) indicated that there was an inverse relation between baseline levels and change over time, that is students who reported lower levels of night-time mobile phone use in Year 8 tended to report steeper increases in use over time. For the conditional univariate model boys reported less night-time mobile phone use ($\beta = -.18, p < .05$) than

girls with no differences for changes over time. Higher (versus lower) SES students reported lower levels of night-time mobile phone use in Year 8, with no SES differences for changes over time.

Sleep behavior. A significant positive mean for the slope factor ($\mu = .08, p < .05$) indicated that overall youth reported increases in night-time sleep behavior over time. A significant variance component in both the intercept ($\psi = .26, p < .05$) and the slope ($\psi = .04, p < .05$) indicated that there were significant individual differences in both the initial levels and growth in night-time sleep behavior over time. The intercept and slope were not significantly correlated.

Wellbeing. A significant positive mean for the slope factor for externalizing ($\mu = 1.40, p < .05$), low self-esteem ($\mu = 0.10, p < .05$), and poor coping ability ($\mu = .08, p < .05$) indicated that overall youth reported declining wellbeing over time. Although the mean slope factor for depressed mood was non-significant, there was a significant variance component for all intercepts and slopes (all $ps < .05$), suggesting that there were significant individual differences in both the initial levels and growth for all wellbeing factors over time.

The concurrent relations between adolescent bedtime and self-reported sleep behavior were examined by including bedtime measures as a time-varying covariate in the prediction of sleep behavior and also provided the same good fit to the data.

Conditional models (gender and SES) provided good fit to the data.

5.8.2 Sleep Habits Survey Items

The eight items from the *Sleep Behavior* measurement instrument (see page 220-221)

include:

In the last two weeks, how often have you.....

Felt satisfied with your sleep?

Never	Once	Twice	Several Times	Every day/night
<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>

Arrived late to class because you overslept?

Never	Once	Twice	Several Times	Every day/night
<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>

Fallen asleep in a morning class?

Never	Once	Twice	Several Times	Every day/night
<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>

Stayed up until at least 3am?

Never	Once	Twice	Several Times	Every day/night
<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>

Needed more than one reminder to get up in the morning?

Never	Once	Twice	Several Times	Every day/night
<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>

Had an extremely hard time falling asleep?

Never	Once	Twice	Several Times	Every day/night
<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>

Felt tired or sleepy during the day?

Never	Once	Twice	Several Times	Every day/night
<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>

Had a good night's sleep?

Never	Once	Twice	Several Times	Every day/night
<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>

Chapter 6 Discussion

As children transition into adolescence, young people experience a strong desire to develop new social relationships with their peers (Côté, 2009) therefore changes occur in the way young people engage with media. Not only are adolescents highly motivated to engage with media, but they are also old enough to join and participate in social media sites, and some scholars suggest that mobile phone ownership now represents a developmental “rite of passage” (p. 165, Blair & Fletcher, 2011). Across adolescence, young people increasingly use electronic media to connect with peers without adult supervision, and they often do so alone in their bedroom. Such peer relationships are an important aspect of development whereby social connectedness facilitates and supports large social networks (Masten & Coatsworth, 1998). Thus, social media platforms and mobile phones have rapidly become an integral part of adolescent daily lives as they facilitate interactive contact with peers any time of the day or night. Although adolescents also partake in many passive media activities as well, it is the social interactions and connectedness with peers afforded through social networking or by mobile phones that may especially challenge adolescents’ healthy adjustment, particularly if it interferes with a good night’s sleep. We hypothesized in this thesis that adolescents who invested heavily in social media would have increased sleep disruption, leading to decreased school satisfaction and increased psychopathology in the form of elevated depressed mood and problem behavior. We also hypothesized that adolescents, who increasingly used their mobile phones into the night to text, message, and phone their peers, would increasingly engage in poor sleep behavior, which in turn would predict future declines in wellbeing, specifically, declines in self-esteem and coping ability and increases in depressed mood and externalizing behaviors. The findings of this thesis clearly show that problematic technology use can

interrupt sleep and contribute to sleep problems in adolescence, with wide-spread impact on their wellbeing.

This thesis places adolescents' sleep within an integrated conceptual framework in which sleep is impacted by and also impacts a range of psychosocial, biological and contextual factors (Becker et al., 2015). Problematic technology use is one contextual factor which may uniquely contribute to the sleep difficulties experienced by adolescents (Bartel et al., 2014; Hale & Guan, 2014). As well, the degree to which adolescent peer relationships are nurtured through the use of social media and mobile phones interferes with the development of healthy sleep habits and, at least partially, as a result, can be associated with adverse health outcomes; that is psychosocial factors impacting sleep (Becker et al., 2015). This link between technology-sleep-and adolescent wellbeing is important because adolescent sleep problems have been identified as a global health issue (Becker et al., 2015; Carskadon, 2010; Zimmerman, 2008). Indeed, sufficient and good quality sleep during adolescence is required for healthy maturation and development (Dahl & Lewin, 2002). Too little, and/or poor quality sleep can have adverse consequences for cognitive ability, emotion regulation, mood, and general health (Carskadon, 2002, 2011; Shochat et al., 2014). Although risks associated with technology via poor sleep have been a topic of increased interest, for the most part, previous research has focussed on snapshots of problematic electronic media use linked to sleep problems and daytime sleepiness (Calamaro et al., 2009). Very little research has taken a developmental approach to electronic media use in relation to problematic sleep, and there has not been a wider approach to understanding the impact of this process on adolescents' functioning.

Part of the concern about adolescents' prolific uptake of electronic media has been the conflicting research findings regarding both positive and negative links to wellbeing (Bartel et al., 2015). This thesis approaches this question with an eye towards

potential risks, in which technology use can undermine sleep which can then be linked to negative outcomes. Specifically, by examining a particular technology activity, social networking, and a type of technological device, the mobile phone, this thesis sought to examine a process through which problematic use of technology might impact adolescents' functioning across a range of indicators of wellbeing. Across all three studies, excessive use of technology was indeed found to be associated with negative outcomes via poor sleep.

The first empirical study took a cross-sectional approach and found that problematic social networking was associated with poor school satisfaction via links to both poor sleep quality and increased sleep disruptions. This study collected data in 2010. The direction for the hypothesis was set up 'a priori' as there was no research at that time related to social networking and the directions for the associations with school and sleep. The second study leveraged longitudinal data over three years and examined changes in problematic social networking use over time in relation to changing sleep and changes in symptoms of psychopathology. Adolescents who increasingly overinvested in social networking reported increasing depressed mood and externalizing behavior, and part of these relations were explained via increases in sleep disruptions. Although this study was over time the reciprocal directions were also tested. The third and final study also used longitudinal data and lagged wellbeing outcomes by a year—psychopathology, coping, and self-esteem and this time explored links between night-time mobile phone use and adolescents' subsequent wellbeing, as mediated through changing sleep. Again, changes in sleep behavior were found to be an explanatory mechanism through which early changes in problematic mobile phone use lead to later increases in depressed mood and externalizing behavior and later declines in self-esteem and coping. Thus, both a technology activity and a technological device were related to poor sleep, and this process affected diverse aspects of adolescents' functioning.

Scholars who have investigated problematic media use find adolescents have a variety of “dysfunctional ways of engaging with media...and devices,..characterized (for some and not for others) as compulsive, obsessive, or unhealthy” (Felt & Robb, 2016, p. 5). This thesis explores some of the ways that adolescents engage with electronic media problematically and in so doing, filled a number of gaps in the research literature. Study-1 focused adolescents’ problematic use of social media and implications for adolescents’ experience at school, as a result of sleep disruption. Importantly, although previous reviews of problematic social networking and associated links to negative indicators of wellbeing (Kuss & Griffiths, 2011), pointed to poor academic functioning as an outcome, this link was not considered via the route of sleep problems. For example, some scholars have posited that links between social media use and poor grades may be due to poor time-management; however sleep problems have been considered as another possible explanation (Kirschner & Karpinski, 2010). Using cross-sectional data, Study-1 was one of the first studies to show that for students who overinvest in social networking, their sleep may be at risk and without good quality, uninterrupted sleep adolescents have difficulties successfully navigating school. This study examined the development of peer networks through the over investment in social media and how this overinvestment in social media associated with sleep and school experiences. This study enabled sleep and social media to be situated within Becker and colleagues (2015) framework whereby psychosocial factors have a reciprocal relationship with sleep and wellbeing.

The second study in this thesis tracked changes in problematic social networking in relation to changes in wellbeing, through changes in disrupted sleep. Given the prolific uptake of social media by adolescents over the last decade, this thesis examined social networking as a psychosocial risk factor for adolescents extending their contact with peers into the night acting to delay the timing of sleep Carskadon (2011). Recent

studies have shown that peer influence predicts poor sleep patterns via nocturnal electronic media use for adolescents (Tochigi et al., 2012) and Study-2 built on this premise, focusing on developmental change in social networking, sleep, and wellbeing over time. In previous cross-sectional research, Lemola and colleagues (2015) showed that sleep disturbance mediated the relationship between problematic nighttime use of electronic media and depressive symptoms. The longitudinal results from Study-2 were expanded beyond these previous findings and indicated that adolescents who invested heavily in social media experienced increases in sleep disruptions, which were associated with increases in symptoms of psychopathology in the form of elevated depressed mood and problem behavior involvement. By mapping the developmental course of these constructs over three years of high school, adolescents were shown to increase their investment in social networking and their sleep-disruptions over-time, on-average, and also their levels of depressed mood and problem behaviors.

These longitudinal findings build on keystone work by Fredriksen and colleagues (2004) which tracked adolescents sleep loss and associated depressive symptoms, lowered self-esteem and poorer grades. Importantly, this work was conducted prior to adolescents' prolific uptake of portable electronic media. As a result, neither this nor many other prior studies have investigated the psychosocial impact of peer relationships on adolescent sleep. For instance, early suggestions by Carskadon (2002) indicated peers had little influence on adolescent sleep patterns, stating, that "evening [students'] socializing is a factor influencing school-night bedtimes in only 10.9%" (p. 8). She did allude to television as a media activity that had a small effect on peer relations "TV watching ...may have a peer-group component" (p.8). Carskadon's finding would appear to be less true today as peers connect at any time of the day or night, so influencing sleep (Van den Bulk, 2007). In an updated approach to these foundational ideas, Study-2 took the approach that peers' psychosocial impact on

adolescents' sleep might be experienced through the problematic use of social networking.

Likewise, Study-3 also considered the recent historical context in which adolescents have embraced technology, this time turning attention to whether their nocturnal mobile phone use could be problematic for a good night's sleep. No prior research had tracked nighttime mobile phone use for adolescents, nor has research done so alongside sleep habits and associated features of wellbeing. Given that over three-quarters of teenagers own a mobile phone, which they keep in their bedrooms and often use to text actively during the night (APS, 2015; Lenhart, 2015), this study speaks to a developmental question of growing concern-how this uptake might be associated with difficulties with sleep and subsequent wellbeing and examines the reciprocal relation between contexts related to media use and sleep (Becker et al., 2015). Across all indicators of wellbeing explored, findings from Study-3 indicate that adolescents' increasing late-night use of mobile phones is linked to increases in poor sleep and subsequent declines in wellbeing. These findings again speak to the need for parents to monitor teenagers' media use in the confines of their bedrooms.

Collectively the three empirical studies of this thesis improve our understanding of how different aspects of heavy technology use are associated with adolescent sleep disruptions and diminished wellbeing. The remaining focus of this chapter is to integrate and discuss overall findings from this thesis and the resulting implications. In an effort to do so, four overarching questions are posited and addressed to highlight empirical contributions. In all, these questions were of substantial theoretical and practical importance and can guide efforts towards adolescents' healthy use of technology especially around bedtime.

6.1 Empirical Implications

6.1.1 How has technological access to social connections 24/7 impacted adolescents?

A primary psycho-social developmental task of adolescence is to achieve social connectedness with peers and developing friends, and social networks outside of family which promotes good health (Barber & Schluterman, 2008; Bukowski & Adams, 2005; Masten & Coatsworth, 1998). Before the arrival of online communication platforms and the prolific uptake of portable mobile phones, adolescents developed these important social connections through face-to-face meetings at school, in structured and unstructured leisure pursuits, or in part-time employment. With the recent uptake of technology, adolescents are now able to text and/or phone or go online to use social media in order to facilitate their social connections almost continually day or night. Social networking allows for more widespread connectedness over longer periods of time whereby friends can peruse posts and see information posted by friend networks (Andreassen et al., 2012). Using mobile phones to talk and text friends also allow adolescents to build cyber-relationships and social connectedness. Self-report data from this thesis supports previous research asserting that adolescents sometimes overinvest in social media (Woods & Scott, 2016) and use their mobile phones well into the night in order to stay connected to their peers (Van den Bulk, 2007; Tochigi et al., 2012).

For some adolescents, there can be an overinvestment in social networking as they strive to connect with peers. Using a novel measure of social networking investment, research findings from Study-1 and Study-2 showed that adolescents report using social networking as a way to make them feel good about themselves and even to feel less moody. However, some adolescents reported that technology use influenced their social relations whereby they experienced family arguments about the time they spent social networking, and where they reported that others were concerned about the time they spent social networking rather than in face-to-face social activities.

Importantly, too, such overinvestment in social networking was associated with poor sleep, low school satisfaction, and symptoms of psychopathology.

6.1.2 Does technology use affect sleep?

Overall, findings revealed that adolescents' problematic use of technology leads to poor sleep functioning. One of the major contributions of this thesis was to show that some adolescents are more engaged than others in two types of technological activities, social networking and use of mobile phone, and variation in engagement in technology is associated with variation in sleep functioning. Here, sleep functioning was differentiated into several categories to consider sleep quality, sleep disturbances and sleep behaviors, in order to further advance conceptual understandings of their relations with technology use.

Cross-sectional associations were found in Study-1 between problematic social media and disrupted sleep, and these associations held true for trajectories of problematic social networking and sleep disruptions examined in Study-2. Prior investigations linking social media use to poor sleep have been scarce and mainly have explored engagement versus no engagement in social networking rather than variability in investment in social networking. Likewise, other research has focused on broad technology constructs and less so on key aspects of technology that are especially salient for adolescents given their importance in facilitating peer relationships—social networking and mobile phone use. For example, in a meta-review of risk and protective factors for adolescent sleep, Bartel and colleagues (2015) indicated that internet use, computer use, phone use, and video gaming were related to later bedtimes. However, none of the studies reviewed considered social networking as an activity related to sleep functioning, *per se*. The studies in this thesis refine this broad approach to adolescents' technology use with the use of more specific measures that are highly germane to peer-

connections, social networking (Study-1 and 2) and mobile phone use (into the night, Study-3) as they relate to sleep functioning.

One significant contribution of this thesis was in the exploration of adolescent investment in social media as a standalone activity rather than collectively lumped together with the Internet or other computer uses. Indeed, more recent studies examining adolescent social networking found the more time spent online with social media, the greater the sleep difficulties, pointing to the need for further exploration of this arena (Arora et al., 2014; Espinoz, & Juvonen, 2011; Lemola et al. 2015). Further, too, part of this thesis also involved design and use of a novel measure of investment in social networking, which helped to tap the salience of the activity rather than frequency of use. This distinction is important because frequency alone would not capture the importance of social networking as it was conceptualized in terms of facilitating peer relationships. Here, social media was considered to be especially likely to disrupt adolescent sleep, because it provides immediate connectivity to peers, tends to be emotionally salient, and its interactive nature further enhances engagement. This conceptualization of social networking lead to the measurement of problematic use through questions related to mood regulation and the tendency to use social networking as a way to feel good. This emotional salience and, likewise, feelings of envy or anxiety that can be elicited by being highly invested in social networking can interfere with a good night's sleep as shown in Study-1 and this relation holds over time as found in Study-2. Because previous research has not focused on these unique features of social networking, nor did they assess how these features related to adolescents' sleep, these represent findings unique to this thesis.

A second significant contribution of this thesis was tracking late-night mobile phone use over time, and linking this to changes in problematic sleep. Recent research investigating mobile phone use into the night has found associations with later bedtimes

(Gradisar et al., 2011; Pieters et al., 2014), reduced sleep duration (Arora et al., 2013, 2014; Munezawa et al., 2011; Oshima et al., 2012; Punamäki et al., 2007) and longer sleep latencies (Arora et al., 2014; Pieters et al., 2014). Taken together, these studies offer some evidence that mobile phone use into the night is related to disturbed sleep. However published studies to date have not tracked changes in mobile phone use over time and related trajectories of sleep difficulties. Study-3 in this thesis focused on the mobile phone habits of adolescents over three years asking at what time of night adolescents sent or received messages or phone calls and tapping sleep behaviors in parallel. Results indicated that problematic mobile phone use increased over the three years, and those who started with lower levels of problematic use reported steeper increases in problematic use over time. Importantly, adolescents who increasingly used their mobile phones at night to text/message/phone also reported increased sleep difficulties. Because mobile phones are used by adolescents as their own private portable device, they are able to send and receive messages well into the night, independent of parental influence. Mobile phones are designed as portable devices for individual ownership; they allow adolescents to move to an area of privacy, usually their bedroom, where social interactions with their peers can be carried on into the night. This thesis showed that late-night mobile phone use can have important implications for adolescents' wellbeing because of its association with poor sleep habits. Within the integrated conceptual framework of Carskadon (2011) and Becker and colleagues (2015) sleep is at the core, influencing healthy functioning and being influenced by the context of mobile phone use at night.

6.1.3 Does poor sleep affect psychological wellbeing and school experience?

One of the aims of this thesis was to determine the effects of sleep on adolescents' wellbeing, including their school experience. The latest research suggests

between 8-10 hours of sleep per night is required (Hirshkowitz et al., 2015) for healthy development and success at school. The research presented in this thesis indicated that the duration of sleep for adolescent participants averaged around 9 hours in their first year of participation (age 13.5 years-old). However, sleep duration decreased by just over half an hour over three years, and adolescents averaged around 8 and a half hours of sleep a night by grade 10. These figures are roughly comparable with another Australian study whereby weekday duration of sleep for 15-year-olds was 8 hours and 17 minutes (Short et al., 2013). Thus by the end of the three years in which youth were tracked, participants were at the lower end of the recommended sleep requirement for healthy development. Indeed one of the strengths of our findings from the third study was to demonstrate that change in sleep behaviour, over and above adolescent bedtime, is one mechanism linking increased night-time mobile phone use to declines in a range of wellbeing indicators. Importantly too there was also considerable variability in sleep duration, with some adolescents at the higher end of sleep duration and others at considerable risk for inadequate sleep.

In addition to concerns about sleep duration, there are also worries about disturbed sleep, because adolescents often position their technology devices in their bedrooms, next to their beds, leading to disturbed sleep through the night as messages are received and replied to (APS, 2015). To capture this behavioral sleep habit of disrupting sleep through technology use in the bedroom, this research used questions from Carskadon's Sleep Habits Survey (Wolfson & Carskadon, 1998). Study-1 introduced the sleep habits scale, and this demonstrated adequate reliability in our sample of Australian adolescents. The survey's underlying factors of sleep quality and sleep disruptions were considered especially important as they tapped risks for poor daily functioning and school performance. Previous research indicated that consistently poor sleep associates with increased risk for poor school performance (Carskadon,

2002; Curcio, Ferrara, De Gennaro, 2006; Hysing, Harvey, Linton, Askeland, Sivertsen, 2016; Short et al., 2013). Study-1 built on this previous research to show that if adolescents' sleep habits included staying up until at least 3 a.m., arriving late because of oversleeping, and feeling unsatisfied with their sleep, then their daily functioning was compromised and their satisfaction with school diminished. These sleep difficulties negatively impacted school satisfaction, and this relation was predicted by adolescents' heavy investment in social networking such that this social activity became problematic and interfered with a good night's sleep.

Later bedtimes and disrupted sleep not only linked to decreased school satisfaction, but also increased risk for lowered psychological wellbeing-including higher depressed mood and externalizing and lower self-esteem, and coping (Becker et al., 2015; Curcio et al., 2006; Hysing et al., 2016; McGlinchey & Harvey, 2015; Shochat et al., 2014). Previous research shows that disturbed sleep over time is associated with increased depressed mood and externalizing and decreased self-esteem (Fredriksen et al., 2004; Lin & Yi, 2015). This thesis shows that developmental trajectories of sleep disruption likewise were associated with poor psychological adjustment, including increases in depressed mood as students reported feeling sad, unhappy and depressed and having little to look forward to. Previous research has also reported links between poor sleep habits and externalizing behaviors (Dahl & Lewin, 2002), a finding further expanded here using trajectories in which change in disturbed sleep was associated with a change in problem behaviors such as damaging public property, and physically fighting with others. Likewise, Fredriksen and colleagues (2004), reported longitudinal findings that poor sleep trajectories associated with declines in self-esteem (and also increases depressive symptoms). Findings in this thesis also revealed that poor sleep habits over time were associated with declines in self-esteem. Further, too, poor sleep habits over time were also linked to changes in

adolescents' ability to cope and regulate their reactions to stressors. In all, poor sleep habits are an important mechanism which needs to be considered when explaining the link between technology stressors in adolescent lives and the development of psychopathology particularly depressed mood, externalizing problems, self-esteem, and coping.

6.1.4 Does engagement in technology matter in the long term?

Integrative conceptual models of adolescent developmental psychopathology include explanatory mechanisms (e.g. mediators), to explain the relation between stressors and psychopathology and wellbeing (Masten, 2005). Healthy or problematic use of technology and psychological development are not static processes and are best examined over time by tracking trajectories of development and change to determine longer-term effects (Garber, Keiley, & Martin, 2002). A final aim of this thesis was to ascertain whether adolescent technology use impacted adolescent wellbeing over the long term, with sleep functioning examined as an explanatory mechanism. A substantial body of work has examined the impact of technology on sleep, mainly in association with broad categories of technology activities and devices. Few studies have focused specifically on social networking activities or mobile phones, even though engagement in these types of technology may have some of the more acute effects on adolescent sleep (for review see Hale & Guan, 2015). Other scholars have linked sleep problems to symptoms of psychopathology and lowered self-esteem (Fredriksen et al., 2004). Still, other research has examined technology use and its associations with wellbeing. However, no studies to date have evaluated relations between technology, sleep, and wellbeing together, no has research tracked their trajectories simultaneously over time to assess parallel developmental change in these constructs.

This thesis was grounded within an integrated conceptual framework posited initially by Carskadon (p. 644, 2011), and extended by Becker et al. (p. 241, 2015), in which sleep is at the core, and both influences and is influenced by a range of psychosocial and contextual factors. Within this framework, in which technology and mobile phone use is a context rich in psychosocial enticements, sleep functions as a mediating process, leading to decreases in wellbeing. Thus change in sleep behavior is one mechanism that links problematic technology use, specifically social networking and mobile phone use, to declines in a range of wellbeing indicators.

First, a psychosocial factor that likely contributes to the sleep problems of adolescents who engage with technology is related to peer relationships which can be facilitated through social networking. This problematic use of social networking can influence sleep and interfere with the developmental of good habits needed to regulate processes associated with sleep physiology. During adolescence, young people increasingly make choices to interact online with their peers and these interactions often occur from the privacy of their bedroom, where adolescents can remain in ‘perpetual contact’ with their peers (p. Title, Katz & Aakhus, 2002). Likewise, as adolescents become increasingly independent, they also make autonomous decisions about their bedtime routine and sleep hygiene, and these are influenced by their social networking. Study-2 revealed that problematic social networking increased over time, in parallel with increased sleep disruptions, which in turn was associated with increasing internalizing and externalizing symptoms.

Second, adolescent mobile phone use is a contextual factor especially relevant to adolescents’ sleep. Mobile phone use was also examined over time in relation to changing sleep over three years. Mobile phones are used as a means to sustain communication with peers and are often kept in the bedroom and available to receive and send messages as well as to access social media. Adolescents now use their mobile

phones frequently to maintain their social connections, particularly through social networking applications, and they report feeling worried and uncomfortable if they cannot access social media (APS, 2015; Salehan & Negahban, 2013). Over half of Australian adolescents report connecting to social media in the 15 minutes before bed, every night (APS, 2015). As a result, late-night mobile phone use pose a risk for adolescents in the form of disrupted sleep. The primary question addressed in Study-3 was whether the growth of late-night mobile phone use during adolescence was related to the changes in adolescents' sleep behaviors and whether this, in turn, leads to changes in wellbeing; in particular increases in depressive symptoms, or problem behaviors and declines in self-esteem and coping. Results supported previous findings that texting into the night is problematic for a good nights sleep (Gupta et al., 2015; Van den Bulk, 2007), and extended this to changing mobile phone use and sleep, and how these affected changing adolescent wellbeing. Adolescents with increasingly problematic phone use also had increasingly poor sleep behaviors and these behaviors mediated links to subsequent declines in all four indicators of wellbeing. Findings also pointed to a direct, predictive role of late-night mobile phone use on adolescent problem behavior which remained beyond the effect of poor sleep behaviors. Thus, this research on adolescent trajectories of nighttime mobile phone use contributes to the contextual framework of Becker and colleagues' (2015) model and helps to identify what mechanisms exert an influence in the development of sleep problems and associated adverse outcomes.

6.2 Community Implications.

The findings from this thesis have broader implications for the community including for parents, teachers, school psychologists and the school system. Firstly parents and teachers need to educate adolescents about problematic technology use and assess their health in terms of daytime tiredness. Health programs with the focus on the

importance of a good night's sleep may help to counter the flow-on effects from tiredness to related declines in wellbeing including developmentally-normative increased depressed mood, increases in externalizing behaviors, decreases in self-esteem and daily ability to cope. As well teachers and school psychologists within the school system should assess students school experience in relation to their alertness in class. In particular introducing school-wide programs that promote the healthy use of technology, and reduce the use of mobile phones and social media around bedtime may be a first step to developing the healthy use of technology. Within the community of practitioners promoting healthy sleep hygiene among adolescents whereby there is an emphasis to reduce overinvestment in social media and reschedule technology related activities away from bedtime will positively impact adolescent long-term wellbeing.

6.3 Limitations

This thesis has made a number of new contributions to the literature, however, the findings should be considered in light of their limitations. Specific limitations for each of the studies are outlined separately within each of the studies in Chapters 3, 4 and 5. More broadly, though, limitations associated with this research include constraints on causal conclusions that can be drawn, sample composition, and measurement issues.

First, data from Study-1 were cross-sectional, which restricts interpretations of causality. As well, accepting the interpretations for the directions of associations in the mediational models needs careful consideration of the theoretical context for the study. That is, an alternate hypothesis is also possible, in which adolescents with negative school experiences may find difficulties sleeping and could engage in social networking as an aid to sleep. That said, the conceptual model tested for Study-1 was carefully specified in the context of the relevant literature. However, future studies need to track

these factors over time in order to gain further confidence in the hypothesized serial-mediating model.

The need to consider longitudinal models testing such potential mediating models of sleep lead to the examination of trajectories of social networking and sleep in Study-2 (and trajectories of mobile phone use in Study-3). These studies used a within-person design, tracking all three variables of interest over time, reducing the likelihood of selection effects in relation to for these findings. Latent growth curve modeling allows for examination of developmental changes in levels and also examination of processes over time, and so is well-suited to the questions of interest within this thesis (Little et al., 2009). Importantly too, yearly measurements were used so that age in years was the common index for representing the developmental process (Little et al., 2009), which is an appropriate characterization of change during adolescence. Thus, Study-2 used three years of data and Study-3 used four years (with a 1 year lag for the outcome variables of interest, 4 years in total) of longitudinal data, spanning year 8 to year 11, to investigate the impact of problematic technology use and its associated links with sleep and wellbeing. Although the reverse direction of effects is still possible in these studies, Study-2 tested the possibility of reverse causal ordering, specifically. Study-3 analyses also minimized the likelihood of an alternative direction of effects in proposed models by measuring wellbeing outcomes subsequently, one year later.

Second, participants for all three studies included in this thesis were drawn from the Youth Activity Participation Study of Western Australia (YAPS-WA). This is a large-scale longitudinal study of adolescents across Western Australia, and the large sample of adolescents surveyed over 4-time points is a considerable strength of the research. However, there were also limitations to the sample which could influence generalizability of the findings. The sample did not include adolescents from a diverse range of cultural backgrounds, which is in-line with the ethnic composition of the state

from which the same were drawn, and the majority of adolescents involved in YAPS-WA being from Caucasian backgrounds. Therefore, findings may not generalize to young people from other cultural backgrounds. For instance, Australian population data shows notable differences across adolescents from different cultural backgrounds in their rate of involvement in online activities (Australian Bureau of Statistics, 2011). Furthermore, demographic predictors (“race and ethnicity”) of media use on developmental outcomes may vary for adolescents from different cultural backgrounds (p.5, Rideout et al., 2010).

As well, self-selection bias may have played a role in the composition of the sample. Students were recruited under the Human Research Ethical Guidelines which required active parental consent. Parents from advantaged backgrounds are more likely to complete forms to participate in research, resulting in an under-representation of adolescents from economically disadvantaged backgrounds. In order to increase representation of lower SES adolescents in the study, recruitment occurred in schools stratified across SES. Specifically, socioeconomic status was measured at the school level for survey schools and obtained from the Australian Curriculum Assessment and Reporting Authority (ACARA), which computes the Index of Community Socio-Educational Advantage (ICSEA, Australian Curriculum, Assessment, and Reporting Authority (ACARA, 2015). Schools included for participation in YAPS-WA were spread across high, average, and low socio-economic index. Survey schools ranged between two standard deviations above and below the state mean on the ICSEA (Australian Curriculum, Assessment and Reporting Authority (ACARA, 2015) and SES was controlled within all the studies. However, the return rate of parental consent was often lower at schools with low SES indices and future research focused on under-represented groups including the non-ethnic majority, and lower SES youth would be especially useful.

Third, measurement of variables were self-report and more detailed, and diverse indicators of constructs of interest would further add to the understanding of processes associated with technology, sleep, and adolescent wellbeing. It was not possible to capture all aspects of overinvestment in social networking or to investigate all aspects of sleep, as the measures were collected as part of a larger survey on leisure activities. As well the data used for this thesis on social media and mobile phone use was collected from 2010 to 2014 and there have been fundamental shifts over time in the way social media is accessed and used by adolescents (Lenhart, 2015). Therefore the self-report data may have changed over time as adolescents use more up-to-date technology, for example snapchat use increased compared to facebook use over this time (Lenhart et al., 2015).

Sleep, in particular, is a multidimensional construct, consisting of domains such as sleep quantity, quality, disruptions, behavior, daytime sleepiness, onset delay and chronotype (See Appendix 8, page 223 for items). This thesis focuses primarily on sleep quality, sleep disruptions, and behaviors because the overinvestment in social networking was thought to be salient in disrupting sleep and affecting sleep quality; as well late-night mobile phone use would affect sleep behaviors. Indeed, shared variance from all self-report constructs could have inflated some of the associations reported here. Due to this specific focus, the results of this thesis cannot be considered applicable to all aspects of sleep functioning, and further research requires a triangulation of sleep self-report measures with actigraphy and sleep diaries to capture real-time sleep behaviors (Short et al., 2013). That said, one of the major strengths of the study is the selection of specific sleep terms in each study to closely match theory in relation to identified technology disruption.

Likewise, this research was also limited by the use of subscales for indicators of well-being. In particular, in Study-3 the coping variable was measured with one item. It

would be useful to include other items to create a scale and ascertain reliability and validity properties for coping in order to better understand how technology use and sleep affect adolescents' ability to cope with stress.

6.4 Future Research

This thesis has provided an extensive investigation of the relation between problematic adolescent use of technology and associated links to sleep functioning and wellbeing. Though each study makes a unique contribution to the empirical literature, each of the studies also serves to generate further questions which require additional investigation. For example, ideally, Study-1 and Study-2 would benefit from future research that investigated whether adolescent involvement in social networking occurs predominantly at night and if so, does this result in physiological arousal which would increase onset delay for sleep. Furthermore, as alluded to above, future research should include a more diverse ethnic population with the balanced inclusion of adolescents from disadvantaged backgrounds. Understanding the role of ethnicity and socio-economic disadvantage in relation to “the digital divide” represents an area of considerable importance for theory and research, and also for policy. For example, there is minimal research that has investigated the impact of technology use on Australian Aboriginal adolescents. Australian Aboriginals comprise a marginalized population with fewer opportunities to digital access (Snyder, 2010) and who have considerable health risks relative to Caucasian individuals (ABS, 2006) therefore identifying factors that may impact on sleep functioning and overall functioning for this population of young people is an important next step.

A strength of this thesis is that the research investigates the mechanisms responsible for the link between problematic technology use and wellbeing. This thesis has begun to address the gap in the knowledge using Becker's et al. (2015) integrated model examining how developmental changes in sleep functioning that occur in

association with changes in problematic technology use underlie links to changes in wellbeing. However, further research is required to understand this processes fully.

6.5 Conclusion

The primary aim of this thesis was to investigate how adolescents' engagement with technology--specifically social networking as a technological activity and mobile phone use as a technological device--was associated with sleep functioning and in turn wellbeing. Consistent with Carskadon's (2011) and Becker's et al. (2015) integrated biopsychosocial and contextual framework, findings highlight the importance of changes in sleep functioning for adolescents as their technological contexts, in particular, social networking activity and mobile phone use, change. Given the rich psychosocial environments afforded by these activities and as they are used to enhance social connectedness, it is not surprising that they impact on adolescents' healthy sleep habits. Study findings provided strong evidence that healthy sleep habits can be compromised in this regard leading to lower school satisfaction and declines in wellbeing.

In sum, the current thesis fills important gaps in the research literature and, across three studies, explores problematic use of technology for adolescents who have embraced a digital lifestyle and how this impacts their sleep. The impact of poor sleep on adolescents' functioning is made clear; poor and disrupted sleep associated with technology use links with poorer academic, psychosocial, and mental health functioning. Sound sleep hygiene requires healthy routines before bedtime, where adolescents are responsive to improve sleep quality and sleep duration. Adolescents need to be responsible for their sleep routine, including going to bed at an appropriate time, avoiding caffeine and alcohol, and having an environment that is conducive to quality sleep which is quiet, dark and, as the current thesis highlights, free from electronic devices which can disrupt sleep.

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Chapter 8 Appendices

Appendix A Survey – YAPS WA

8.1.1 Wave 4 Survey

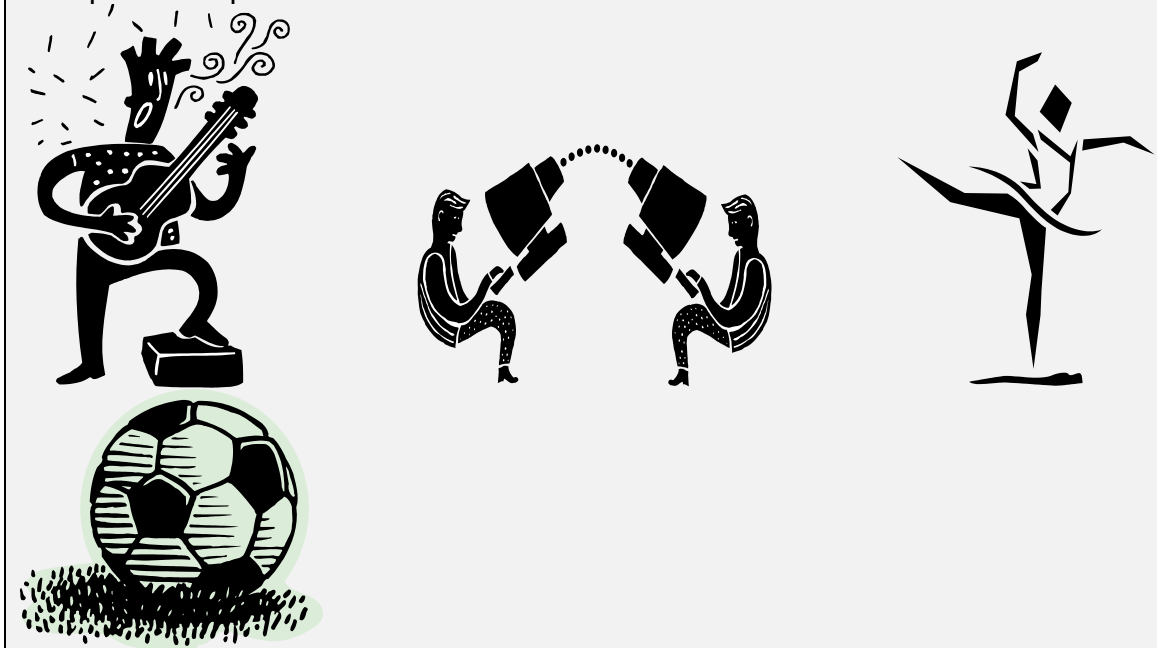
Wave 4

Youth Activity Participation Survey

Western Australia

2010

Thank you for choosing to participate in this survey. As the survey is completely confidential please try and answer all the questions as openly and honestly as you can. If you do not feel comfortable answering any of the questions please feel free to leave them blank.



Reference - YAPS

ID Number  _____

Date of Birth (dd/mm/yy) ✍️ _____/_____/_____

What year are you in at school? Year 8 Year 9 Year 10 Year 11
Year 12

What is your gender? Male Female

What suburb/town do you live in? ✍️ _____ **Post Code:**

✍️ _____

(If you Board at school, Please write your **family home** suburb/town)

Youth Activity Participation Survey – Western Australia

Section A - Sports Participation

Reference - YAPS

Q1) Have you participated in any **organised school sports/teams** outside of physical education classes in this school year? *(Please circle all the sports you do and indicate how many hours per week you participate in each of the sports you have selected).*

If you participate in Dance, you will find under performing arts activities on non-sports page (Page 9 and 10).

If you don't participate in any school-based sports please go onto the next page.

Example:

Activity	Approx hrs/week
Hockey	3 hrs per week

School-Based Sports (not Phys Ed)

Activity	Approx hrs/wk	Activity	Approx hrs/wk
<u>SPORTS</u>			
Athletics		Rugby	
Basketball		Soccer	
Cricket		Softball	
Cross Country		Swimming/Diving	

Cycling		Tennis	
Football (AFL)		Touch Rugby	
Hockey		Volleyball	
Netball		Water Polo	
Country Week (please specify sport) ✍ _____ _____		Other (please specify) ✍ _____ _____	

Reference - YAPS

Q2) Have you participated in any of the following **organised sports outside of school** in this school year? (*Please circle all the activities you do and indicate how many hours per week you participate in each of the activities you have selected*).




If you don't participate in any out-of-school-based sports please go onto the next page.

Example:

Activity	Approx hrs/week
Soccer	1.5 hrs per week

Out-of-School Sports

Activity	Approx hrs/wk	Activity	Approx hrs/wk
<u>SPORTS</u>			
Athletics		Horse riding/Pony club	
Baseball		Karate/Taekwondo	
Basketball		Netball	
BMX		Rugby	
Body Boarding		Soccer	
Boxing		Squash	
Cricket		Surfing	
Cycling		Swimming/Divin g	

Football (AFL)		Tennis	
Golf		Touch Rugby	
Gymnastics		Volleyball	
Hockey		Other (please specify) 	
Other (please specify) 		Other (please specify) 	

If you participate in both In-School and Out-of-School sport, answer Q3 – Q13 about the sport you spend the most time in.

Reference -YAPS

Q3) Please specify which sporting activity you spend the most time in

(If you do not participate in any sporting activities please go to section B on page 9)

 _____

Q4) Is this a school-based activity? (e.g. school team)

Yes

No

Q5) How many hours per week do you spend in this activity?

 _____ Hours

Q6) How many months/years have you been participating in this activity?

 _____ Years  _____ Months

Q7) Do you participate in this activity on your own or with a group of other people around your age?

On my own

In a group

Q8) Other people in this activity are

The same sex as me

A mixture of boys and girls

Q9) Do you participate in this sport at an elite level?

No

- Yes
- National
- State
- District
- Senior

Q10) How much time do you spend interacting with an adult during this activity?

(Circle one)

None of the time	A little of the time	Half of the time	Most of the time	All of the time
1	2	3	4	5

Experiences Based on Main Sport

YES 2.0 Scales (Hansen & Larson)/Blomfield/YAPS Items

Q11) Based on your involvement in this sport please rate whether you have had the following experiences by ticking the appropriate box.

	1 Not At All	2 A Little	3 Quite A Bit	4 Yes, Definitely
Was able to experience the challenges of being a leader				
This activity got me thinking about who I am				
I felt like what I did made a difference				
Tried a new way of acting around people				

Others in this activity counted on me				
This activity has stressed me out				
When I start something in this activity I always try my best to finish it				
I put all my energy into this activity				
Tried doing new things				
Had an opportunity to be in charge of a group of peers				
I set goals for myself in this activity				
Had the chance to push myself				
Worked with other people my own age on a common goal				
This activity has been a positive turning point in				

my life				
Experienced feeling liked by others in this activity				
Had to focus my attention				
I made friends with someone new				
Had to consider possible obstacles when making plans				
Got to know people in the community				

	1 Not At All	2 A Little	3 Quite A Bit	4 Yes, Definitely
I do things in this activity I don't get to do anywhere else				
Had experiences with organising time and not procrastinating (not putting things off)				
Started thinking more about my future because of this activity				
When this activity is difficult I keep trying anyway				
Came to feel more supported by the community				
Had to find ways to achieve my goals				
I have been successful in this activity				
Felt like I didn't belong in this activity				
I regularly achieve what I aim to in this activity				
Practiced self discipline				
Learned to get along with others				
Came to feel more part of my				

community				
I felt like what I did mattered				
In this activity I saw that hard work pays off				
This activity has given me many opportunities to improve my abilities				
Learned about setting priorities				

Adult Leadership in Sport

Q12) The following questions are about the adult leader in your sport; if your sport does not involve an adult leader please go onto question 13.

The adult leader in this activity.....	1 Not At All	2 A Little	3 Quite A Bit	4 Yes, Definitely
Encourages me to always try my best				

Supports me when I am having difficulties				
Puts too much pressure on me during this activity				
Makes me feel like I can succeed in this activity				
Listens to my point of view				
Puts me down in front of others in this activity				
Creates a strong positive environment				

Q13) Please read the following statements about your sport.

(Circle one number).

Attainment Value

How important is it to you to be good at this sport?

Not at all

important

Veryimportant

2
3
4
5
6
7
1

Liking

How much do you enjoy participating in this sport?

A little

A lot

1 2 3 4 5 6 7

Self Concept of Ability

Compared to other kids your age, how good do you feel you are at this sport?

One of the
Worst

One of the
Best

1 2 3 4 5 6 7

Identity Participating in this sport gives me a strong feeling that this is who I am

Never

Always

1 2 3 4 5 6 7

Flow

During this sport I feel so involved that nothing seems to matter

Never

Always

1 2 3 4 5 6 7

Flow

I become so involved in this sport that I lose track of time

Never

Always

1 2 3 4 5 6 7

Flow I concentrate so intensely that I can't think about anything else

Never

Always

1 2 3 4 5 6 7

Peers in this Sport

Q14) What proportion of your friends participating in this sport are...

(Circle one number)

Prosocial peers

Planning to go to university?

None Half All
1 2 3 4 5

Prosocial peers

Doing very well in school?

None Half All
1 2 3 4 5

Prosocial peers

Encourage you to do your best in school?

None Half All
1 2 3 4 5

Risky peers

Regularly drink alcohol?

None Half All
1 2 3 4 5

Risky peers

Regularly use illegal drugs?

None Half All
1 2 3 4 5

Risky peers

Likely to skip class?

None Half All
1 2 3 4 5

Peers

More than one year older than you?

None Half All
1 2 3 4 5

Section B - Activity Participation

Reference - YAPS



Q15) Which of the following **activities or clubs at school** have you participated in this school year outside of school classes? (*Please circle all the activities you do and indicate how many hours per week you participate in each of the activities you have selected*).

If you don't participate in any school-based activities go to the next page.

Example:

Activity	Approx hrs/week
<div style="border: 1px solid black; border-radius: 50%; width: 40px; height: 40px; display: flex; align-items: center; justify-content: center; margin: 0 auto;"> Drama </div>	4 hrs per week

School-Based Activities & Clubs

Activity	Approx hrs/wk	Activity	Approx hrs/wk
<u>Arts and Performing Arts</u>			
Art		Youth and Health Festival	
Band or Orchestra		Modeling	
Choir		Music Lessons (please specify)	
Dance			
Drama		Other (please specify)	
Rock - Eisteddfod			

Clubs			
Chess Club		School Committee	
Service Clubs		School Council	
Computer Game Club		Debate Club/Public Speaking	
Country Week (please specify activity) ✍ _____ _____		Other (please specify) ✍ _____	

Reference - YAPS

Q16) Have you participated in any of the following **activities or clubs outside of school** in this school year? (*Please circle all the activities you do and indicate how many hours per week you participate in each of the activities you have selected*).



If you don't participate in any out-of-school activities go onto the next page.

Example:

Activity	Approx hrs/week
Cadets	2.5 hrs per week

Out-of-School Activities & Clubs

Activity	Approx hrs/wk	Activity	Approx hrs/wk
<u>Arts and Performing Arts</u>			
Community Band		Dance Club/Competitions	
Private Band		Music Lessons (Please specify) ✍	
Drama Club		Other (Please Specify) ✍	
<u>Recreational Clubs</u>			
Computer Gaming/ Networking		Other (Please specify)	

			
<u>Service Clubs</u>			
Cadets		Surf Life Saving	
Church/Youth Groups		Volunteer/Service Work	
Scouts/Girls, Boys Clubs		Other (Please Specify) 	

If you participate in both In-School and Out-of-School non-sporting activities, answer Q17 – Q26 about the non-sport you spend the most time in.

Reference - YAPS

Q17) If you have circled any non-sporting activities please tell us which one you spend the most time in.

(If you do not participate in any non-sporting activities please go to Section C on page 16)

 _____

Q18) Is this a school based-activity? (e.g. school team)

Yes

No

Q19) How many hours per week (*not including school time*) do you spend in this activity?

✍ _____ Hours

Q20) How many months/years have you been participating in this activity?

✍ _____ Years *✍* _____ Months

Q21) Do you participate in this activity on your own or with a group of other people around your age?

On my own In a group

Q22) Other people in this activity are

The same sex as me A mixture of boys and girls

Q23) Do you participate in this activity at an elite level?

No

Yes

National

State

District

Senior

Q24) How much time do you spend interacting with an adult during this activity?

(Circle one)

None of A little of

Half of

Most of

All of

the time the time the time the time the
time
1 2 3 4
_____ 5

Experiences in Activities

Scales same as Page 5

Q25) Based on your involvement in this activity please rate whether you have had the following experiences by ticking the appropriate box.

	1 Not At All	2 A Little	3 Quite A Bit	4 Yes, Definitely
Was able to experience the challenges of being a leader				
This activity got me thinking about who I am				
I felt like what I did made a difference				
Tried a new way of acting around people				
Others in this activity counted on me				
This activity has stressed me out				
When I start something in this				

activity I always try my best to finish it				
I put all my energy into this activity				
Tried doing new things				
Had an opportunity to be in charge of a group of peers				
I set goals for myself in this activity				
Had the chance to push myself				
Worked with other people my own age on a common goal				
This activity has been a positive turning point in my life				
Experienced feeling liked by others in this activity				

Had to focus my attention				
I made friends with someone new				
Had to consider possible obstacles when making plans				

	1 Not At All	2 A Little	3 Quite A Bit	4 Yes, Definitely
I do things in this activity I don't get to do anywhere else				
Had experiences with organising time and not procrastinating (not putting things off)				
Started thinking more about my future because of this activity				
When this activity is difficult I keep trying anyway				
Came to feel more supported by the community				
Had to find ways to achieve my goals				
I have been successful in this activity				
Felt like I didn't belong in this activity				
I regularly achieve what I aim to in this activity				
Practiced self discipline				
Learned to get along with others				

Came to feel more part of my community				
I felt like what I did mattered				
In this activity I saw that hard work pays off				
This activity has given me many opportunities to improve my abilities				
Learned about setting priorities				

Adult Leadership in Activities

Q26) The following questions are about the adult leader in your activity; if your activity does not involve an adult leader please go onto question 27.

The adult leader in this activity.....	1 Not At All	2 A Little	3 Quite A Bit	4 Yes, Definitely
Encourages me to always try my best				

Supports me when I am having difficulties				
Puts too much pressure on me during this activity				
Makes me feel like I can succeed in this activity				
Listens to my point of view				
Puts me down in front of others in this activity				
Creates a strong positive environment				

Scales same as page 7

Q27) Please read the following statements about your non-sporting activity and respond by circling one number.

Attainment value

How important is it to you to be good at this activity?

Not at all

Very

important

important

1 2 3 4 5 6 7

Liking How much do you enjoy participating in this activity?

A little

A lot

1 2 3 4 5 6 7

Self Concept of Ability

Compared to other kids your age, how good do you feel you are at this activity?

One of the

One of the

Worst

Best

1 2 3 4 5 6 7

Identity

Participating in this activity gives me a strong feeling that this is who I am

Never

Always

1 2 3 4 5 6 7

Flow

During this activity I feel so involved that nothing seems to matter

Never

Always

1 2 3 4 5 6 7

Flow

I become so involved in this activity that I lose track of time

Never

Always

1 2 3 4 5 6 7

Flow

I concentrate so intensely that I can't think about anything else

Never

Always

1 2 3 4 5 6 7

Peers in this Activity

Scales same as page 8 - MSALT

Q28) What proportion of your friends participating in this activity are...

Planning to go to university? (*Circle one number*)

None		Half		All
<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>

Doing very well in school?

None		Half		All
<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>

Encourage you to do your best in school?

None		Half		All
<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>

Regularly drink alcohol?

None		Half		All
<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>

Regularly use illegal drugs?

None		Half		All
<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>

Likely to skip class?

None Half All
1 2 3 4 5

More than one year older than you?

None Half All
1 2 3 4 5

Please go on to Section D on Page 17 

Section C - Your Friends

Only answer the following questions if you do not participate in any sporting or non-sporting activities and have skipped sections A & B.

If you have answered sections A & B please go onto section D on page 17

Peers

Scales same as page 8 and 15 - MSALT

Q29) What proportion of your friends are...

(Circle one number)

Planning to go to university?

None Half All
1 2 3 4 5

Doing very well in school?

None Half All
1 2 3 4 5

Encourage you to do your best in school?

None Half All
1 2 3 4 5

Regularly drink alcohol?

None Half All
 1 2 3 4 5

Regularly use illegal drugs?

None Half All
 1 2 3 4 5

Likely to skip class?

None Half All
 1 2 3 4 5

More than one year older than you?







None Half All
 1 2 3 4 5

Section D – Time Use

Reference - YAPS

Q30) If you participate in any of the following activities outside of school hours please tell us how many hours per week you spend in each activity.

How many hours per week do you spend in each of these activities?	Hours per week
Paid Work (part time/casual job, not including work from parents)	
Doing homework or studying (outside of school)	
Home chores (doing dishes, cleaning)	

Taking care of younger siblings	
Practicing or playing a musical instrument	
Watching Television	
<p>Working out or physical activity (on your own or at the gym, not as a part of an organised sports activity)</p> <p>Please Specify</p> <p> _____</p>	
<p>Computer Console Gaming (Playstation, X-Box etc)</p> <p>Which game do you play the most?</p> <p> _____</p>	
<p>Internet Gaming (online games)</p> <p>Which one do you play the most?</p> <p> _____</p>	
<p>Internet Usage – Social Networking (Facebook, webchat, MySpace)</p> <p>Which one do you use the most?</p> <p> _____</p>	
<p>Internet Usage – Other (downloading music, ebay)</p> <p>Please specify</p> <p> _____</p>	
<p>Hobbies (model making, scrapbooking etc)</p> <p>What hobbies do you do the most?</p> <p> _____</p>	

Section E - You and School

Q31) Please rate how true the following statements are for you. (Circle one number)

School Liking

How much do you like school?

Not at all

A lot

1 2 3 4 5 6 7

School Attachment

I feel like I really belong in my school

Not at all
true for me

Very true
for me

1 2 3 4 5

8.1.2 School Satisfaction

School is interesting

Not at all

Very true

true for me

for me

1

2

3

4

5

School Attachment

I feel that working hard at school is a waste of my time

Not at all
true for me

Very true
for me

1

2

3

4

5

School Satisfaction

I enjoy school activities

Not at all				Very true
true for me				for me
	2	3	4	5

School Attachment

I believe that succeeding at school is important

Not at all				Very true
true for me				for me
	2	3	4	5

School Satisfaction

I look forward to going to school

Not at all				Very true
true for me				for me
	2	3	4	5

School Attachment

I know that school can be boring but I try hard anyway because it will lead to better opportunities for me in the future

Not at all				Very true
true for me				for me
	2	3	4	5

Self Concept/Social Ability

Compared to other teenagers in your school, how popular are you?

Least				Most
Popular				Popular
1	2	3	4	5

University Aspirations

Q32) How likely is it that you will go to university after high school?

Not at all

Likely

Extremely

Likely

1 2 3 4 5 6 7

Reference

Q33) If you are in Year 12, how many paired (A&B, C&D) units are you completing this year in:

Stage 3 ✍ _____

Stage 2 ✍ _____

Stage 1 ✍ _____

Q34) Do you board (live) at your school? Yes No

Q35) How much time does it take you to travel one way from school to home?

____ Minutes

Section F – About You

Self-Concept

Q36) Please read the following statements and rate how true each statement is for you. (Circle one number)

I am very good at making friends

Not at all true for me Very true for me
1 2 3 4 5 6

If I don't understand something in class I know I am capable of learning it

Not at all true for me Very true for me
1 2 3 4 5 6

I am able to do most things very well

Not at all true for me Very true for me
1 2 3 4 5 6

If I work really hard I could be one of the best students in my school year

Not at all true for me Very true for me
1 2 3 4 5 6

I am always comfortable talking to other people my age

Not at all true for me Very true for me
1 2 3 4 5 6

A lot of things about me are good

Not at all true for me Very true for me

Q37) How often are the following statements true for you?

I like the way things are going for me.

Never Almost always
1 2 3 4 5 6

My life is going well.

Never Almost always
1 2 3 4 5 6

I would like to change many things about my life.

Never Almost always
1 2 3 4 5 6

I have a good life.

Never Almost always
1 2 3 4 5 6

I feel good about what's happening to me.

Never Almost always
1 2 3 4 5 6

Psychological Well-Being

Q38) How often do you.....

Self Esteem

Feel good about yourself? (*Circle one number*)

Never Daily
1 2 3 4 5 6

8.1.3 Depressed Mood

Lose your appetite or eat a lot when you get upset?

Never Daily
1 2 3 4 5 6

Depressed Mood

Feel that difficulties are piling up so high that you can't overcome them?

Never Daily
1 2 3 4 5 6

8.1.4 Self Esteem

Feel satisfied with who you are?

Never Daily
1 2 3 4 5 6

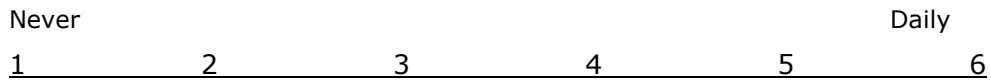
8.1.5 Coping

Feel that you are capable of coping with most of your problems?



Social Isolation

Feel lonely?



Coping

Keep a cool head in emergencies?



Self Esteem

Feel sure about yourself?



Depressed Mood

Feel unhappy, sad or depressed?



Depressed Mood

Feel there is nothing nice you can look forward to?



Section G – You Physically

Body Image

Q39) Please read the following statements and rate how true each statement is for you. (Circle one number)

Aesthetic Satisfaction

I feel really good about the way I look

Not at all true for me
1 _____ 2 _____ 3 _____ 4 _____ 5
Very true for me

Functional Satisfaction

Overall I am satisfied with my physical abilities

Not at all true for me
1 _____ 2 _____ 3 _____ 4 _____ 5
Very true for me

Functional Satisfaction

I feel really good about what I can do physically

Not at all true for me
1 _____ 2 _____ 3 _____ 4 _____ 5
Very true for me

Aesthetic Satisfaction

I am very happy with the appearance of my body

Not at all true for me
1 _____ 2 _____ 3 _____ 4 _____ 5
Very true for me

Aesthetic Satisfaction

Overall I am satisfied with my appearance

Not at all
true for me

Very true
for me

1 _____ 2 _____ 3 _____ 4 _____ 5

Functional Satisfaction

I am very happy with my performance in physical activities

Not at all
true for me

Very true
for me

1 _____ 2 _____ 3 _____ 4 _____ 5

Section H – Your Sleep

8.1.6 Sleep Habits

40) Please give the one answer that best describes the way your sleep has been in the last two school weeks. List ONE time, not a range.

Duration : School-Night / Week-End Total Sleep Time

These questions are to do with your usual schedule during the school terms.

What time do you **usually** go to bed on school days? _____

What time do you **usually** wake up on school days? _____

What time do you **usually** go to bed on weekends? _____

What time do you **usually** wake up on weekends? _____

On school days, after you go to bed at night, about how long does it **usually** take you to fall asleep?
_____minutes.

41) In the last two weeks, how often have you.....

Quality of Sleep

Felt satisfied with your sleep?

Never	Once	Twice	Several Times Every day/night
1	2	3	4 5

Sleep Delay

Arrived late to class because you overslept?

Never	Once	Twice	Several Times Every day/night
1	2	3	4 5

Sleepiness

Fallen asleep in a morning class?

Never	Once	Twice	Several Times Every day/night
1	2	3	4 5

Sleep Delay

Stayed up until at least 3am?

Never	Once	Twice	Several Times	Every day/night
1	2	3	4	5

Sleep Delay

Needed more than one reminder to get up in the morning?

Never	Once	Twice	Several Times	Every day/night
1	2	3	4	5

Sleep Delay

Had an extremely hard time falling asleep?

Never	Once	Twice	Several Times	Every day/night
1	2	3	4	5

Sleepiness

Felt tired or sleepy during the day?

Never	Once	Twice	Several Times	Every day/night
1	2	3	4	5


Quality of Sleep


Had a good night's sleep?

Never	Once	Twice	Several Times	Every day/night
1	2	3	4	5

8.1.7 Mobile Phone /Internet Use

Q42) Do you have a mobile phone?

No  skip questions below; go to **Question 43**

Yes  answer the questions below

Over the past month how often have you sent or received text messages and/or phone calls after lights out on school nights?

- Never
- Less than once per week
- 1-2 school nights per week
- 3-4 school nights per week
- Every school night

Over the past month how often have you sent or received text messages and/or phone calls after lights out on weekend nights?

- Never
- Less than once per week
- 1 night per weekend
- Both weekend nights


At what time of night do you usually send or receive messages and/or phone calls?

Please tick **all** the boxes that **apply** to you.

- Never text or phone after lights out
- Immediately after lights out
- 10pm – 11pm
- 11pm – 12am (midnight)
- 12am – 1am
- 1am – 2am
- 2am - 6am
- At any time of the night

Q43) Do you have access to the Internet in your bedroom?

No  skip next 2 questions below; go to **Question 44**

Yes  answer the questions below.

Over the past month how often have you accessed your internet after lights out on school nights?

- Never
- Less than once per week
- 1-2 school nights per week
- 3-4 school nights per week
- Every school night

Over the past month how often have you accessed the internet after lights out on weekend nights?

- Never
- Less than once per week
- 1 night per weekend
- Both weekend nights

At what time of night do you usually access the Internet in your bedroom?

Please tick **all** the boxes that **apply** to you.

- Never access the internet after lights out
- Immediately after lights out
- 10pm – 11pm
- 11pm – 12am (midnight)
- 12am – 1am
- 1am – 2am
- 2am - 6am
- At any time of the night

Please answer the following questions by ticking the applicable answer.

High Energy Caffeine Use

Reference - YAPS

44) During the last two weeks, how often did you drink high caffeine energy drinks (e.g. Red Bull, Mother)?

- Never



- Less than once per day
- Once a day
- 2 times a day
- 3 times or more a day

During the last two weeks, how often did you take caffeine tablets (e.g. Alert, No-Doz)?

- Never
- Less than once per day
- Once a day
- 2 times a day
- 3 times or more a day

Section I- Social Networking

Q45) Have you ever created your own profile online that others can see, like on a social networking site like Facebook, Myspace, or Bebo? (This does not include MSN/Yahoo chat)

- No  skip questions below; go to **Section J, Page 29**
- Yes  answer the questions on the next page.

What is the profile you use, or update most often? (Adapted Lenhart & Madden, 2007).

 _____

Answer the following questions about the profile (Facebook/Myspace/Bebo) you use the most often. Please tick the applicable answer.

Q50) Compared to other people your age with a profile, how many friends do you have? (YAPS)

- A lot less than others
- A little less than others
- About the same as others
- A bit more than others
- A lot more than others

8.1.8 Problematic Social Networking

Q51) How much do you agree/disagree with the following statements?

Facebook/Myspace/Bebo has become part of my daily routine.

Completely disagree					Completely agree
1	2	3	4	5	

I feel out of touch when I haven't logged on to Facebook/Myspace/Bebo.

Completely disagree					Completely agree
1	2	3	4	5	

I use Facebook/Myspace/Bebo as a way of making me feel good.

Completely disagree					Completely agree
1	2	3	4	5	

I get into arguments with other people about the amount of time I spend on Facebook/Myspace/Bebo.

Completely disagree					Completely agree
1	2	3	4	5	

I prefer to spend time on Facebook/Myspace/Bebo rather than attend social activities/events.

Completely				Completely
disagree				agree
1	2	3	4	5

If I can't access Facebook/Myspace/Bebo I feel moody and irritable.

Completely				Completely
disagree				agree
1	2	3	4	5

Cyberbullying

Q52) About how often in the last 6 months has a student or group of students told lies or made fun of you using the Internet(email, instant messaging, text messaging, or websites)? (Circle one answer)

N	once	2-3	4-6	7-10	11-20	21-30	31 or
one		times	times	times	times	times	more
							times

Section J – More About You

Personality

Q61) Please read each item carefully and circle the answer that best corresponds to your agreement or disagreement:

I see myself as:	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Sociable, enthusiastic	SD	D	N	A	SA
Argumentative, critical	SD	D	N	A	SA
Reliable, self-disciplined	SD	D	N	A	SA
Anxious, easily upset	SD	D	N	A	SA
Creative, open to new experiences	SD	D	N	A	SA
Quiet, reserved	SD	D	N	A	SA
Sympathetic, caring	SD	D	N	A	SA
Careless, disorganised	SD	D	N	A	SA

Calm, relaxed	SD	D	N	A	SA
Uncreative, conforming	SD	D	N	A	SA

Section K – Behaviour Choices

Q53) The following questions ask you about behaviours that may be considered risky, if you are uncomfortable answering any of the questions feel free to leave them blank.

Alcohol About how often in the **last 6 months have you drunk alcohol?**

(Circle one answer)

†

none	once	2-3 times	4-6 times	7-10 times	11-20 times	21-30 times	31 or more times
------	------	-----------	-----------	------------	-------------	-------------	------------------

Alcohol

About how often in the **last 6 months have you had more than 5 alcoholic drinks on one occasion?**

†

none	once	2-3 times	4-6 times	7-10 times	11-20 times	21-30 times	31 or more times
------	------	-----------	-----------	------------	-------------	-------------	------------------

Alcohol

About how often in the **last 6 months have you been drunk?**

†

none	once	2-3 times	4-6 times	7-10 times	11-20 times	21-30 times	31 or more times
------	------	-----------	-----------	------------	-------------	-------------	------------------

Drug Use

About how often in the **last 6 months have you used illegal drugs?**

†

none	once	2-3 times	4-6 times	7-10 times	11-20 times	21-30 times	31 or more times
------	------	--------------	--------------	---------------	----------------	----------------	------------------------

School related

About how often in the **last 6 months have you skipped school without parent permission?**

†

none	once	2-3 times	4-6 times	7-10 times	11-20 times	21-30 times	31 or more times
------	------	--------------	--------------	---------------	----------------	----------------	------------------------

8.1.9 Risky Behaviors

Dangerous About how often in the **last 6 months have you done something you knew was dangerous just for the thrill of it?**

none	once	2-3 times	4-6 times	7-10 times	11-20 times	21-30 times	31 or more times
------	------	--------------	--------------	---------------	----------------	----------------	------------------------

Miscellaneous Risky

About how often in the **last 6 months have you damaged public property?**

none	once	2-3 times	4-6 times	7-10 times	11-20 times	21-30 times	31 or more times
------	------	--------------	--------------	---------------	----------------	----------------	------------------------

Miscellaneous Risky

About how often in the **last 6 months have you had contact with police for something you did or something they thought you did?**

none	once	2-3 times	4-6 times	7-10 times	11-20 times	21-30 times	31 or more times
------	------	--------------	--------------	---------------	----------------	----------------	------------------------

Dangerous

About how often in the **last 6 months have you done some pretty risky things because you thought it was a kick?**

none	once	2-3 times	4-6 times	7-10 times	11-20 times	21-30 times	31 or more times
------	------	--------------	--------------	---------------	----------------	----------------	------------------------

Miscellaneous Risky

About how often in the **last 6 months have you gotten in a physical fight with another person?**

none	once	2-3 times	4-6 times	7-10 times	11-20 times	21-30 times	31 or more times
------	------	--------------	--------------	---------------	----------------	----------------	------------------------

Cyberbullying About how often in the **last 6 months have you told lies or made fun of some students using the Internet (email, instant messaging, text messaging, or websites)?**

none	once	2-3 times	4-6 times	7-10 times	11-20 times	21-30 times	31 or more times
------	------	--------------	--------------	---------------	----------------	----------------	------------------------

Miscellaneous Risky

About how often in the **last 6 months have you cheated on an exam, or copied someone else's homework?**

none	once	2-3 times	4-6 times	7-10 times	11-20 times	21-30 times	31 or more times
------	------	--------------	--------------	---------------	----------------	----------------	------------------------

Miscellaneous Risky

About how often in the **last 6 months have you taken something from a store without paying for it?**

none	once	2-3 times	4-6 times	7-10 times	11-20 times	21-30 times	31 or more times
------	------	--------------	--------------	---------------	----------------	----------------	------------------------

Miscellaneous Risky

About how often in the **last 6 months have you taken money from home that was not your own without asking?**

none	once	2-3 times	4-6 times	7-10 times	11-20 times	21-30 times	31 or more times
------	------	--------------	--------------	---------------	----------------	----------------	------------------------

Miscellaneous Risky

About how often in the **last 6 months have you not used your seatbelt in a car?**

none	once	2-3 times	4-6 times	7-10 times	11-20 times	21-30 times	31 or more times
------	------	--------------	--------------	---------------	----------------	----------------	------------------------

Section L - Your Background

8.1.10 Descriptives

Reference - YAPS

Q54) How much do you weigh? ✍ _____ **What is your height?** ✍ _____

Q55) How would you describe your family background? *(Tick all that apply)*

Caucasian (Anglo-Australian, European or American)

Aboriginal/Torres Strait Islander

Asian

Middle Eastern

African

Other (please specify) ✍ _____

In what country were you born? ✍ _____

If born outside Australia how old were you when you moved here?

✍ _____

In what country was your father born? ✍ _____

In what country was your mother born? ✍ _____

Q56) Are your parents?

Married and living together all the time

Divorced

Married and living together but one works away a lot of the time (fly in-fly out)

Single/ sole parent (never married)

out)

Living together in a marriage-like relationship

Widowed/widower (parent(s) passed away)

Separated

Q57) What education has your father completed?

(Please tick the highest qualification)

Did not finish High School

Finished High School

Finished University

Do not know

Q58) Does your father work for pay?

Yes

No

If your father is currently employed, what does he do in his job? ✎ _____

Q59) What education has your mother completed?

(Please tick the highest qualification)

Did not finish High School

Finished High School

Finished University

Do not know

Q60) Does your mother work for pay?

Yes

No

If your mother is currently employed, what does she do in her job? ✎ _____

😊 **End of Survey - Thank you for your participation** 😊

Appendix B Manuscript First Pages

8.1.11 Published Paper Study-1

CYBERPSYCHOLOGY, BEHAVIOR, AND SOCIAL NETWORKING
Volume 18, Number 7, 2015
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DOI: 10.1089/cyber.2015.0107

Adolescent Problematic Social Networking and School Experiences: The Mediating Effects of Sleep Disruptions and Sleep Quality

Lynette Vernon, BA, BSc,¹ Bonnie L Barber, PhD,^{2,3} and Kathryn L Modecki, PhD,¹⁻³

Abstract

An important developmental task for adolescents is to become increasingly responsible for their own health behaviors. Establishing healthy sleep routines and controlling media use before bedtime are important for adequate, quality sleep so adolescents are alert during the day and perform well at school. Despite the prevalence of adolescent social media use and the large percentage of computers and cell phones in adolescents' bedrooms, no studies to date have investigated the link between problematic adolescent investment in social networking, their sleep practices, and associated experiences at school. A sample of 1,886 students in Australia aged between 12 and 18 years of age completed self-report data on problematic social networking use, sleep disturbances, sleep quality, and school satisfaction. Structural equation modeling (SEM) substantiated the serial mediation hypothesis: for adolescents, problematic social networking use significantly increased sleep disturbances, which adversely affected perceptions of sleep quality that, in turn, lowered adolescents' appraisals of their school satisfaction. This significant pattern was largely driven by the indirect effect of sleep disturbances. These findings suggest that adolescents are vulnerable to negative consequences from social networking use. Specifically, problematic social networking is associated with poor school experiences, which result from poor sleep habits. Promoting better sleep routines by minimizing sleep disturbances from social media use could improve school experiences for adolescents with enhanced emotional engagement and improved subjective well-being.

Introduction

ADOLESCENTS SPEND A GREAT DEAL of time immersed in technology, and for some youth, this can become problematic.^{1,2} Extensive use of technology, often accessible in the bedroom, raises a number of issues concerning adolescents' reliance on social media to fulfil their emotional needs. In particular, heavy media use can alter sleeping and waking patterns,¹ and thus undermine adolescents' performance at school.² Research investigating whether such excessive use of technology by adolescents has negative implications is growing.³⁻⁷ Studies have documented young people's growing dependency on social networking,⁸ labeling it a behavioral addiction (see Kuss and Griffiths⁹ for literature review), which is strongly correlated with other dysfunctional Internet behaviors such as online gambling.⁷ Further, problematic use of social networking has been associated with negative indicators such as depression,^{10,11} low self-esteem,¹² and suppression of empathic social skill.⁴ Because computers and online media devices have been

woven into the fabric of society, it is crucial to understand whether some young people may be vulnerable to problematic social networking use and so to reduced sleep quality that is so vital for engaging in key aspects of daily life, particularly schooling.

Many parents, encouraged to develop a habitual bedtime routine for their young child, indicate "time for bed" or "lights out" by darkening their child's bedroom. Yet, this may not continue to signal for adolescents the same imperative to settle into a quality night's sleep. Rather, for some young people, social interactions with peers can occur via communication technology, 24 hours a day, 7 days a week, and can interfere with the ability to get a good night's sleep. Developmentally, adolescents require about 9 hours of sleep per night, and inadequate sleep on a regular basis can have adverse effects, including decreased motivation.^{1,13} Time in bed often now includes sending and receiving text messages, posting on or perusing social networking sites (SNS), or gaming with online "friends," all of which can keep adolescents up well into the night, steadily eroding their sleep.

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8.1.12 Published Paper Study-2

Vernon, L., Modecki, K.L., & Barber, B.L. (2017). Tracking effects of problematic social networking on adolescent psychopathology: The mediating role of sleep disruptions. *Journal of Clinical Child & Adolescent Psychology*, 46(2), 269-283. doi.org/10.1080/15374416.2016.1188702

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Tracking Effects of Problematic Social Networking on Adolescent Psychopathology: The Mediating Role of Sleep Disruptions

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Concerns are growing about adolescents' problematic social networking and possible links to depressed mood and externalizing behavior. Yet there remains little understanding of underlying processes that may account for these associations, including the mediating role of sleep disruption. This study tests this putative mediating process and examines change in problematic social networking investment and disrupted sleep, in relation to change in depressed mood and externalizing behavior. A sample of 874 students (41% male; 57.2% Caucasian; baseline *M* age = 14.4 years) from 27 high schools were surveyed. Participants' problematic social networking, sleep disruption, and psychopathology (depressed mood, externalizing behaviors) were measured annually over 3 years. Longitudinal mediation was tested using latent trajectories of problematic social networking use, sleep disruption, and psychopathology. Both problematic social networking and sleep disruption underwent positive linear growth over time. Adolescents who increasingly invested in social networking reported increased depressed mood, with around 53% of this association explained by the indirect effect of increased sleep disruptions. Further, adolescents who increasingly invested in social networking also reported increased externalizing behavior; some of this relation was explained (13%) via increased sleep disruptions. However an alternative model in which increased externalizing was associated with increased social networking, mediated by sleep disruptions, indicated a reciprocal relation of similar magnitude. It is important for parents, teachers, and psychologists to minimize the negative effects of social networking on adolescents' psychopathology. Interventions should potentially target promoting healthy sleep habits through reductions in social networking investment and rescheduling usage away from bedtime.

Recognition of the importance of quality sleep in healthy adolescent development has led to increased concerns about technology and the role it could play in disrupting bedtime behaviors (Cain & Gradisar, 2010; Carskadon, 2011; Gradisar

& Short, 2013; Sugauma et al., 2007; Van den Bulck, 2004, 2007; Zimmerman, 2008). Electronic media has become an integral part of adolescent lives, with a recent report finding that adolescents use an average of 9 hr of entertainment media per day, with slightly more than 1 hr of that time, on average, devoted to social media (Rideout, 2015). At nighttime, adolescents' engagement with electronic media can affect their sleep duration and quality, which can subsequently lead to problematic daytime functioning (Cain & Gradisar, 2010;

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Mobile phones in the bedroom: Trajectories of sleep habits and subsequent adolescent psychosocial development.

Journal:	<i>Child Development</i>
Manuscript ID	2016-254.R1
Wiley - Manuscript type:	Special Section
Keywords:	Mobile Phone, Sleep, Wellbeing
Abstract:	Mobile phones are an essential part of adolescent life, leading them to text, phone or message into the night. Longitudinal latent growth models were used to examine relations between changes in adolescent problematic mobile phone use, changes in sleep behavior and changes in wellbeing: depressed mood, externalizing behavior, self-esteem and coping, for 1101 students (43% male) from 13- to 16-years-old. Both problematic phone use and poor sleep behavior underwent positive linear growth over time. Increased mobile phone use was directly associated with increased externalizing and decreased self-esteem and coping. Changes in sleep behavior mediated the relation between early changes in problematic mobile phone use and later increases in depressed mood and externalizing behavior and later declines in self-esteem and coping.

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05-Dec-2016

Lynette Vernon
 School of Psychology and Exercise Science
 Murdoch University
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 Australia

RE: MS 2016-254.R2, "Mobile phones in the bedroom: Trajectories of sleep habits and subsequent adolescent psychosocial development"

Dear Mrs. Vernon,

We have now read the most recent version of your provisionally accepted manuscript. The previous concerns have been effectively addressed and the result is a well-crafted report that makes a significant contribution to the field. All appears to be complete with the exception of a few production details and required forms (see below). Thus, we are delighted to accept your manuscript for publication in the special section on Contemporary Mobile Technology and Child and Adolescent Development.