Juggling with media

The consequences of media multitasking for adolescent development

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JUGGLING WITH MEDIA:
THE CONSEQUENCES OF MEDIA MULTITASKING FOR ADOLESCENT DEVELOPMENT

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Drastic changes in the media landscape typically evoke concerns about its negative impact on society. These concerns mainly focus on youth, as people fear that these new technological advances hinder the healthy development of children and adolescents. Over the past decade, a new development in the media landscape has caught people's attention, namely the increasing omnipresence of media and communication devices. People nowadays use media and communication devices more than ever, which has also resulted in a dramatic rise in media multitasking. Media multitasking encompasses the concurrent use of multiple media, and the usage of media during non-media activities, for example, watching television while concurrently sending text messages or using social networking sites during face-to-face conversations (Baumgartner, Weeda, van der Heijden, & Huizinga, 2014; Jeong & Hwang, 2012).

People particularly worry about the negative consequences of media multitasking on adolescents. The belief that media multitasking hinders adolescent development has not only been stressed by the popular press (e.g., Hamilton, 2008, October 9; Holmes, 2015, November 13; Woodruff, 2015, November 3), but also by parents, educators, and researchers (Wallis, 2010). All have voiced strong concerns that media multitasking negatively affects a variety of aspects of adolescents' development, such as their ability to pay attention, their academic performance, their socioemotional functioning, and their sleep (e.g., Wallis, 2010). But what do we really know about the adverse impact of media multitasking on adolescent development?

Media multitasking is known to be particularly common among adolescents (e.g., Carrier, Cheever, Rosen, Benitez, & Chang, 2009; Voorveld & van der Goot, 2013). In 2010, adolescents spent 29% of their media time engaging in media multitasking, whereas this was 16% in 1999 (Rideout, Foehr, & Roberts, 2010). Moreover, adolescents frequently use media during non-media activities, such as while attending class or during a conversation with their friends or family members (Fulkerson et al., 2014; Lenhart, Ling, Campbell, Purcell, 2010; Rideout et al., 2010). For example, researchers found that 43% of the adolescents who take their cell phone to school reported that they send at least one text message a day while attending class (Lenhart et al., 2010). Additionally, 67% of the adolescents at least sometimes watched television during family meals (Fulkerson et al., 2014).

Not only are adolescents avid media multitaskers, the possible impact of media multitasking could be particularly problematic during this developmental period because it may hinder crucial developments that take place during adolescence (Baumgartner et al., 2014; Wallis, 2010). Adolescence is distinguished by significant developmental changes within the cognitive, emotional, and social domain (e.g., Burnett, Sebastian, Kadosh, & Blakemore, 2011; Steinberg, 2008). If media multitasking interferes with these domains of adolescent development this could also affect them later in life. For example, if adolescents do not sufficiently learn to concentrate during their academic activities due to frequent non-

academic media use during homework, this may be problematic when they are enrolled in jobs that require employees to focus on one specific activity.

Both the high prevalence of media multitasking among adolescents, and the specific developmental changes faced by adolescents explain why the current concerns on the negative influences of media multitasking focus on this particular age group. Although the common assumption is that media multitasking will disrupt adolescent development, it actually is unclear whether these concerns can be supported by empirical studies. A growing body of research is starting to examine the relationship between media multitasking and several domains of adolescent development, such as attention, academic performance, and socioemotional functioning (e.g., Bowman, Waite, & Levine, 2015; Ophir, Nass, & Wagner, 2009; Pea et al., 2012). While these existing studies contribute to our current knowledge of the associations between media multitasking and adolescent development, important questions remain unanswered. There are two main shortcomings in the current scientific literature that require particular research attention.

First, we do not know whether and for which particular developmental domains media multitasking is harmful. Studies on the associations between media multitasking and adolescent development have been largely fragmented (e.g., Kazakova, Cauberghe, Pandelaere, & de Pelsmacker, 2015). Researchers from multiple disciplines, such as psychology, education, and communication, have examined the same or overlapping relationships between media multitasking and adolescent development. However, because these researchers come from different disciplines, both the terminology and the theoretical background often differs. Due to this fragmented research field, it is difficult to really understand media multitasking effects on adolescent development. Therefore, the first aim of this dissertation is to provide an overview of studies that investigated the possible consequences of media multitasking on adolescent development by carefully reviewing the existing literature.

Second, studies on the relationship between media multitasking and adolescent development have been either cross-sectional or experimental. As cross-sectional studies have only one measurement point, these studies do not provide us with information on causal relationships (e.g., Curran & Bauer, 2011). For example, based on these studies we do not know whether media multitasking really causes attention problems. Furthermore, although experimental studies do inform us on causal relationships, these studies solely measure immediate effects and therefore do not capture actual developmental processes that take place during adolescence. Therefore, the second aim of this dissertations is to provide first insights in the causal relationships between media multitasking and adolescent development by using a longitudinal approach.

Conceptualizing Media Multitasking Among Adolescents

Adolescents engage in at least three main types of media multitasking, media-media multitasking, academic-media multitasking, and technological interferences during offline interactions (TIDOC). Media-media multitasking entails the simultaneous use of multiple media or the rapid switching between multiple media (Shih, 2013; Yang & Zhu, 2016). For example, while watching television adolescents concurrently send text messages to friends. Academic-media multitasking refers to using media during academic activities, such as while doing homework and while attending class (e.g., Calderwood, Ackerman, & Conklin, 2014). For example, adolescents may watch videos on YouTube while doing homework. TIDOC refers to the use of media and communication devices that interfere with offline interactions, such as talking with friends or having dinner with family (e.g., Fulkerson et al., 2014; Harrison & Gilmore, 2012). For example, adolescents may use social networking sites during a conversation with a friend.

Why Media Multitasking may be Detrimental to Adolescent Development

In this relatively young field of research and the ever-changing media landscape, theoretical explanations of the possible impact of media multitasking on adolescents are scarce. However, there are three main explanations in the scientific literature for the adverse impact of media multitasking on adolescent development. First, within the field of communication, researchers have argued that the time spent on media multitasking may displace the time spent on activities that are important for adolescent development, such as doing homework, having a conversation with friends, and sleep (e.g., Calamaro, Mason, & Ratcliffe, 2009; Coyne, Padilla-Walker, Fraser, Fellows, & Day, 2014; Fox, Rosen, & Crawford, 2009). For example, when adolescents repeatedly switch between a media activity, such as texting their friends, and a homework task, the time spent on the media activity may displace the time spent on the homework task at hand (e.g., Fox et al., 2009). As a result, adolescents may not spent enough time on their academic activities, which could hinder their academic achievement scores.

Second, media multitasking may disrupt the processing of information during important activities, such as doing homework or having face-to-face conversations with friends. Cognitive learning theories posit that processing multiple sources of information hinders information processing due to people's limited cognitive resources (e.g., Lang, 2000, 2006; Salvucci & Taatgen, 2008, 2010). When adolescents engage in media use during a non-media activity this limits the resources that are available for the non-media activity (e.g., Junco & Cotten, 2011). For example, with respect to media interferences during offline interactions, it is not possible to sufficiently process both the content of the offline interaction and the media content (e.g., Bowman et al., 2010; Ophir et al., 2009). Consequently, adolescents may insufficiently process the information provided by the conversation partner when engaging in media during offline conversations, which is likely to disrupt the offline interaction.

Finally, frequently engaging in media multitasking may result in a cognitive processing style of scattered attention (Baumgartner et al., 2014; Ophir et al., 2009). Adolescents who often engage in media multitasking may eventually habituate to respond to distractions in everyday situations. In particular, adolescents may show more difficulties in filtering irrelevant information and sustaining their attention on the primary activity, because they are accustomed to respond to internal (e.g., boredom) and external (e.g., sounds) cues (Ophir et al., 2009). This dissertation refers to this assumption as the scattered attention hypothesis (van der Schuur, Baumgartner, Sumter, & Valkenburg, 2015). Being able to pay attention is crucial to sufficiently process information, such as academic content (e.g., Ophir et al., 2009; Wallis, 2010). Overall, media multitasking may eventually lead to a cognitive processing style of scattered attention, which may manifest itself predominantly as attention problems in everyday life, but it may also affect other domains of adolescent development, such as academic achievement and social functioning.

A Longitudinal Approach

While the first chapter of this dissertation entails a literature review, the following three chapters are based on a three-wave longitudinal study, conducted among adolescents between 11 and 15 years old. There are two advantages of using a longitudinal design. First, compared to cross-sectional studies, longitudinal studies provide the opportunity to better understand the temporal precedence of variables (Curran & Bauer, 2011). Specifically, by using a longitudinal design we know how often adolescents engage in media multitasking over time and how changes in the frequency of engaging in media multitasking relate to changes in aspects of adolescent development over time. Thus, longitudinal data allow us to provide critical information on the associations between media multitasking and domains of adolescent development.

Second, a longitudinal design allows us to disentangle within-person processes from between-person processes (Curran & Bauer, 2011). Cross-sectional studies solely provide information on the rank order position of an individual in media multitasking and the rank order position of an individual's developmental domain, also referred to as the between-person relationship. However, from a theoretical standpoint we are actually interested in processes that occur within an adolescent rather than between adolescents (Curran & Bauer, 2011; Hamaker, Kuiper, & Grasman, 2015). For example, we assume that if a particular adolescent who engages in media multitasking more frequently will experience more difficulties in social functioning over time. Thus, disentangling within-person processes from between-person processes is imperative. By taking into account that the repeated measures in the longitudinal design are nested within individuals, researchers can examine within-person relationships (Hamaker et al., 2015).

Dissertation Outline

This dissertation aims to examine the relationship between media multitasking and

multiple domains of adolescent development, using a literature review in Chapter 1 and a three-wave longitudinal study in Chapters 2 to 4. In line with the two overarching aims of this dissertation, this dissertation encompasses four studies on the consequences of media multitasking on adolescent development. All chapters are either published, under revision, or submitted.

Chapter 1: Literature Review on Media Multitasking

The media multitasking literature is known to be highly fragmented (e.g., Kazakova et al., 2015). The first chapter of this dissertation therefore provides a detailed overview of studies that have examined the link between media multitasking and three developmental domains: cognitive control, academic performance, and socioemotional functioning. Within each of the three domains, this study starts with a short overview of the current field, followed by the theoretical background underlying each field, and finally a detailed review of previous findings. Overall, the literature review revealed that media multitasking was negatively associated with all three developmental domains. However, to move the field forward, there are important steps that need to be taken to, for example, expand theoretical explanations and understand causality. The identified research gaps and suggested directions for future research have been used as inspiration for chapters 2 to 4 of this dissertation.

Chapter 2: Media Multitasking and Academic Achievement

The literature review in the first chapter clearly showed that most attention has been paid to the impact of academic-media multitasking (i.e., media use during homework and while attending class) on academic achievement including both cross-sectional and experimental studies. However, studies that have examined the longitudinal relationships between academic-media multitasking and adolescents' academic achievement were still lacking. Chapter 2 aims to fill this gap by investigating the relationship between academic-media multitasking and subsequent academic achievement scores. In addition, based on the scattered attention hypothesis, this study investigates whether this expected longitudinal relationship was mediated by academic attention problems. The findings demonstrated that academic-media multitasking did neither directly nor indirectly predict adolescents' academic achievement scores over time. Academic-media multitasking was, however, related to more subsequent academic attention problems. These findings are important, as it suggest the impact of academic-media multitasking on adolescents' academic achievement is likely to be more nuanced than previously expected.

Chapter 3: Media Multitasking and Emotional Problems

A recent development in the media multitasking literature is the increase in studies on the possible impact of technological interferences during offline conversations (i.e., TIDOC) among college students and adults. However, our understanding on TIDOC among adolescents is limited. Moreover, researchers have argued that TIDOC may enhance

people's emotional problems (McDaniel & Coyne, 2016; Roberts & David, 2016). Recent studies have indeed shown that TIDOC was positively related to emotional problems among college students and adults (e.g., McDaniel & Coyne, 2016; Roberts & David, 2016). The aim of Chapter 3 was therefore to examine TIDOC among adolescents and its association with their emotional problems. TIDOC among adolescents was common and adolescents particularly engaged in social TIDOC, which includes text messaging and using social networking sites. Additionally, in line with the findings among college students and adults, our findings demonstrated a small cross-sectional relationship between TIDOC and adolescents' emotional problems. Meaning that adolescent who reported more TIDOC showed more emotional problems. However, there was no evidence for a longitudinal relationship between TIDOC and emotional problems. Thus, although TIDOC was common among adolescents and related to emotional problems, more frequently engaging in TIDOC did not predict emotional problems over time.

Chapter 4: Media Multitasking and Sleep-Related Problems

Although the majority of media effect studies on sleep have focused on the relationship between electronic media use and sleep-related problems, studies have indicated that media-media multitasking was adversely related to several aspects of sleep (e.g., Pea et al., 2012; Calamaro et al., 2009). Chapter 4 aims to advance our current knowledge of this relationship by investigating the reciprocal relationships between media-media multitasking and sleep-related problems. Moreover, in this chapter, we examine whether this relationship is moderated by important individual factors, particularly age and sex. The findings showed that media-media multitasking was related to more subsequent sleep-related problems among early adolescents and girls. No evidence was found for the reversed relationship between sleep-related problems and subsequent media-media multitasking. Together, these findings suggest that it is important to consider media multitasking behaviors when examining the influence of media use on adolescents' sleep, particularly among early adolescents and girls.

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CHAPTER 1

The Consequences of Media Multitasking for Youth: A Review

ABSTRACT

The increasing prevalence of media multitasking among youth has raised concerns regarding its negative effects on youths' functioning. Although the number of empirical studies on the consequences of media multitasking for youth has grown rapidly, there has been no attempt to integrate theory with the results of these studies. This review integrates available findings on the relationship between media multitasking and three domains of youths' functioning: cognitive control, academic performance, and socioemotional functioning. Three databases (PsycINFO, ERIC, and CMMC) were searched to identify relevant studies, resulting in 8448 citations. Fifty-six studies met the inclusion criteria: nine studies on cognitive control, 43 on academic performance, and four on socioemotional functioning. Overall, the findings indicate a small to moderate negative relationship between media multitasking and the three domains of youths' functioning. However, evidence regarding the causal direction of this relationship is lacking. Based on the included studies, we identify several research gaps and present five main directions for future research: examining causality, establishing more targeted theories, improving media multitasking measurements, focusing on individual and contextual differences, and including representative samples.

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With the rise of mobile media technologies, the availability of media for youth has increased dramatically. The constant availability of media has led to an increase in media multitasking (e.g., Carrier, Cheever, Rosen, Benitez, & Chang, 2009; Rideout, Foehr, & Roberts, 2010). Media multitasking is typically defined as either simultaneously engaging in two or more types of media or using media while engaging in non-media activities, such as text messaging while studying (e.g., Jeong & Hwang, 2012; Wallis, 2010). The increase in media multitasking has raised concerns regarding its potential negative consequences for youth (Wallis, 2010). To date, research on media multitasking among youth has focused on three domains of youths' functioning: (1) youths' cognitive control abilities (e.g., the ability to sustain attention and efficiently switch between tasks); (2) their academic performance (e.g., perceived academic learning and course grades); and, more recently, (3) their socioemotional functioning (e.g., depression and social anxiety). Researchers often implicitly or explicitly state that media multitasking has negative effects on these three domains of youths' functioning.

The main assumption of the existing studies is that when youth frequently engage in media multitasking, they become accustomed to constant switching between activities and eventually lose their ability to focus on a single activity (Wallis, 2006, 2010). Media multitasking may therefore result in deficits in the control processes that regulate thoughts and actions (Ophir, Nass, & Wagner, 2009), also referred to as cognitive control abilities (Miller & Cohen, 2001). Deficits in cognitive control may in turn explain why media multitasking interferes with academic performance (e.g., Ophir et al., 2009) and socioemotional functioning (e.g., Becker, Alzahabi, & Hopwood, 2013).

Despite an increasing amount of studies on the relationship between media multitasking and the three domains of youths' functioning, our understanding of the potential effects of media multitasking on youths' functioning remains limited for two reasons. First, there is no consensus on the strength or direction of the effects of media multitasking on youths' functioning. Some studies have found a negative relationship between media multitasking and youths' functioning, but others have been unable to replicate these effects. These differences in findings across studies may result from the wide diversity in the conceptualization and measurement of outcome variables. Second, studies have rarely provided a clear theoretical background for the effects of media multitasking. The mixed findings and the lack of a theoretical framework make it difficult to interpret and integrate the findings. To advance the field, it is necessary to integrate the findings within the three domains based on existing theory.

Although a quantitative meta-analysis would be the optimal integrative method to take stock of this new strand of research, the available studies in each of the three domains are still too scarce and heterogeneous to justify a quantitative meta-analysis (Petticrew & Roberts, 2008). Therefore, we opted for a qualitative review which has three aims: (1)

to provide an overview of existing theories regarding the possible consequences of media multitasking within the three domains, (2) to integrate the existing findings to understand the potential influence of media multitasking on the three domains of youths' functioning, and (3) to identify the most important research gaps to provide guidelines for future research.

The focus of this review is on adolescents and emerging adults. Adolescence covers the age span between 12 and 18 years, and emerging adulthood is defined as the phase from the late teens through the late twenties (Arnett, 2000). Media multitasking is especially prevalent among these age groups (Carrier et al., 2009; Rideout et al., 2010; Voorveld & van der Groot, 2013). Moreover, these age groups may be particularly vulnerable to the effects of media multitasking because important aspects of cognitive, academic and socioemotional skills continue to develop during this period (Arnett, 2000; Crone & Dahl, 2012; Steinberg, 2005).

Media Multitasking Definition and Prevalence

At least two types of media multitasking can be distinguished: (1) using multiple media simultaneously and (2) using media while engaging in a non-media activity (Baumgartner, Weeda, van der Heijden, & Huizinga, 2014; Jeong & Hwang, 2012; Wallis, 2010). The first type of media multitasking involves the simultaneous use of two different types of media (e.g., the simultaneous use of TV and mobile phone) or engaging in multiple activities on a single device (e.g., using a laptop for watching movies and online shopping simultaneously; Yeykelis, Cummings, & Reeves, 2014). Recent research among 702 American adolescents between 12 and 18 years revealed that about 30% of their media use involves more than one medium concurrently (Rideout et al., 2010).

The second type of media multitasking involves the use of media while engaging in non-media activities, such as completing homework and engaging in face-to-face interactions. Particularly among adolescents and emerging adults, media are often used during academic activities (Wallis, 2010). On average, 31% of adolescents between eight and 18 years (N = 2002) reported using task-related and task-unrelated media "most of the time" while studying (Rideout et al., 2010). Moreover, approximately 62% of university students surveyed (N = 1026) reported using electronic media during academic activities (Jacobsen & Forste, 2011). This second form of media multitasking is particularly interesting because of its potential negative effect on academic performance (Wallis, 2010). The present review addresses the effects of both types of media multitasking among youth: (1) using multiple media simultaneously and (2) using media while engaging in a non-media activity.

METHOD

Search Strategies

We systematically searched for peer-reviewed quantitative empirical studies that were published prior to July 2014 using an electronic automated search strategy, developed by a librarian. Three databases were searched (PsycINFO, ERIC, and CMMC). The outcomes of this automated search were compared with a literature list of several media multitasking articles on the three domains that we retrieved through a manual search prior to the automated search. This literature list was used as a control group to verify the effectiveness of the automated search terms in locating relevant literature. First, variations of the word "media" (e.g., laptop/, social network/, and text messag/) were combined with variations of the word "multitasking" (e.g., multitask/, task analysis, and task complexity) for the automated search. This search strategy appeared satisfactory for media multitasking articles on cognitive control and socioemotional functioning, but not for articles on academic performance. Therefore, we added variations of the words "academic performance" (e.g., GPA, homework/, and reading comprehension) and "youth" (e.g., adolesc/, student/, and undergrad/) combined with the variations of the word "media" to the automated search strategy to find more studies on media use during academic activities. See Appendix A for a complete overview of the final search strategy. This automated database search was supplemented by examining the reference lists of the identified articles.

Inclusion Criteria

Studies were included in this review if they (1) examined the simultaneous use of multiple media, media use while engaging in a non-media activity, or both types of media multitasking; (2) investigated at least one of the three domains of youths' functioning (cognitive control, academic performance, and socioemotional functioning); (3) focused on adolescents and/or emerging adults; and (4) were published in a peer-reviewed English-language journal. We excluded studies that examined the specific effects of listening to music during academic activities. Research on background music is a specialized field often addressing the potential benefits of listening to specific types of music (e.g., relaxation or instrumental) during academic activities. Moreover, several reviews and meta-analyses already exist on the use of music during academic activities (e.g., Kämpfe, Sedlmeier, & Renkewitz, 2011; Črnčec, Wilson, & Prior, 2006).

Search Results

Our search resulted in 8448 citations (PsycINFO N = 3024, ERIC N = 4747, and CMMC N = 677). After removing duplicates, the first, second, and third author screened the titles of the remaining 7873 articles. The first author also screened a subsample of the articles (n = 1500) that were screened by the second and third author to double-check their selection. Thereafter, the first author determined from the remaining 662 abstracts whether the inclusion criteria were met. This procedure resulted in the identification of 147 potentially

relevant articles. These articles either clearly met the inclusion criteria after inspecting the abstract, or required an additional scanning of the full text to determine whether the articles met the inclusion criteria. This procedure resulted in a selection of 56 relevant articles that met the inclusion criteria: nine studies on cognitive control, 43 on academic performance, and four on socioemotional functioning.

MEDIA MULTITASKING AND COGNITIVE CONTROL

One of the main concerns regarding media multitasking is that it may result in deficits in cognitive control (Wallis, 2010). Cognitive control refers to the ability to select and maintain thoughts and actions that represent internal goals and means to achieve these goals (Miller & Cohen, 2001). Cognitive control is a complex top-down mechanism that includes several control processes, such as focusing attention on goal-relevant information, filtering irrelevant information, switching efficiently between tasks, and retaining temporary information (e.g., Miller & Cohen, 2001; Savine & Braver, 2010). These abilities are important components of youths' cognitive functioning, including their ability to concentrate. Youth with weak cognitive control abilities have reported difficulties staying focused (Kane et al., 2007).

Theoretical Background

Two contrasting hypotheses can be distinguished with regard to the effect of media multitasking on cognitive control. The first assumption is that media multitasking negatively affects cognitive control. More specifically, constant simultaneous exposure to several media activities may lead to "breadth-biased" cognitive control (Ophir et al., 2009). This term has been used to describe a cognitive processing style characterized by scattered attention toward several sources of information. Youth who frequently use several media simultaneously may become accustomed to processing information from several sources simultaneously. These youths may have more problems filtering irrelevant information from the environment as they attend to both relevant and irrelevant information (Ophir et al., 2009). By attending to all information to which they are exposed, these youths are more easily distracted from their main activity. According to this assumption, media multitasking may negatively affect cognitive control processes in the long term. We refer to this possibility as the "scattered attention hypothesis".

In contrast to the possible negative effects of media multitasking on cognitive control, some researchers argue that frequent media multitasking could also have a positive effect on cognitive control. Frequent media multitaskers may repeatedly practice coping efficiently with multiple streams of information (e.g., Alzahabi & Becker, 2013; Ophir et al., 2009). By constantly alternating between multiple media, youth may eventually train and improve certain control processes, such as task switching and filtering irrelevant information. In this paper, we refer to this assumption as the "trained attention hypothesis".

Studies Included

In total, nine correlational studies that examined the relationship between media multitasking frequency and control processes were included (see Table 1). Eight of these studies focused on emerging adults by including university students, and one study was conducted among adolescents (Baumgartner et al., 2014).

Table 1. Correlational Studies on Media Multitasking and Performance-Based Cognitive Control

Study	Age	*N* (HMMs/LMMs)	*Control process*	Correlation	HMMs vs. LMMs[a]
			Switching		
Ophir et al. (2009)	students	262 (19/20)	Number letter	n/a	-.31/-.39
Alzahabi & Becker (2013)	students	80 (20/20)/49 (13/13)	Number letter	.25/.30	.36/.45
Baumgartner et al. (2014)	11-15	523 (51/53)	Dots-Triangles	ns	ns
Minear et al. (2013)	18-25	221 (33/36)	Number letter	n/a	ns
			Filtering		
Ophir et al. (2009)	students	262 (19/20)	Filtering,/AX-CPT/ N-back	n/a	-.31 to -.34
Lui & Wong (2012)	19-28	63 (10/9)	Pip-and-pop	-.37	n/a
Baumgartner et al. (2014)	11-15	523 (51/53)	Eriksen Flankers	-.09/-.12ns[β]	ns
Minear et al. (2013)	18-25	53 (27/26)	Attention Network	n/a	ns
			Working memory		
Ophir et al. (2009)	students	262 (19/20)	AX-CPT	n/a	ns
Baumgartner et al. (2014)	11-15	523 (51/53)	Digit Span	ns/-.09ns[β]	ns
Minear et al. (2013)	18-25	53 (27/26)	Reading span// Recognition	n/a	ns
Sanbonmatsu et al. (2013)	18-44	277 (n/a)	Operation Span	-.19	-.25
			Sustained attention		
Cain & Mitroff (2013)	students	85 (21/21)	Additional singleton	n/a	-.37
Yap & Lim (2013)	students	66 (33/33)	Visual attention	n/a	-
			Response inhibition		
Ophir et al. (2009)	students	262 (19/20)	Stop-signal	n/a	ns

Note. Age = range or mean; HMMs = heavy media multitaskers; LMMs = low media multitaskers; n/a = not available; ns = not significant; - = media multitasking is negatively related to cognitive control; + = media multitasking is positively related to cognitive control; HMMs/LMMs = comparison between HMMs and LMMs (– indicating that HMMs performed worse, + indicating that HMMs performed better than LMMs); [β] = partial correlation; [a] = calculated Pearson product-moment correlation coefficient.

Measurements

All studies used the Media Multitasking Index (MMI, Ophir et al., 2009) or an adapted version of the MMI to examine media multitasking frequency. A higher score on the MMI indicates more frequent use of media multitasking. Based on the MMI scores, researchers typically compared two extreme media multitasking groups, heavy media multitaskers (HMMs) and light media multitaskers (LMMs), using different cut-off scores (e.g., based on quartiles, percentiles, or standard deviations).

Control processes were measured using standardized performance-based tasks or self-report questionnaires. Performance-based tasks are performed on a computer within a controlled laboratory setting (Ralph, Thomson, Cheyne, & Smilek, 2014). For example, Ophir et al. (2009) used the number-letter task to measure the ability to efficiently switch between identifying numbers (even or odd) and letters (vowel or consonant). For an overview of them performance-based tasks used in these studies, see Table 1. In contrast to performance-based tasks, self-report questionnaires measure control processes in everyday life (Baumgartner et al., 2014; Ralph et al., 2014). Seven studies used only performance-based tasks, one study used only self-reports (Ralph et al., 2014), and one study included both types of measures (Baumgartner et al., 2014).

Findings of Performance-Based Tasks

The eight studies that used performance-based tasks examined five control processes: (1) task switching (i.e., the ability to efficiently switch between multiple tasks, Monsell, 2003), (2) the filtering of irrelevant informant (i.e., the ability to ignore irrelevant information from the environment and internal representations in working memory, Ophir et al., 2009), (3) working memory capacity (i.e., the ability to temporarily store and retain information, Jeneson & Squire, 2012), (4) sustained attention (i.e., the ability to focus attention on the primary task, Cain & Mitroff, 2011), and (5) response inhibition (i.e., the ability to withhold a response if necessary, Verbruggen & Logan, 2008).

Task switching. Four studies examined the relationship between media multitasking and task switching (see Table 1). One study found that heavy media multitaskers (HMMs) were less able to efficiently switch between tasks than light media multitaskers, r = -.35 and -.43 (LMMs, Ophir et al., 2009). Although this result is consistent with the scattered attention hypothesis, three recent studies could not replicate these findings. Two studies found no significant correlation and/or difference between HMMs and LMMs (Baumgartner et al., 2014; Minear, Brasher, McCurdy, Lewis, & Younggren, 2013); one study indicated that, consistent with the trained attention hypothesis, media multitasking is related to more (rather than less) efficient task switching, r_{range} = .25 to .45 (Alzahabi & Becker, 2013).

Filtering of information. The second control process, the filtering of irrelevant information, was investigated in four studies (see Table 1). Consistent with the scattered attention

hypothesis, two studies showed that HMMs were less able to filter irrelevant information from the environment compared with LMMs, r_{range} = -.32 to -.52 (Lui & Wong, 2012; Ophir et al., 2009). In addition, Lui and Wong (2012) examined the performance of HMMs and LMMs in a multisensory integration task in which supposedly irrelevant information was presented (i.e., a signal) that in fact was relevant to fulfill the main task. Similar to the previous findings, HMMs were more sensitive to this relevant tone and therefore performed better than LMMs on the multisensory integration task. This finding shows that HMMs were more sensitive to supposedly irrelevant information, which may indicate that they have more difficulties filtering out information. Two studies, however, indicated that the correlation with and/or the difference between HMMs and LMMs was insignificant (Baumgartner et al., 2014; Minear et al., 2013).

Working memory capacity. Four studies examined the third control process, namely, working memory capacity (see Table 1). One study indicated that higher levels of media multitasking were related to lower performance on working memory tasks, *r* = -.19 and -.25 (Sanbonmatsu, Strayer, Medeiros-Ward, & Watson, 2013), whereas three other studies indicated that the correlations and/or differences between HMMs and LMMs were not significant (Baumgartner et al., 2014; Minear et al., 2013; Ophir et al., 2009).

Sustained attention. Two studies examined the effects on sustained attention. Both studies found support for the scattered attention hypothesis (see Table 1). One study found that HMMs appear to be less able to selectively attend to a specific target compared with LMMs, *r* = -.36 (Cain & Mitroff, 2011). The other study showed that HMMs have a greater tendency to divide their attention than LMMs do (Yap & Lim, 2013).

Response inhibition. To date, only one study investigated the effects of media multitasking on response inhibition. This study indicated that the ability to inhibit a motor response, when examined in a stop-signal task, was similar for HMMs and LMMs (Ophir et al., 2009).

Findings of Self-Report Questionnaires

Two studies used self-report questionnaires to measure control processes in everyday life. Although these studies included different questionnaires, both studies showed that media multitasking was negatively related to a variety of control processes. Baumgartner et al. (2014) controlled for age, sex, and media use and showed that adolescents who frequently engaged in media multitasking reported more problems remaining focused (working memory), inhibiting inappropriate behavior (response inhibition), and switching between tasks (shifting) in their everyday lives (Baumgartner et al., 2014). Similarly, Ralph et al. (2014) found that media multitasking was positively related to self-reports of attentional failures and mind wandering. However, media multitasking was unrelated to attentional control (Ralph et al., 2014).

Conclusions on Media Multitasking and Cognitive Control

Despite common concerns regarding the negative effects of media multitasking on cognitive control (e.g., Wallis, 2010), the existing studies only partly support this concern. The empirical evidence for both the scattered attention and trained attention hypotheses is mixed. However, the findings are more consistent with the scattered attention hypothesis than the trained attention hypothesis. More specifically, higher levels of media multitasking were found to be negatively related to specific control processes (i.e., sustained attention) and cognitive control in everyday life when measured with self-report questionnaires. However, in contrast to expectations, media multitasking was unrelated to performance-based measures of working memory capacity, task switching, and response inhibition.

Overall, the two studies that used self-report questionnaires appear to be consistent with the scattered attention hypothesis. Both studies indicated that media multitasking is negatively related to cognitive control in everyday life. However, studies using performance-based tasks yielded evidence for either a null relationship or small to moderate negative relationship between media multitasking and cognitive control. The discrepancy between the results for these two types of measures may result from possible differences in the cognitive levels or skills that these measures assess (see Toplak, West, & Stanovich, 2013, for a discussion). Another reason may be the shared method variance between the self-report questionnaires of media multitasking and cognitive control (Baumgartner et al., 2014).

MEDIA MULTITASKING AND ACADEMIC PERFORMANCE

In most studies on the relationship between media multitasking and academic performance, academic performance refers to academic outcomes, such as grade point average (GPA), course grades, or test scores (e.g., Junco & Cotten, 2012; Wood et al., 2012). In addition to these academic outcomes, some studies have examined study-related attitudes and behaviors (e.g., study time, motivation, and the ability to focus on a study task) and perceived academic learning (i.e., students' perceived performance on academic tasks and their perceived understanding). In this review, we included studies on academic outcomes, study-related attitudes and behaviors, and perceived academic learning to examine whether media multitasking has negative consequences for youths' academic performance.

Theoretical Background

Researchers that have examined the relationship between media use during academic activities and academic performance hypothesize that media use during academic activities may lead to negative consequences for youths' academic performance. This hypothesis is based on two explanations. First, the time spent using media during academic activities may displace the time spent on academic activities (e.g., Fox, Rosen, & Crawford, 2009).

If students do not spend sufficient time on academic assignments, they may not perform to the best of their abilities. Second, several cognitive learning theories assume that using multiple streams of information decreases information processing as a result of people's limited cognitive capacity (Lang, 2000, 2006; Salvucci & Taatgen, 2008; Salvucci & Taatgen, 2010). Therefore, it has been argued that the use of media during academic activities limits the information processing capacity that is available for academic content (e.g., Junco & Cotten, 2011). Media use during academic activities thus hinders students' learning of academic content. Both the time displacement hypothesis and the limited information processing capacity hypothesis may explain why media use during academic activities interferes with academic performance.

In addition to the effects of media use during academic activities on academic performance, engaging in multiple media simultaneously may also be related to academic performance. Frequently using multiple media simultaneously may eventually result in deficits in cognitive control, as is argued by the scattered attention hypothesis (e.g., Ophir et al., 2009). These deficits in cognitive control may, for example, interfere with youths' ability to focus on an academic task (e.g., Ophir et al., 2009; Wallis, 2010). As a result, media multitasking may result in lower academic performance, mediated by deficits in cognitive control. To date, however, researchers have focused only on the effects of media use during academic activities. Therefore, we were able to examine only the relationship between media use during academic activities and academic performance.

Studies Included

In total, 43 studies examining media use during academic activities were included: 16 correlational studies (see Table 2), 25 experimental studies (see Table 3), and two descriptive studies (Braguglia, 2011; Johri, Teo, Lo, Dufour, & Schram, 2014). Thirty-seven of these studies focused on emerging adults by including university students, five studies focused on adolescents (Beentjes, Koolstra, & van der Voort, 1996; Pool, Koolstra, & van der Voort, 2003a, 2003b; Pool, van der Voort, Beentjes, & Koolstra, 2000), one study focused on pre-adolescents (Fetler, 1984), and one study focused on both adolescents and emerging adults (Rosen, Carrier, & Cheever, 2013).

Measurements

In all studies, media multitasking was measured by examining youths' media use during academic activities, either while studying or in class. Correlational studies used either questionnaires or observations to measure the frequency of media use during academic activities and largely focused on one media activity (e.g., text messaging and watching soap operas). To measure academic performance, correlational studies primarily used questionnaires. In the experimental studies, participants were exposed to media during an academic activity and subsequently their understanding of academic content and/or the time spent on the academic activity was measured.

Findings on Academic Outcomes

School grades. Eleven correlational studies examined whether media use during academic activities was associated with overall grades or test scores (see Table 2). Three studies had access to documented grades or GPA (Fetler, 1984; Junco, 2012; Junco & Cotten, 2012), whereas all other studies used self-reported grades or GPA. Three of 11 studies found no relationship (Clayson & Haley, 2013; Karpinski, Kirschner, Ozer, Mellott, & Ochwo, 20121; Wei, Wang, & Klausner, 2012), whereas eight studies found small to moderate negative relationships between the use of media while studying or in class and students' grades or GPA, r_{range} = -.03 to -.30 (Burak, 2012; Duncan, Hoekstra, & Wilcox, 2012; Fetler, 1984; Gaudreau, Miranda, & Gareau, 2014; Junco, 2012; Junco & Cotten, 2012; Ravizza, Hambrick, & Fenn, 2014; Rosen et al., 2013). Three of these eight studies found that the effect of media multitasking on academic performance was dependent on which type of media was used during academic activities. In particular, using Facebook (Junco, 2012; Junco & Cotten, 2012; Rosen et al., 2013) and engaging in text messaging (Junco, 2012; Junco & Cotten, 2012) during academic activities were related to lower GPA. This result may be explained by the highly interruptive nature of these two specific media (Rosen et al., 2013).

Course and lecture outcomes. Fourteen studies examined whether media use during class was related to course and lecture outcomes: three correlational studies on final course grades (see Table 2) and 11 experimental studies on test scores relating to the content of the lecture(s) (see Table 3). All studies found that greater media use during class was related to lower course grades, r_{range} = -.16 to -.28 (Clayson & Haley, 2013; Fried, 2008; Grace-Martin & Gay, 2001) or lower test scores, r_{range} = -.21 to -.48 (Conard & Marsh, 2014; Ellis, Daniels, & Jauregui, 2010; End, Worthman, Mathews, & Wetterau, 2010; Hembrooke & Gay, 2003; Kraushaar & Novak, 2010; Kuznekoff & Titsworth, 2013; McDonald, 2013; Rosen, Lim, Carrier, & Cheever, 2011; Sana, Weston, & Cepeda, 2013; Wei, Wang, & Fass, 2014; Wood et al., 2012). One experimental study examined which specific type of media use during class had an influence on test scores. This study showed that it was not text messaging, e-mailing, or instant messaging but the use of Facebook during class that had a negative effect on students' test scores (Wood et al., 2012).

Homework outcomes. Fourteen experimental studies focused on homework outcomes. All of these experiments investigated reading assignments, and two of them additionally investigated math assignments. To study the effect of using media while reading, three types of reading outcomes can be distinguished: recognition, recall, and reading comprehension (see Table 3). Although one of three studies found that using media while reading negatively affected recognition, r = -.29 (Srivastava, 2013), two studies found no effect (Armstrong & Chung, 2000; Fox et al., 2009). In contrast, studies that investigated recall and reading comprehension rather than recognition presented clear evidence for the negative effects

of media use while reading. Five of six studies showed that students' recall deteriorated when simultaneously using media, r_{range} = -.23 to -.46 (Armstrong, Boiarsky, & Mares, 1991; Armstrong & Chung, 2000; Pool et al., 2003a, 2003b; Srivastava, 2013); only one study found no effect of media use while reading (Fox et al., 2009).

Table 2. Correlational Studies on Media Multitasking and Academic Performance

							SRAB	
Study	Age	*N*	MT	A	Grades /GPA[a]	Course grade[a]	Focus[a]	Perceived learning[a]
Junco & Cotton (2012)	17-56	1774	MP	S	-.09[β]/-.11[β]	n/a	n/a	n/a
Junco (2012)	17-56	1774	MP	C	-.09[β]	n/a	n/a	n/a
Fetler (1984)	6th grade	10603	TV	S	-.03[β]/-.08	n/a	n/a	n/a
Gaudreau et al. (2014)	16-50	1129	MP	C	-.28[β]	n/a	n/a	n/a
Rosen et al. (2013)	12-24	263	MP	S	-.23[β]	n/a	n/a	n/a
Ravizza et al. (2014)	students	508	MM	C	-.30	n/a	n/a	n/a
Burak (2012)	18-55	774	MP	C	-	n/a	n/a	n/a
Duncan et al. (2012)	n/a	316	CP	C	-	n/a	n/a	n/a
Karpinski et al. (2012)	students	451/406	SN	S	ns[eu]/-.28[us] ns[β]	n/a	n/a	n/a
Clayson & Haley (2012)	23	298	TM	C	ns	-.16	n/a	n/a
Wei et al. (2012)	18-49	190	TM	C	ns	n/a	-.26[β]/-.62[β]	ns
Grace-Martin & Gay (2001)	students	83	LT	C	n/a	-.28	n/a	n/a
Fried (2008)	students	137	LT	C	n/a	-.18[β]	-.32	-.17/-.19
Calderwood et al. (2014)	students	58	MP	S	n/a	n/a	-.34/-.38	n/a
Junco & Cotton (2011)	18-26+	4491	IM	S	n/a	n/a	n/a	-.37
Beentjes et al. (1996)	8-10th grade	1700	TV	S	n/a	n/a	n/a	-

Note. Age = range or mean; MT = media type (MP = multiple, TV = television, CP = cell-phone, SN = social network sites, FB = Facebook, TM = text messaging, LT= laptop, IM = instant messaging); A = activity (S = while studying, C = while in class); SRAB = study-related attitudes and behavior; n/a = not available; ns = not significant; - = media use during academic activities is negatively related to this component of academic performance; [β] = partial correlation; [a] = calculated Pearson product-moment; correlation coefficient; [eu] = Europe; [us] = United States.

Table 3. Experimental Studies on Media multitasking and Academic Performance

						Homework Outcomes				SRAB
Study	Age	*N*	MT	A	LO[a]	RG[a]	RC[a]	CP[a]	Math[a]	Time[a]
Wood et al. (2012)	20	145	MP	C	-	n/a	n/a	n/a	n/a	n/a
Ellis et al. (2010)	students	62	TM	C	-.48	n/a	n/a	n/a	n/a	n/a
Rosen et al. (2011)	18-66	185	TM	C	-.21	n/a	n/a	n/a	n/a	n/a
Hembrooke & Gay (2003)	students	44	LT	C	-.30	n/a	n/a	n/a	n/a	n/a
Sana et al (2013)	students	40	LT	C	-.43	n/a	n/a	n/a	n/a	n/a
Wei et al (2014)	19-22	127	OC	C	-.47	n/a	n/a	n/a	n/a	n/a
End et al. (2010)	20	71	CP	C	-.31/-.35	n/a	n/a	n/a	n/a	n/a
McDonald (2013)	students	119	TM	C	-.22[β]/-.41	n/a	n/a	n/a	n/a	n/a
Kraushaar & Novak (2010)	students	97	LT	C	-.36 to -.48	n/a	n/a	n/a	n/a	n/a
Conard & Marsh (2014)	21	110	TV	C	-.21[β] to -.31	n/a	n/a	n/a	n/a	n/a
Kuznekoff & Titsworth (2013)	18	47	TM	C	-.42 and -.43	n/a	n/a	n/a	n/a	n/a
Srivastava (2013)	students	295	PC	S	n/a	-.29	-.29/-.46	n/a	n/a	n/a
Armstrong & Chung (2000)	20	90	TV	S	n/a	ns	-.23	n/a	n/a	n/a
Fox et al. (2009)	students	69	IM	S	n/a	ns	ns	n/a	n/a	.44
Bowman et al. (2010)	17-46	89	IM	S	n/a	n/a	n/a	ns	n/a	.26
Armstrong et al. (1991)	students	95	TV	S	n/a	n/a	-.23[β]	n/a	n/a	n/a
Furnham et al. (1994)	18-30	60	TV	S	n/a	n/a	n/a	-.51	n/a	n/a
Armstrong & Greenberg (1990)	students	84	TV	S	n/a	n/a	n/a	-.36	n/a	n/a
Jeong and Hwang (2012)	23	88	TV	S	n/a	n/a	n/a	-.43/-.51	n/a	n/a
Lee et al. (2012)	students	30	TV	S	n/a	n/a	n/a	ns	n/a	n/a
Subrahmanyam et al (2013)	18-30	120	IN	S	n/a	n/a	n/a	ns	n/a	.41/.43
Pool et al. (2000)	14	144	TV	S	n/a	n/a	n/a	-.27	-.27	ns
Pool et al. (2003b)	14	192	TV	S	n/a	n/a	-.24/-.31	-.24/-.31	n/a	.38/.40
Pool et al. (2003a)	14	160	TV	S	n/a	n/a	-.36	-.36	n/a	ns
Cool et al. (1994)	nov-13	12	TV	S	n/a	n/a	n/a	ns	ns	ns

Note. Age = range or mean; MT = media type (MP = multiple, TV = television, CP = cell-phone, TM = text messaging, LT= laptop, OC= online chatting, PC = podcast, IM = instant messaging, IN = internet) ; A = activity (S = while studying, C = while in class); LO = lecture outcomes; SRAB = study-related attitudes and behavior (Time = study time, with + indicating that students in the multitasking condition needed more time to complete the task); RG = recognition; RC = recall, CP = reading comprehension; n/a = not available; ns = not significant; - = students in the multitasking condition performed significantly worse than students in de control condition; [β] = partial correlation; [a] = calculated Pearson product-moment correlation coefficient.

In addition, six of ten studies found that media use while reading interfered with reading comprehension, r_{range} = -.24 to -.51 (Armstrong & Greenberg, 1990; Furnham, Gunter, & Peterson, 1994; Jeong & Hwang, 2012; Pool et al., 2000, 2003a, 2003b). The other four studies found no effect (Bowman, Levine, Waite, & Gendron, 2010; Cool, Yarbrough, Patton, Runde, & Keith, 1994; Lee, Lin, & Robertson, 2012; Subrahmanyam et al., 2013).

In addition to examining reading outcomes, two experimental studies examined how math performance is affected by television use while working on a math assignment (see Table 3). One study found that watching television while working on a math assignment resulted in lower performance, r = -.27 (Pool et al., 2000), whereas the other study found that watching television while working on a math assignment had no effect on math performance (Cool et al., 1994).

Findings on Study-Related Attitudes and Behaviors

Fifteen studies examined study-related attitudes and behaviors: six correlational studies and nine experimental studies. These studies primarily examined two types of study-related attitudes and behaviors. Seven experimental studies investigated study time (see Table 3), and three correlation studies investigated the ability to focus on an academic activity (see Table 2).

First, four of the seven experimental studies on study time found that youth who used media while studying needed more time to complete an academic task, r_{range} = .26 to .44 (Bowman et al., 2010; Fox et al., 2009; Pool et al., 2003a; Subrahmanyam et al., 2013). The other three studies found no relationship (Cool et al., 1994; Pool et al., 2000, 2003b). Second, all three correlational studies on the ability to focus on an academic activity found that greater media use during academic activities was related to a perceived lower ability to focus, r_{range} = -.23 to -.38 (Calderwood, Ackerman, & Conklin, 2014; Fried, 2008; Wei et al., 2012).

Additionally, three correlational studies (Calderwood et al., 2014; Gaudreau et al., 2014; Junco & Cotten, 2011) and two experimental study (End et al., 2010; Kuznekoff & Titsworth, 2013) investigated other study-related attitudes and behaviors. These studies showed that media use during academic activities was related to perceived interference with finishing homework (Junco & Cotten, 2011), less academic satisfaction (Gaudreau et al., 2014), lower homework motivation (Calderwood et al., 2014), and interference with note-taking (End et al., 2010; Kuznekoff & Titsworth, 2013).

Findings on Perceived Academic Learning

Three correlational studies (see Table 2) and two descriptive studies (Braguglia, 2011; Johri et al., 2014) examined the relationship between media use during academic activities and youths' perceptions of interference with academic learning (Beentjes et al., 1996;

Fried, 2008; Wei et al., 2012). Two of three studies showed that media use during academic activities was related to lower perceived learning, namely, lower perceived performance on study assignments (Beentjes et al., 1996), and less perceived clarity and understanding of academic content (r = -.17 and -.19, Fried, 2008). One study, however, found no relationship between media use during academic activities and perceived learning (Wei et al., 2012). In addition, in two descriptive studies, youth frequently reported that their media use interfered with learning academic content (Braguglia, 2011; Johri et al., 2014).

Conclusions on Media Multitasking and Academic Performance

Studies of academic performance have solely addressed the specific effects of media use during academic activities. The majority of these studies indicated that media use during academic activities is negatively related to or interferes with three aspects of academic performance: (a) academic outcomes (i.e., GPA, grades, course/lecture outcomes, homework outcomes), (b) study-related behaviors and attitudes, and (c) perceived academic learning. However, the observed negative relationships or effects were often small to moderate and not always significant (see Tables 2 and 3).

MEDIA MULTITASKING AND SOCIOEMOTIONAL FUNCTIONING

Recently, concerns regarding the negative consequences of media multitasking on socioemotional functioning have been raised. Socioemotional functioning is a broad concept that is used to highlight the intertwining relationship between social and emotional functioning (Ochsner, 2008) and includes multiple components (e.g., Carter, Briggs-Gowan, Jones, & Little, 2003). To date, studies of media multitasking have focused on three possible components of socioemotional functioning: emotional functioning (e.g., depression and social anxiety), social functioning (e.g., sociability and social success), and regulatory behaviors (e.g., sleep).

Theoretical Background

Researchers have provided two potential explanations for why media multitasking may have a negative effect on socioemotional functioning. The first explanation is based on cognitive control as the underlying mechanism. It has been argued that deficits in cognitive control can explain the negative relationship between media multitasking on socioemotional functioning (e.g., Becker et al., 2013). The ability to control attention and cognitions – also known as effortful control in the psychological literature on socioemotional functioning – has often been linked to the ability to regulate emotions (Eisenberg, Hofer, & Vaughan, 2007). The ability to effectively regulate emotions is in turn related to a variety of positive social and emotional outcomes (Eisenberg et al., 2007). For example, more effective management of emotions may evoke more positive responses of others and may thus eventually enhance feelings of social competence (e.g., Eisenberg, Fabes, Guthrie, & Reiser,

2000; Eisenberg et al., 2007). If media multitasking causes cognitive control to deteriorate, then the ability to regulate emotions may be affected, leading to deficits in socioemotional functioning.

The second explanation focuses on the disruption and displacement of face-to-face interactions. Youth who engage in habitual media multitasking may actually use media during face-to-face communication, which could disrupt and displace face-to-face communication. As face-to-face interactions play a crucial role in youths' healthy socioemotional development (Pea et al., 2012), limited face-to-face interactions may have a negative influence on socioemotional functioning.

Studies Included

In total, four correlational studies that have examined the relationship between media multitasking and socioemotional functioning among youth were included (see Table 4). Two studies included university students (Becker et al., 2013; Shih, 2013), one study included adolescents (12-18 years old, Calamaro, Mason, & Ratcliffe, 2009), and one study included pre- and early adolescents (8-12 years old, Pea et al., 2012).

Measurements

All studies used the MMI (Ophir et al., 2009) or an adapted version. In addition, one study included an instrument called the Survey of the Previous Day, which examines youths' media multitasking behaviors of the previous day (Shih, 2013). To measure socioemotional functioning, several subdomains of socioemotional functioning have been assessed using questionnaires (for an overview of these subdomains, see Table 4).

Findings on Socioemotional Functioning

The four studies examined different components of socioemotional functioning: three studies on emotional functioning, two on social functioning, and two on regulatory behaviors (i.e., sleep) (see Table 4). Although one study found that media multitasking was unrelated to positive aspects of emotional functioning (i.e., emotional positivity and well-being, Shih, 2013), the other two studies showed that media multitasking was related to problematic emotional functioning, r_{range} = .05 to .19. In particular, more media multitasking was related to more symptoms of depression, higher levels of social anxiety (Becker et al., 2013), and fewer feelings of normalcy (Pea et al., 2012). Moreover, the two studies on sleep showed that more media multitasking was related to less sleep, r = -.09 (Calamaro et al., 2009; Pea et al., 2012), more difficulties in falling asleep on a weeknight, and a higher likelihood of falling asleep during school (Calamaro et al., 2009). By contrast, both studies on social functioning found no relationship between media multitasking and social functioning (Pea et al., 2012; Shih, 2013).

Table 4. Correlational Studies on Media Multitasking and Socioemotional Functioning

Study	Age	*N*	Socioemotional Functioning	Correlation
			Emotional functioning	
Becker et al. (2013)	students	318	Depression	.19$^{\beta}$
			Social anxiety	.17$^{\beta}$
Pea et al. (2012)	8-12	3461 girls	Feelings of normalcy	-.05$^{\beta}$
Shih (2013)	18-43	138	Emotional positivity	ns
			Emotional well-being	ns
			Social functioning	ns
Pea et al. (2012)	8-12	3461 girls	Social success	ns
Shih (2013)	18-43	138	Sociability	ns
			Regulatory behaviors	
Pea et al. (2012)	8-12	3461 girls	Hours of sleep	-.09$^{\beta}$
Calamaro et al. (2009)	12-18	100	Hours of sleep on school nights	-
			Falling asleep during school	-
			Difficulties falling asleep on a weeknight	-

Note. Age = range or mean; 0 = not significant, - = media multitasking is negatively related to this aspect of socioemotional functioning; + = media multitasking is positively related to this aspect of socioemotional functioning; $^{\beta}$ = partial correlation.

Conclusions on Media Multitasking and Socioemotional Functioning

The few available studies on socioemotional functioning indicate that media multitasking is related to lower emotional functioning, less sleep and more sleeping problems. In contrast, media multitasking appears to be unrelated to social functioning.

DISCUSSION

Despite an increasing number of empirical studies on the consequences of media multitasking for youth, there is still little clarity regarding the potential negative effects of media multitasking on the three domains of youths' functioning: cognitive control, academic performance, and socioemotional functioning. The aim of the present review was therefore to summarize existing theories and integrate available findings.

Overall, the studies on cognitive control show that media multitasking is negatively related to cognitive control in everyday life as measured with self-reports of cognitive control. Moreover, media multitasking is negatively related to specific cognitive control processes as measured with performance-based tasks, in particular to the ability to sustain attention. These findings are in line with the scattered attention hypothesis, which states that

youth who frequently engage in media multitasking may lose the ability to focus on one activity. It must be noted, however, that media multitasking is unrelated to some cognitive control processes, measured with performance-based tasks. For example, the majority of the studies found no evidence for a relationship between media multitasking and task switching or working memory capacity (e.g., Baumgartner et al., 2014; Minear et al., 2013).

With regard to academic performance, the majority of the studies show that media use during academic activities is negatively related to the three aspects of academic performance (i.e., academic outcomes, study-related attitudes and behaviors, and perceived academic learning). These negative relationships were found in experimental as well as survey studies, although the effects in both types of studies are small to moderate. Two potential explanations for these effects have been put forward: (1) media multitasking may displace the time spent on academic activities (e.g., Fox et al., 2009), and (2) media use during academic activities may limit the information processing capacity that is available for the academic content (e.g., Junco & Cotten, 2011). However, because none of the studies has investigated the underlying mechanisms of this relationship, it is as yet not possible to single out which explanation is most valid.

Lastly, the few studies on socioemotional functioning show that media multitasking is negatively related to several subdomains of socioemotional functioning. Youth who reported higher levels of media multitasking showed lower emotional well-being and more sleep problems. Although the theoretical link remains somewhat vague and possible underlying mechanisms have not been examined yet, media multitasking could interfere with socioemotional functioning through (1) deficits in cognitive control, and (2) disruption and displacement of face-to-face interactions.

Overall, the available studies indicate a small to moderate negative relationship between media multitasking and cognitive control, academic performance, and socioemotional functioning. Although the findings of previous research have been important in highlighting current concerns regarding media multitasking among youth, this review identifies important research gaps. To further advance this research field, we have thus identified five areas that need more attention in future research on media multitasking among youth: examining causality, establishing more targeted theories, improving media multitasking measurements, examining individual differences, and including representative samples.

Research Gaps and Directions for Future Research

Examining causality. Most importantly, the direction of the relationship between media multitasking and the three domains of youths' functioning remains unclear. To date, researchers have primarily relied on cross-sectional data. Therefore, findings regarding the direction of the relationship between media multitasking and the three domains of youths'

functioning are inconclusive. Although it is typically argued that media multitasking leads to problems in cognitive control, academic performance, and socioemotional functioning, the relationship could also be reversed or reciprocal, as is consistent with many contemporary media-effects theories (Valkenburg & Peter, 2013). For example, it is possible that youth who show deficits in cognitive control, academic performance, and socioemotional functioning are more likely to engage in media multitasking. Youth who show deficits in cognitive control may have difficulties in their ability to sustain attention on one media activity and may therefore simultaneously engage in other media or non-media activities. Similarly, it could be that students with lower academic performance are less motivated at school (Richardson, Abraham, & Bond, 2012), which may lead to an increased use of media during school-related activities. Less motivated students may also be less willing to regulate their media use while learning (e.g., Schunk & Zimmerman, 2008). Therefore, to advance the field and address the question of causality, longitudinal studies of media multitasking and youths' functioning are needed.

Establishing more targeted theories. Few studies on media multitasking among youth have been conducted using a clear theoretical framework. A clear theoretical framework can provide guidelines regarding the variables that should be investigated and can enhance the cohesiveness of research on media multitasking among youth. Many studies have not included an explicit hypothesis regarding the mechanisms that explain the relationship between media multitasking and youths' functioning. To establish these theories, future research should formulate and test specific hypotheses and examine potential underlying mechanisms to explain why media multitasking interferes with cognitive control, academic performance, and socioemotional functioning.

For example, a clear theoretical framework for the underlying mechanisms in the relationship between media multitasking and academic performance is missing. Two potential mechanisms that could explain this relationship could be (1) the displacement of time spent on an academic task (e.g., Fox et al., 2009), or (2) limited information processing capacities for academic content when using media simultaneously (e.g., Junco & Cotten, 2011), or both. The displacement hypothesis might also play an important role for explaining the negative relationship between media multitasking and socioemotional functioning. More specifically, media multitasking could simply displace the time spent on face-to-face interactions (Pea et al., 2012). This displacement of face-to-face interactions may lead to lower socioemotional functioning.

In addition, cognitive control may play a crucial role in the explanation of media multitasking effects, not only as a direct effect but also as a mediator of the effects between media multitasking and academic performance and socioemotional functioning. If media multitasking results in deficits in cognitive control, these deficits may lead to lower academic performance and lower socioemotional functioning. For example, adolescents

who have difficulties sustaining their attention may have difficulties to perform well in school. Similarly, it has been argued that deficits in cognitive control may result in lower socioemotional functioning, because the ability to control attention and cognitions has been linked to the ability to regulate emotions and expressions (Eisenberg et al., 2007).

Another aspect that needs to be taken into account in future studies is that media multitasking includes at least two types of multitasking with media: the simultaneous use of more than one medium and media use while engaging in non-media activities (Jeong & Hwang, 2012; Wallis, 2010). Studies vary greatly in the type of media multitasking that they include. Whereas some studies focus explicitly on the simultaneous use of more than one medium (e.g., Ophir et al., 2009), others also examine media use while engaging in non-media activities (e.g., Shih, 2013). To improve the comparability across studies and to examine the consequences of each type of media multitasking, both types should be examined.

Moreover, studies of academic performance have solely addressed the effects of media use during academic activities on academic performance. This type of media multitasking may have a direct effect on academic performance because it may directly interfere with academic activity. However, media multitasking could in the long-term also have an indirect effect on academic performance through its effect on cognitive control (e.g., Ophir et al., 2009). If adolescents lose their ability to focus and sustain attention, this may have negative consequences for their academic performance in the long run. Therefore, future studies on academic performance should examine not only the direct effect of media use during academic activities but also the long-term effects of media multitasking.

Finally, conceptualizations of the consequences of media multitasking vary considerably, which makes it difficult to compare findings across studies. More specifically, the included studies examined (1) various control processes and different performance-based tasks for the same control process, (2) multiple measures of academic performance, and (3) highly diverse subdomains of socioemotional functioning. Future studies should emphasize which subdomains are included, why these domains are chosen, and how they are measured.

Improving media multitasking measurements. Tools for measuring media multitasking are sometimes questionable. Although all studies on the relationship between media multitasking and cognitive control have used the MMI to measure the simultaneous use of multiple media, researchers have used several different cut-off scores to differentiate heavy media multitaskers from light media multitaskers (Minear et al., 2013). The majority of the studies use the upper and lower quartiles to select heavy media multitaskers and light media multitaskers respectively. Therefore, we suggest that future studies should use the upper and lower quartiles as a fixed cut-off mark to facilitate comparisons across studies. Moreover, only a few researchers have examined the continuum of media

multitasking. Solely investigating extreme groups and using different cut-offs weakens the comparability among studies. Therefore, future research should address the continuum of media multitasking and should not solely use cut-offs to categorize multitaskers.

Finally, research on the relationship between media multitasking and academic performance often includes only one type of media use (e.g., Facebook, text messaging, or TV). It is important to realize that this focus on a single medium does not accurately capture the current media-saturated environment of youth (e.g., Lee et al., 2012), who may actually be Facebooking, texting, and watching TV while they are working on their homework.

Focusing on individual and contextual differences. Some initial attempts have been made to examine individual differences in the relationship between media use during academic activities and academic performance. Studies on personality characteristics indicated that introverts perform worse than extroverts when exposed to television while reading (Furnham et al., 1994; Ylias & Heaven, 2003). Ylias and Heaven (2003) also examined four other personality characteristics (neuroticism, agreeableness, conscientiousness, and openness) but found that none of these characteristics moderated the relationship between multitasking and performance. Finally, several individual difference factors that are directly related to academic performance have been examined, such as level of expertise (Lin, Robertson, & Lee, 2009), interest level (Conard & Marsh, 2014), and self-regulation (Parks-Stamm, Gollwitzer, & Oettingen, 2010). These studies have indicated that when youth show lower levels of expertise and self-regulation media multitasking interferes more with their academic performance. Interest level, however, does not moderate the effects of media multitasking on academic performance.

Although some studies have examined individual differences related to the academic context, other possible individual differences that may moderate the relationship between media multitasking and youths' functioning have been widely ignored. The available studies have often found small to moderate negative relationships, possibly as a result of individual differences, as some individuals may be more susceptible to media multitasking effects than others (Valkenburg & Peter, 2013). To increase our understanding of the influence of media multitasking on youths' functioning, we need to identify which individuals are more susceptible to these effects by examining, for example, demographic (e.g., age and gender) and dispositional moderators (e.g., sensation seeking and impulsivity).

In addition to individual differences, contextual differences may also explain the differences in the consequences of media multitasking. To date, studies have only focused on contextual factors that are related to the academic context. For example, studies have focused on contextual factors, such as task relevance (Srivastava, 2013), task difficulty (Fox et al., 2009; Pool et al., 2000), and note-taking (Subrahmanyam et al., 2013; Wei et al., 2014). Although task difficulty does not moderate media multitasking effects on academic

performance, the studies have indicated media multitasking is more disruptive when task-relevance is high and youth do not engage in note-taking. However, future research should, for instance, also investigate which types of media may be particularly disruptive. For example, it is conceivable that media on digital mobile devices (e.g., text-messaging and social media platforms) are especially disruptive due to their ubiquitousness and highly disruptive potential through beeps, alerts, and pop-ups.

Including representative samples. Although concerns regarding media multitasking primarily focus on adolescents, only a few studies have actually investigated adolescents. Moreover, an important shortcoming of the existing studies is the inclusion of unrepresentative samples. Most studies of emerging adults are small and included only students from one specific university with a wide age range. Media multitasking and its effects may, however, differ by age. For instance, self-regulatory skills continue to develop throughout adolescence (Steinberg, 2004). Adolescents may therefore be less able to self-regulate their media multitasking behaviors than college students, which could result in higher levels of media multitasking in adolescence than in emerging adulthood. In addition, we observed high levels of gender bias within studies, often characterized by an overrepresentation of girls. Previous research highlighted that media use and its effects could differ for gender (Valkenburg & Peter, 2013). Therefore, to improve our understanding of media multitasking effects on youth, we need more representative samples of youth.

Conclusion

Researchers often implicitly or explicitly state that media multitasking has negative effects on youths' functioning. After carefully integrating the existing studies, the weight of evidence appears to support a small to moderate negative relationship between media multitasking and the three domains of youths' functioning. However, some studies found no significant relationship and evidence regarding the causality of this relationship is still lacking. Therefore, a more nuanced view of the negative effects of media multitasking on youths' functioning is needed. Future research should particularly focus on building more targeted theories, examining moderators, and establishing causality.

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CHAPTER 2

Exploring the Long-Term Relationship between Academic-Media Multitasking and Adolescents' Academic Achievement

ABSTRACT

Adolescents commonly use media and communication devices during academic activities, a phenomenon known as academic-media multitasking. Although there is first evidence for the short-term effect of academic-media multitasking on academic achievement, support for its long-term effect is lacking. Therefore, we investigated the long-term relationship between academic-media multitasking and academic achievement, and the possible underlying mechanism of academic attention problems using a three-wave longitudinal study among 1,215 adolescents (11-15 years, 52% boys). The findings supported neither a direct nor indirect long-term relationship between academic-media multitasking and subsequent academic achievement scores. However, academic-media multitasking was associated with more subsequent academic attention problems. This study indicates that concerns regarding the long-term impact of academic-media multitasking on academic achievement need to be qualified.

The development of mobile communication technologies has increased adolescents' opportunities to use media and communication devices during academic activities. Consequently, adolescents often use media and communication devices during homework and while attending class, not only for academic but also for non-academic purposes (Wallis, 2010). Using media during academic activities for non-academic purposes is referred to as academic-media multitasking. About half of adolescents indicated that they sometimes or often watch television, use social media (e.g., Facebook, Instagram), or engage in text messaging during their homework (Common Sense Media, 2015). Furthermore, approximately 64% of adolescents reported that they regularly text while attending class (Lenhart, Ling, Campbell, & Purcell, 2010).

The rise in academic-media multitasking (AMM) among adolescents has been paralleled with an increase in studies on the impact of AMM on adolescents' academic achievement (for reviews, see Carrier, Rosen, Cheever, & Lim, 2015; Jeong & Hwang, 2016; Levine, Waite, & Bowman, 2012; van der Schuur, Baumgartner, Sumter, & Valkenburg, 2015). Academic achievement has been operationalized as grade point average (GPA) or course grades (e.g., Junco & Cotten, 2012; Rosen, Lim, Carrier, & Cheever, 2011), or as homework or lecture outcomes, for example, a test on one specific lecture (e.g., Pool, Koolstra, & van der Voort, 2003; Wood et al., 2012). Overall, the literature has yielded consistent negative relationships between AMM and academic achievement (e.g., Clayson & Haley, 2013; Junco & Cotten, 2012; Wei, Wang, & Fass, 2014).

Although studies in the field of AMM on academic achievement have rapidly accumulated, it is marked by two main gaps. First, evidence on the long-term effects of AMM on adolescents' academic achievement is lacking. Specifically, studies have either examined the short-term impact of AMM on homework and lecture outcomes (e.g., Armstrong, Boiarsky, & Mares, 1991; Rosen et al., 2011; Wood et al., 2012), or the cross-sectional relationship between AMM and GPA or course grades (e.g., Junco, 2012; Junco & Cotten, 2012; Ravizza, Hambrick, & Fenn, 2014). Therefore, it is yet unknown whether frequently engaging in AMM results in lower academic achievements in the long-term (Carrier et al., 2015).

Second, potential underlying mechanisms that may explain how AMM negatively affects academic achievement in the long-term have not been investigated. Previous research has suggested that academic attention problems (i.e., having difficulties focusing on academic tasks) may function as an important underlying mechanism (Ophir, Nass, & Wagner, 2009). AMM may in the long-term hinder adolescents' general ability to focus on the academic activity, which may lead to lower academic achievement.

The current study will address both gaps by conducting a longitudinal study among adolescents in which we aim to examine: (1) the long-term relationship between AMM and

subsequent academic achievement scores, and (2) the possible underlying mechanism of academic attention problems in this long-term relationship.

The Short-Term Effects of Academic-Media Multitasking on Academic Achievement

Several experimental studies have investigated the short-term effects of AMM on academic achievement scores. These studies focused largely on college student samples (e.g., Rosen et al., 2011; Wei et al., 2014; Wood et al., 2012) and examined specific aspects of AMM, such as engaging in text messaging while in class (Rosen et al., 2011) or watching TV during a homework assignment (Pool et al., 2003). These experimental studies consistently showed that AMM has a moderate negative impact on homework and lecture outcomes (e.g., Jeong & Hwang, 2012; Srivastava, 2013; Wood et al., 2012). For example, watching television while reading decreased reading comprehension (e.g., Armstrong & Greenberg, 1990; Jeong & Hwang, 2012). In addition, watching television during a math assignment detoriated performance on the math assignment in question (Pool, van der Voort, Beentjes, & Koolstra, 2000). Similarly, students who frequently engaged in text messaging during a lecture showed lower performance on a test related to that lecture, than students who did not engage or sometimes engaged in text messaging (Rosen et al., 2011). Overall, we can conclude that there is a short-term impact of AMM on academic achievement.

Researchers have proposed two explanations for AMM's negative short-term impact on adolescents' academic achievement. First, the time displacement hypothesis (e.g., Lee, 2009; Nie & Hillygus, 2002) states that adolescents who engage in AMM may spend insufficient time on the academic activity, because the time spent on the media directly displaces the time spent on the academic activity (e.g., Fox, Rosen, & Crawford, 2009). If adolescents do not spend enough time on academic activities this may hinder their academic achievement. Findings of experimental studies have supported that AMM may indeed interfere with the time spent on the academic activity (e.g., Bowman, Levine, Waite, & Gendron, 2010; Lee, Lin, & Robertson, 2012; Subrahmanyam et al., 2013). For example, two studies demonstrated that college students who engaged more often in text messaging during a reading comprehension task, needed more time to finish the task (Bowman et al., 2010; Fox et al., 2009). Although in some cases adolescents will have enough time available to complete the tasks at hand, in many academic activities time is limited. For instance, exams are limited by time and homework has to be finished within a restricted amount of time as well.

Second, cognitive capacity theories assume that because individuals have a limited pool of cognitive resources, they are unable to sufficiently process different content simultaneously (e.g., Lang, 2000; Lang, 2006; Salvucci & Taatgen, 2008; Salvucci & Taatgen, 2010). When engaging in AMM, adolescents need to allocate their cognitive resources to both the academic content and the media content. When academic content and media content compete for the same cognitive resources, it is expected that these resources

will be allocated to the media content. Specifically, Fisch (2000) argues that individuals primarily focus on processing the entertainment content, followed by the educational content. Consequently, adolescent may not have sufficient cognitive resources left for processing the academic content sufficiently, resulting in lower performance on academic tasks (Chen & Yan, 2016; Junco & Cotten, 2012; Junco, 2012).

The Long-Term Effects of Academic-Media Multitasking on Academic Achievement

Researchers have implicitly or explicitly assumed that AMM may also have a long-term influence on adolescents' academic achievement, reflected in their GPA or their course grades (Junco, 2012; Junco & Cotten, 2012; Levine et al., 2012). To date, cross-sectional studies have found negative relationships between either media use during homework or media use in class and academic achievement scores among college students (e.g., Clayson & Haley, 2013; Junco, 2012; Ravizza et al., 2014; Rosen, Carrier, & Cheever, 2013). For example, using Facebook and engaging in text messaging during homework was related to lower GPA (Junco & Cotten, 2012). Furthermore, sending text messages while attending class was associated with lower course grades (Clayson & Haley, 2013). Overall, the size of the association between AMM and academic achievement scores ranged from small (e.g., Junco & Cotten, 2012; Junco, 2012) to moderate (e.g., Ravizza et al., 2014; Rosen et al., 2013). However, all of the existing studies are cross-sectional. Therefore, it remains unclear whether this relationship is due to AMM leading to lower academic achievement in the long-term, meaning that adolescents who frequently engage in AMM perform worse in school over time. There are two main explanations for the possible long-term effect of AMM on academic achievement.

A first explanation for the long-term effect of AMM on academic achievement is that AMM interferes with adolescents' long-term learning process. Learning is often a reflection of the extent to which multiple pieces of information on a specific topic have been integrated over time (Mercer, 2008). Specifically, adolescents first need to learn the basic principles of a topic before they can expand and deepen their knowledge (Frey, Fisher, & Hattie, 2016). When AMM repeatedly interferes with adolescents' homework and lecture outcomes, this may interfere with their learning process over time because crucial pieces of information that need to be integrated could be missing. Because AMM may hinder adolescents' long-term learning process over time, this could in the long-term result in lower academic achievement.

A second explanation for a long-term negative impact of AMM on academic achievement is that frequently engaging in AMM may result in academic attention problems (Ophir et al., 2009), which in turn has a negative impact on academic achievement scores. Based on the definition of attention problems (American Psychiatric Association, 2013), we refer to academic attention problems as difficulties with regulating and guiding attention, for example experiencing difficulties in sustaining attention, getting easily distracted, and

being forgetful during academic activities. To understand the possible long-term impact of AMM on academic attention problems, we rely on the literature regarding the effect of media-media multitasking (i.e., the simultaneous use of multiple media [Shih, 2013]) on attention problems (Ophir et al., 2009; van der Schuur et al., 2015).

Researchers have argued that frequently engaging in media-media multitasking may over time result in a habit characterized by continuous scattered attention (Ophir et al., 2009). Specifically, the constant switching between several media activities may interfere with adolescents' general ability to focus on one activity because they are accustomed to continuously respond to internal (e.g., boredom) and external (e.g., social media alerts, talking peers) triggers (Ophir et al., 2009). Similar to media-media multitasking, adolescents who repeatedly engage in AMM may become used to being constantly distracted during their academic activities and may find it increasingly challenging to focus and sustain their attention on the academic task (e.g., Levine et al., 2012).

Academic attention problems are problematic for adolescents' academic achievement because the ability to focus attention on an academic activity is crucial for processing the academic content efficiently (Wei, Wang, & Klausner, 2012). Previous studies already indicated that attention problems interfere with academic achievement (for a review, see Polderman, Boomsma, Bartels, Verhulst, & Huizink, 2010). Attention problems had a negative influence on academic achievement scores, even if controlled for IQ and socio-economic status (Polderman et al., 2010). Moreover, the predictive effect of attention problems on academic achievement was almost as strong as the predictive effect of motivation and cognitive ability (Birchwood & Daley, 2012), two of the most important precursors of academic achievement (e.g., Gottschling, Spengler, Spinath, & Spinath, 2012). Thus, because AMM could lead to more academic attention problems, this may indirectly interfere with adolescents' academic achievement.

Taken together, both explanations of why AMM interferes with adolescents' academic achievement in the long-term are plausible. Therefore, we hypothesize that the frequency of AMM is negatively related to subsequent academic achievement among adolescents (H1). In addition, we examine the role of academic attention problems as a potential underlying mechanism, and expect that academic attention problems will mediate the negative relationship between AMM and subsequent academic achievement (H2).

METHODS

Sample

We conducted a three-wave longitudinal study to examine various types of media multitasking and domains of adolescents' functioning in seven secondary schools across

the Netherlands. For six of the seven schools data was available on adolescents' academic achievement. Of these six schools, 1,090 adolescents participated in Wave 1, 1,075 in Wave 2, and 1,057 in Wave 3. The attrition across the three waves can mainly be explained by illness, student numbers that could not be matched, and busy school schedules during the assessment points that allowed some classes not to participate in one of the waves. In total, 1,215 adolescents filled out the survey in at least one wave (52% boys). The age of these adolescents ranged between 11 and 15 years old (M_{age} = 12.68, SD = 0.76). Fifty percent (n = 608) of the adolescents were in their first year (grade 7) and 50% (n = 607) were in their second year (grade 8) of the secondary school. Data from these 1,215 adolescents were used in the analyses.

Procedure

Before the start of the study, we obtained ethical approval by the ethical committee of the University of Amsterdam. After contacting schools via e-mail, seven schools agreed to participate in the larger longitudinal study with multiple classes of grade 7 and grade 8. Of the seven schools, six schools agreed to provide information on adolescents' academic achievement scores. Data was collected three times during one school year, namely in November 2014, in March 2015, and at end of June 2015. These data collection time points were selected because they were all around the end of a school term (first term, midterm, and final term), resulting in three-to-four month intervals.

Of the participating classes, we obtained passive informed consent of the parents and informed assent of the adolescents. Both parents and adolescents received information about the study and were assured that their participation was completely confidential and voluntary. The participants filled out the online survey in class, which took approximately 30 minutes, under supervision of a member of the research team and/or the teacher. After each wave, the participants received a small incentive (monetary value around $ 0.50).

Measurements

Academic-media multitasking. The measure of AMM consisted of 17 items and was based on the Media Multitasking Index (MMI) developed by Ophir et al. (2009). Participants had to indicate how often they typically engage in the following media activities for non-academic reasons during homework (9 items, activity 1 to 9) and while attending class (8 items, activity 2 to 9): (1) watching television, (2) reading, (3) listening to music, (4) talking on the phone, (5) sending messages via phone or computer, (6) using social network sites, (7) watching movies on the computer, (8) playing video games, and (9) other computer activities. We excluded watching TV while attending class, because this is a very unlikely combination. The items were introduced with 'Can you indicate how often you typically use the different media during your homework / while attending class? When answering, think only of media use that has nothing to do with your homework / the class'. An example item

for media use while attending class was: "During class, I read or send messages via phone or computer". An example item for media use during homework was "During homework, I watch television". AMM was rated on a five-point scale, 0 = *never*, 1 = *almost never*, 2 = *sometimes*, 3 = *often*, and 4 = *very often*. All 17 items were averaged into one mean index for AMM (Wave 1: *M* = 0.83, *SD* = 0.57, Cronbach's alpha = .86; Wave 2: *M* = 0.92, *SD* = 0.63, Cronbach's alpha = .89; Wave 3: *M* = 0.98, *SD* = 0.68, Cronbach's alpha = .90). A higher score indicated more frequent AMM.

Academic attention problems. The scale of academic attention problems was based on the School Questionnaire for elementary and secondary school (Smits & Vorst, 1990). We aimed to measure both attention problems in class and during homework. The scale originally consisted of eight items on attention problems in class. For this study, we selected four items from this scale that could be easily adapted to the homework environment. In total, we included eight items for academic attention problems, four items on attention problems in class and four items on attention problems during homework.

The four items on attention problems in class were: (1) "I find it hard to keep my mind on my work throughout the class", (2) "In the classroom, I often think about things that have nothing to do with the class", (3) "I get easily distracted in class" , and (4) "I can easily keep my attention on the class (reversed)". The four items on attention problems during homework were: (1) "I find it hard to keep my mind on homework all the time", (2) "While doing homework, I often think about things that have nothing to do with my homework", (3) "I get easily distracted while doing my homework", and (4) "I can easily keep my attention on my homework (reversed)".

The eight items were rated on a five-point scale, 0 = *completely untrue*, 1 = *untrue*, 2 = *somewhat true*, 3 = *true*, and 4 = *completely true*. An exploratory factor analysis demonstrated that the items loaded on one factor. Therefore, the items were averaged into one mean index for academic attention problems (Wave 1: *M* = 1.97, *SD* = 0.81, Cronbach's alpha = .90; Wave 2: *M* = 1.96, *SD* = 0.81, Cronbach's alpha = .90; Wave 3: *M* = 1.90, *SD* = 0.78, Cronbach's alpha = .88). A higher score indicated more academic attention problems.

Academic achievement scores. Adolescents' academic achievement was operationalized as the academic achievement scores, which was based on the documented first term, midterm, and final term course grades of the adolescents. The term course grades were provided by the schools around the same time as the survey data collection of each wave and were provided by the school. The term course grades ranged between 1 and 10, with a 5.5 or higher needed to pass a course. We selected three term course grades (Dutch, English, and Math) to calculate one composite academic achievement scores for each wave (Wave 1: *M* = 6.85, *SD* = 0.97; Wave 2: *M* = 6.71, *SD* = 0.95; Wave 3: *M* = 6.63, *SD* = 1.01). We chose these three courses because these are mandatory subjects within the Dutch

educational system. Moreover, this strategy has been used in previous studies (e.g., Busch, Laninga-Wijnen, Schrijvers, & De Leeuw, 2015; Scholtens, Rydell, & Wallentin, 2013).

Analyses

To examine our hypotheses, we applied a random-intercepts cross-lagged panel model (RI-CLPM; Hamaker et al., 2015). The RI-CLPM has recently been developed to tackle serious shortcomings of the common cross-lagged panel model (CLPM; Curran & Bauer, 2011; Hamaker et al., 2015). Most importantly, the CLPM combines between-person variance and within-person variance. Aggregating these sources of variance is worrisome because it is unclear whether the cross-lagged paths reflect between-person or within-person relationships. Consequently, interpreting these cross-lagged paths may lead to inaccurate conclusions regarding the causal relationships within individuals (Hamaker et al., 2015). Because we are specifically interested in these within-person relationships, we employed the RI-CLPM (for full descriptions of the model see Hamaker et al., 2015). The RI-CLPM is able to disentangle between-person variance from within-person variance. Specifically, by controlling for the stable between-person correlation and stable confounding variables (e.g., age and biological sex), the RI-CLPM provides insight into the within-person cross-lagged correlations (Hamaker et al., 2015).

Because we aim to examine the within-person cross-lagged paths by employing the RI-CLPM, we first calculated the intra-class correlations (ICC) for AMM, academic achievement scores, and academic attention problems over time to test if there is within-person variance. For AMM, the ICC was .63, demonstrating that 63% of the variance was explained by between-person variance and that 37% of the variance was explained by within-person variance over time. For academic achievement scores, the ICC was .58, indicating that 58% of the variance was explained by between-person variance and 42% by within-person variance. For academic attention problems, the ICC was .68, meaning that 68% of the variance was explained by between-person variance and 32% by within-person variance. Together, the findings showed that an important part of the variance was due to the within-person variance, which supports the need to examine within-person relationships between AMM and academic achievement over time.

The RI-CLPM (see Figure 1) was build following the detailed description of Hamaker et al. (2015). At the between-person level, random intercept factors of each variable were added to the model. The observed scores were the indicators of these random intercept factors, with all factor loadings constrained to 1. To control for the stable between-person relationship over time, a covariance was added to the model between the random factors. At the within-person level, each observed variable loaded on its own latent factor and these factor loadings were constrained to 1. Similar to the CLPM, stability paths, cross-lagged paths, covariances at Wave 1, and covariances between the disturbances at Wave 2 and Wave 3 were added between the within-person latent factors.

The RI-CLPM was examined in Mplus 7 (Muthén & Muthén, 2012). To deal with the missing data across the three waves, we employed the Full Information Maximum Likelihood estimation (Muthén & Muthén, 2012). We controlled for the clustering in our data on class level. We evaluated the model fit using the chi-square measure of exact fit, the Root Mean Square Error of Approximation (RMSEA) and its 95% confidence interval, and the Comparative Fit Index (CFI). RMSEA values below .05 and CFI values above .95 implied good fit, whereas RMSEA values below .08 and CFI values above .90 implied satisfactory fit.

RESULTS

Descriptive Statistics

Table 1 displays the correlations, means, and standard deviations for AMM, academic achievement scores, and academic attention problems of Wave 1. Similar patterns were found for Wave 2 and Wave 3. Similar to previous studies, AMM was negatively related to academic achievement scores, and positively to academic attention problems. In addition, as expected, academic achievement scores was negatively related to academic attention problems.

The Long-Term Relationship Between AMM and Academic Achievement

The RI-CLPM of the long-term relationship between AMM and academic achievement is depicted in Figure 1. The model fit was satisfactory, χ^2 (5) = 16.21, p = .006; RMSEA = .04 (95% CI [.02, .07]); CFI = .99. At the between-person level, there was a significant negative correlation between AMM and academic achievement scores (b^* = -.28, p < .001), which means that adolescents who engaged in AMM more frequently had a lower academic achievement scores across the three waves.

Table 1. Zero-order Pearson Correlations, Means, and Standard Deviations for Academic-Media Multitasking, Academic Achievement Scores, Academic Attention Problems, Age, and Gender, at Wave 1.

		1	2	3	4
1	Academic-Media Multitasking	-			
2	Academic Achievement Scores[a]	-.19**			
3	Academic Attention Problems	.38**	-.22**		
4	Age	.12**	-.28**	.05	
5	Sex (0 = *boy*)	.08*	-.16**	-.02	-.01
	M	0.83	6.85	1.97	12.68
	SD	0.57	0.97	0.81	0.76

Note: * p < .05; ** p < .001. [a] ranging between 1 and 10.

Inconsistent with Hypothesis 1, the within-person correlation of AMM to subsequent academic achievement scores was not significant from Wave 1 to Wave 2 nor from Wave 2 to Wave 3 (both b^* = .01, p = .899), see Figure 1. Additionally, we included the cross-lagged paths from academic achievement scores to AMM. The findings showed that the within-person correlation between academic achievement scores and subsequent AMM was not significant from Wave 1 to Wave 2 (b^* = .04, p = .585), nor from Wave 2 to Wave 3 (b^* = .03, p = .577). Thus, in contrast to H1, we did not find support for a long-term relationship between AMM and subsequent academic achievement[1].

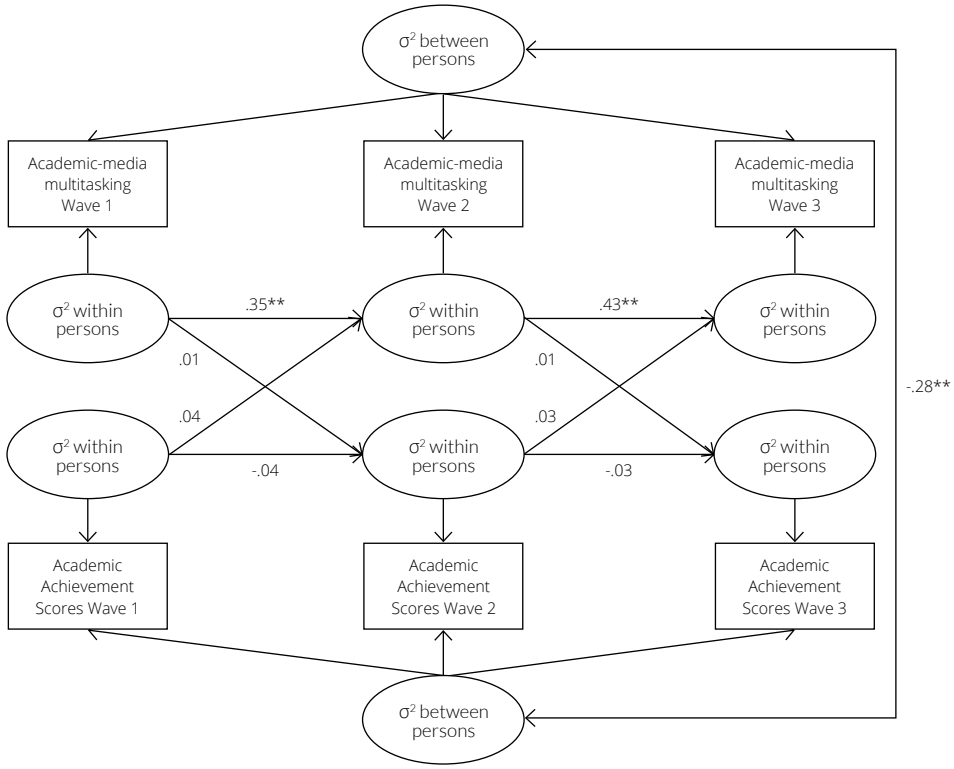

Figure 1. Simplified model with the standardized maximum likelihood parameter estimates for the between-person correlation and the within-person relationships between academic-media multitasking and academic achievement scores.

Note: * *p < .001.

[1] We also examined two additional models in which we included media use during homework and media use while attending class separately. However, in both models we found no significant cross-lagged paths. The results were highly similar to the overall model.

Examining Academic Attention Problems as Underlying Mechanism

Because we found no evidence for the direct relationship between AMM and subsequent academic achievement scores, it was not possible to examine the mediating role of academic attention problems. However, we did examine if there was an indirect relationship of AMM on subsequent academic achievement scores via academic attention problems. Therefore, we added academic attention problems to the model (see Figure 2). The model showed good fit, χ^2 (12) = 21.92, p = .038; RMSEA = .03 (95% CI [.01, .04]); and CFI = 1.00.

At the between-person level, there was a significant correlation between AMM and academic achievement scores (b^* = -.27, p < .001), AMM and academic attention problems (b^* = .46, p < .001), and academic attention problems and academic achievement scores (b^* = -.31, p < .001). This indicates that adolescents who more often engaged in AMM had a lower academic achievement score and reported more academic attention problems across the three waves. In addition, adolescents who reported more academic attention problems had a lower academic achievement score across the three waves.

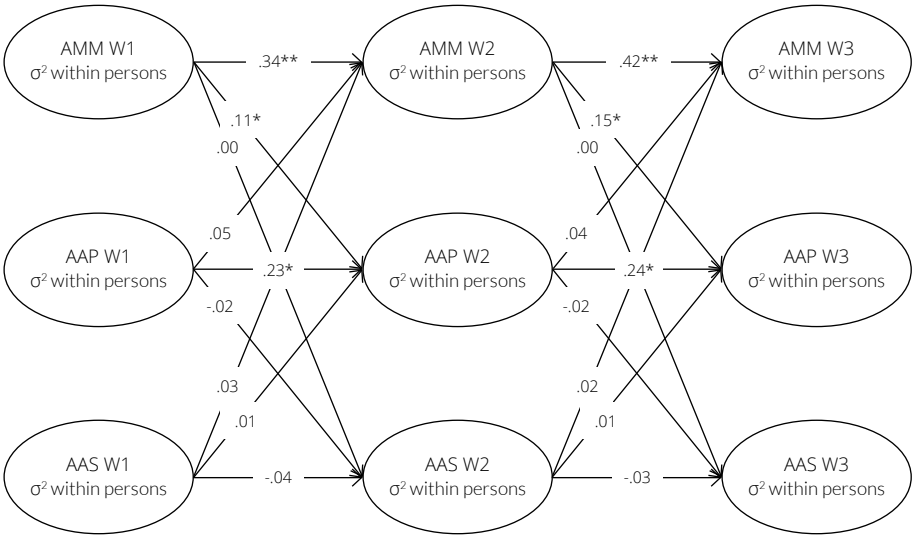

Figure 2. Simplified model with the standardized maximum likelihood parameter estimates for the within-person effeects between academic-media multitasking, academic attention problems, and academic achievement scores.

Note: * *p < .001; * p < .05. AMM = academic-media multitasking; AAP = academic attention problems; AAS = academic achievement scores; W1 = Wave 1; W2 = Wave 2; W3 = Wave 3.

The findings regarding the within-person cross-lagged paths showed that AMM positively predicted academic attention problems from Wave 1 to Wave 2 (b^* = .11, p = .031) and from Wave 2 to Wave 3 (b^* = .15, p = .028). However, the within-person correlations

between academic attention problems and subsequent academic achievement scores was not significant from Wave 1 to Wave 2 (b^* = -.02, p = .827) and from Wave 2 to Wave 3 (b^* = -.02, p = .828). Thus, this implies AMM was not negatively related to subsequent academic achievement via academic attention problems, which did not support H2.

DISCUSSION

The ubiquitousness of mobile media and communication devices has significantly increased adolescents' opportunities to engage in academic-media multitasking (AMM). Adolescents engagement in AMM is related to their GPA and course grades (e.g., Junco, 2012; Junco & Cotten, 2012; Ravizza et al., 2014), and has a short-term impact on their academic achievement (e.g., Armstrong et al., 1991; Rosen et al., 2011; Wood et al., 2012). These findings fuelled concerns that AMM would also deteriorate adolescents' academic achievement in the long term. Therefore, we investigated the potential long-term relationship between AMM and subsequent academic achievement. To examine the long-term relationship, we employed a RI-CLPM, which allowed us to specifically test within-person processes over time by controlling for the stable between-person relationship. Overall, this study has yielded three important results regarding the relationship between AMM and academic achievement scores.

First, we found a moderate stable negative association between AMM and academic achievement scores at the between-person level. This implies that adolescents who engaged in AMM more frequently had a lower academic achievement scores than adolescents who engaged in AMM less frequently across the school year. This finding at the between-person level can be compared to previous cross-sectional findings. Specifically, similar results were found in cross-sectional studies, which showed small to moderate negative relationships between AMM and GPA or course grades (e.g., Junco, 2012; Junco & Cotten, 2012; Ravizza et al., 2014). These cross-sectional relationships have been typically interpreted as possible evidence for the assumption that AMM causes a decrease in academic achievement.

However, in contrast to these common beliefs regarding the effects of AMM on academic achievement, the second main finding was that there was no support for the long-term relationship between AMM and subsequent academic achievement at the within-person level. This suggests that, although adolescents who engaged in AMM more frequently had a lower academic achievement scores, AMM did not further detoriate their academic achievement scores over the period of one school year. Thus, the possible causal effect of AMM on academic achievement could not be supported by our longitudinal findings. This indicates that the long-term effect of AMM on academic achievement may be more complex than previously assumed.

An explanation for why AMM does not deteriorate academic achievement in the long-

term might be that adolescents use metacognitive strategies to counteract the potential negative effects of AMM. Metacognitive strategies reflect processes that guide one's own learning, such as planning, monitoring, and evaluation (Karlen, 2016). These metacognitive strategies may help adolescents to compensate for engaging in AMM, and to strategically select when they engage in AMM. For example, adolescents may compensate for their multitasking behavior by spending more time on studying or homework at other times. This would suggest that by engaging in AMM, adolescents may take longer to finish their homework and study tasks, but they may still be able to complete them on time and do them equally well as students who did not engage in AMM. Moreover, adolescents may strategically select when they engage in AMM. Specifically, they may select moments in which their multitasking behavior does not interfere with important academic activities. For example, they may engage in AMM the week after an important exam rather than the week before an important exam. Because we focused on examining the impact of the overall frequency of AMM on academic achievement, we do not know if adolescents compensate for AMM or strategically choose when to engage in AMM, which could explain why AMM did not hinder adolescents' academic achievement.

Meta-cognitive strategies may also explain the contrasting findings of our longitudinal study and findings of experimental studies, which consistently found detrimental short-term effects of AMM on academic achievement (e.g., Armstrong et al., 1991; Rosen et al., 2011; Wood et al., 2012). In these experimental studies participants are typically forced to multitask during specific learning situations. These experimental AMM situations may limit the use of meta-cognitive strategies, such as compensation and strategically choosing when to engage in AMM. In line with this reasoning, experimental studies that allowed students in the AMM condition to spend more time on the academic activity found no significant impact on homework outcomes (Bowman et al., 2010; Fox et al., 2009). Similarly, a meta-analytic review showed that when individuals have control over their media use during non-media activities this resulted in minimal information loss (Jeong & Hwang, 2016). This may suggest that when adolescents have the possibility to apply important metacognitive strategies, AMM may not be as harmful for their academic achievement as previous research has suggested.

Because our findings indicated that the consistent cross-sectional relationship between AMM and academic achievement may not be due to causal effects of AMM on academic achievement, we need to consider other explanations for the negative cross-sectional relationship between AMM and academic achievement. An explanation could be that the cross-sectional relationship is spurious, meaning that confounding factors are responsible for the negative relationship between AMM and academic achievement. One confounding factor may be academic self-regulation, which refers to an individual's ability to control their behavior to attain academic goals (Zimmerman, 2000). Academic self-regulation has been acknowledged as a key predictor of both AMM and academic achievement.

Specifically, the lack of self-regulation has been associated with more AMM (Sanbonmatsu, Strayer, Medeiros-Ward, & Watson, 2013; Wei et al., 2012; Zhang, 2015) and lower academic achievement (Blair & Diamond, 2008; Duckworth & Seligman, 2005; Robbins et al., 2004). Because academic self-regulation is expected to influence both AMM and academic achievement, the cross-sectional relationships between AMM and academic achievement may not be due to causal effects but rather to the effects of academic self-regulation on both constructs.

The third main finding is that AMM positivily predicted academic attention problems three-to-four months later. Thus, adolescents who engaged in AMM more frequently seemed to become more easily distracted during academic activities over time. This first indication of a long-term relationship between AMM and subsequent academic attention problems provides support for the scattered attention hypothesis (Ophir et al., 2009). To date, researchers have relied on this hypothesis to explain the effect of media-media multitasking (i.e., the simultaneous use of multiple media) on attention problems. However, our findings showed that this hypothesis can be transferred to other types of media multitasking as well. Specifically, when adolescents repeatedly engage in AMM this may result in a habit of scattered attention during academic activities.

Surprisingly, academic attention problems was not related to subsequent academic achievement scores average over time. Although adolescents who often engaged in AMM became increasingly distracted during academic activities, but this had no influence on their course grades. This finding may be due to the short time intervals used in this study. Previous research has shown that finding a long-term relationship between academic attention problems and subsequent academic achievement may depend on the chosen time interval. For example, one study found negative long-term relationships between attention problems and subsequent overall grade point average within a five-year interval (grade 6 to grade 11), but not within a one-year interval (grade 11 to grade 12; Scholtens et al., 2013). We collected data using three-to-four-month intervals to cover one school year. Thus, the time intervals adopted in our study may not be sufficient to discern long-term relationships between AMM and subsequent academic achievement.

Future Directions

The insights of this study provide important directions for future research. First, future studies are advised to examine in more detail why AMM may not interfere with adolescents' academic achievement in the long-run. For example, cross-sectional studies are advised to include possible third variables, such as academic self-regulation, to examine if the cross-sectional relationship is spurious. In addition, future research should investigate if adolescents apply metacognitive strategies to cope with the negative effects of AMM on academic achievement. These studies may, for example, examine if adolescents compensate for engaging in AMM by spending more time on the academic activity or by strategically

choosing moments in which they can engage in AMM.

Second, future studies may use different sampling procedures and measurement techniques to improve our understanding of the influence of AMM on academic achievement. For example, to fully understand the timespan in which the effect of AMM on academic achievement may occur, we need longitudinal studies that include various time intervals to examine both its short-term and long-term effects. In addition, in our study, AMM was assessed with subjective self-report measurements. However, there is a vital need for studies that combine various subjective (e.g., surveys, experience sampling surveys) and objective measurements (e.g., automated tracking software) to measure AMM.

Finally, although in the present study no evidence was found for a long-term relationship between AMM and subsequent academic achievement, it may be that for specific subgroups of adolescents AMM does lead to a deterioration of their academic achievement. It is therefore important to investigate potential moderators in future studies. Adolescents' academic self-regulation may play a moderating role in the long-term effect of AMM on academic achievement. Specifically, adolescents with low levels of academic self-regulation may find it difficult to cope with the ongoing media distractions during important academic activities (Wei et al., 2012). Consequently, AMM may have more impact on academic achievement for adolescents with low levels of academic self-regulation, compared to adolescents with high levels academic of self-regulation. By including possible moderating variables, future studies will be able to unravel for which adolescents AMM may be harmful for academic achievement.

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CHAPTER 3

Technological Interferences during Offline Conversations among Adolescents and its Relationship with their Emotional Problems

ABSTRACT

As media and communication technologies are increasingly integrated in people's lives, these technologies frequently interfere with face-to-face interactions. This phenomenon – technological interferences during offline conversations (TIDOC) - has primarily been examined among college students and adults. Therefore, our understanding on how often media and communication devices interfere with conversations among adolescents is limited. Moreover, researchers have argued that TIDOC enhances adolescents' emotional problems. As a first step towards understanding TIDOC among adolescents and its relationship with emotional problems, we conducted a three-wave longitudinal study among 1,440 adolescents (11-15 years, 51% boys). The results showed that TIDOC among adolescents is common. Adolescents particularly engaged in sending text messages, watching television, listening to music, and using social networking sites during offline conversations. Similar to previous cross-sectional studies we found that TIDOC was positively related to emotional problems indicating that adolescents who more often reported TIDOC also reported more emotional problems. However, we found no evidence for the longitudinal relationship between TIDOC and emotional problems.

Media and communication technologies have become increasingly integrated in people's lives. Consequently, people also use these technologies during everyday situations, including face-to-face conversations with friends and family (e.g., Fulkerson et al., 2014; Harrison & Gilmore, 2012). We refer to this type of media use as technological interferences during offline conversations (TIDOC). While the number of studies on TIDOC among college students and adults has been increasing (e.g., Halpern & Katz, 2017; McDaniel & Coyne, 2016a; McDaniel & Coyne, 2016b; Roberts & David, 2016), we know little about how frequently adolescents use technologies during their offline conversations, and which types of technologies they typically use during these conversations. This is surprising because adolescents are known to frequently engage in other types of media multitasking (e.g., Rideout, Foehr, & Roberts, 2010), a behavior that is closely related to TIDOC (Pea et al., 2012).

Although media and communication technologies have the potential to be beneficial to adolescents' emotional functioning (e.g., Reinecke, Vorderer, & Knop, 2014; Valkenburg & Peter, 2011), when technologies interfere with offline conversation this may actually result in emotional problems (e.g., McDaniel & Coyne, 2016a; Roberts & David, 2016; Wang, Xie, Wang, Wang, & Lei, 2017). Emotional problems refer to difficulties in an individual's intrapersonal state, that is their subjective mental health, including symptoms of depression or anxiety (e.g., Durkin & Conti-Ramsden, 2007; Golombok, MacCallum, & Goodman, 2001; Goodman, 1997). Cross-sectional studies have demonstrated positive relationships between TIDOC and emotional problems among college students and adults (e.g., McDaniel & Coyne, 2016a; Roberts & David, 2016; Wang et al., 2017), but this has not yet been studied among adolescents. However, examining the relationships between TIDOC and emotional problems may be particularly important during adolescence. This developmental stage is marked by an increase in emotional problems (Steinberg, 2005, 2008), most notably depressive symptoms (Costello, Mustillo, Erkanli, Keeler, & Angold, 2003). Moreover, adolescents who experience emotional problems are more at risk for similar problems during adulthood (Hayden & Mash, 2014; Pine, Cohen, Gurley, Brook, & Ma, 1998). Therefore, it is crucial to examine whether TIDOC could potentially enhance adolescents' emotional problems.

Following the need to research TIDOC in general, and its relationship with emotional problems among adolescents in particular, this study has two aims. The first aim is to provide insight into both the frequency and the specific types of TIDOC that occur in adolescence, and to examine sex as a correlate of TIDOC. It is well established that adolescents' media multitasking differs for boys and girls (Foehr, 2006; Rideout et al., 2010), and therefore it is likely that these sex differences also predict the frequency of TIDOC among adolescents. A second aim of this study is to investigate the cross-sectional and longitudinal relationships between TIDOC and emotional problems among adolescents. It is yet unknown whether TIDOC is cross-sectionally and/or longitudinally related to adolescents' emotional

problems. Furthermore, because important predictors of media use may also moderate the influence of this use (Valkenburg & Peter, 2013), we will also examine sex as a moderator of the cross-sectional and longitudinal relationships between TIDOC and emotional problems.

Technological Interferences during Offline Conversations

TIDOC has mainly been conceptualized as interferences of technological devices during offline conversations. Recently, an increasing number of studies have examined how the use of smartphones can disrupt offline conversations (e.g., Chotpitayasunondh & Douglas, 2016; Roberts & David, 2017; vanden Abeele, Antheunis, & Schouten, 2016; Wang et al., 2017). These studies typically employ the term phubbing, which combines the words "phone" and "snubbing". For example, a study on phubbing among romantic partners showed that approximately 46% of the adult respondents experienced phubbing in social settings with their romantic partner (Roberts & David, 2016). Other researchers have employed a broader approach, and examined the usage of a variety of technological devices during offline interactions. For example, McDaniel and Coyne (2016a, 2016b) investigated how the use of multiple devices interferes with offline conversations among adults. Their findings among adult females indicated that approximately 70% reported that a wide array of technological devices, such as smartphones, computers, and television, interfered with offline interactions with their romantic partner (McDaniel & Coyne, 2016a).

Although these studies on technological devices have been an important first step in understanding TIDOC, it remains unclear how these devices are used during offline interactions. After all, one device can be used for a variety of media activities. For example, smartphones can be used for sending text messages and using social networking sites, but also for looking up information on the internet and watching videos. Therefore, to understand what adolescents actually do when using these devices during offline conversations, it is crucial to examine which specific media activities they engage in. Only a few studies have examined more specific media activities during offline conversations among college students and adolescents, such as playing video games, sending text messages, and using social media (e.g., Fulkerson et al., 2014; Pea et al., 2012; Xu, Wang, & David, 2016). For example, Fulkerson et al. (2014) examined various types of media activities among adolescents during family mealtime as reported by parents. According to two thirds of the parents, their adolescent sometimes watched television or movies during family mealtime, while a quarter of the parents indicated that their children frequently watched television or a movie. Additionally, 28% of the parents reported that their adolescent at least sometimes engaged in text messaging.

Investigating specific media activities instead of just looking at devices that are used, allows us to draw a detailed picture of the media activities that adolescents engage in during offline conversations. Moreover, this approach allows us to categorize these behaviors in a

more meaningful way. Specifically, based on media use categorizations in previous research (Elhai, Levine, Dvorak, & Hall, 2017; Song, Larose, Eastin, & Lin, 2004; van Deursen, Bolle, Hegner, Kommers, 2015; Xu et al., 2016), we distinguish between two main types of TIDOC, social and non-social TIDOC. Social TIDOC involves media activities that are predominantly used for social reasons, for example, sending text messages, using social networking sites, and calling. Non-social TIDOC includes media activities that are mainly used for entertainment or relaxation purposes, such as watching television, listening to music, and playing video games. This distinction will provide a more theory-driven understanding of TIDOC. As specific media activities rapidly change over time, due to ongoing technological developments, categorizing such behaviors may help to understand TIDOC on a theoretical rather than technological-driven basis.

In all, we still know little about the prevalence of TIDOC in general and about which types of media activities adolescents engage in during offline conversations. For this reason, the current study aims to measure TIDOC broadly by examining a wide array of media activities and by distinguishing between social and non-social technology-related behaviors. We propose the following two research questions:

> RQ1a: Which types of media activities do adolescents engage in during offline conversations?
>
> RQ1b: How frequently do adolescents engage in these media activities during offline conversations?
>
> RQ2: Do adolescents more frequently engage in social or non-social media activities during offline conversations?

Differences among boys and girls. Studies among adolescents have repeatedly shown that girls more frequently engage in various media multitasking behaviors than boys (e.g., Foehr, 2006; Rideout et al., 2010; Baumgartner, Weeda, van der Heijden, & Huizinga, 2014). Foehr (2006) found that girls more frequently use multiple media simultaneously than boys. Furthermore, girls more often use media during non-media activities, such as during homework or face-to-face interactions (Baumgartner et al., 2014). Although our specific knowledge of adolescent sex differences in TIDOC is limited, a few studies suggest that girls more frequently engage in TIDOC. A study among college students showed that the amount of phubbing is higher among women compared to men (Chotpitayasunondh & Douglas, 2016). Similarly, a study among adolescents found that girls more frequently used technologies during family mealtimes than boys (Fulkerson et al., 2014). Thus, based on our current knowledge, our first hypothesis is that girls are more likely to engage in TIDOC than boys (H1). Moreover, as researchers have argued that girls are more likely to use technologies for social purposes than boys (van Deursen et al., 2015, Yang & Zhu, 2015),

we expect that this difference is particularly present for social TIDOC (H2).

The Relationship between Technological Interferences and Emotional Problems

It has been assumed that frequently using technologies during offline conversations may be positively related to emotional problems. Several, cross-sectional studies support these claims among college students and adults (e.g., David & Roberts, 2017; McDaniel & Coyne, 2016a; Roberts & David, 2017; Wang et al., 2017). For example, McDaniel and Coyne (2016a) found that adults who more frequently used technological devices, such as smartphones, computers, or tablets, during offline interactions with their romantic partner reported more symptoms of depression and lower life satisfaction. Similarly, Wang et al. (2017) showed that phubbing among romantic partners was related to more depressive symptoms.

It has been argued that TIDOC may enhance emotional problems, through two main mechanisms. First, it may hinder adolescents' relationships with their friends due to the repeated disruption of offline conversations. Second, it may lead to higher levels of stress that in turn increase emotional problems. With respect to the first mechanism, TIDOC may lead to a lower quality of offline relationships because if offline conversations are repeatedly disturbed, adolescents may not be able to build and maintain healthy relationships with others. When using technologies during offline conversations, it is not possible to pay attention to and process both, the information provided by the conversation partner and the information contained in the media (e.g., Bowman, Levine, Waite, & Gendron, 2010; Ophir, Nass, & Wagner, 2009). This assumption is based on cognitive learning theories which state that an individual's cognitive resources are limited (Lang, 2000, 2006).

Thus, adolescents who use technologies during conversations may pay less attention to and insufficiently process information provided by the conversation partner, which is likely to hinder the quality of the conversations (Leggett & Rossouw, 2014). In line with this assumption, two studies among young adults found that the mere presence of technological devices during a face-to-face conversation was related to less perceived empathic concern, and less interpersonal connection with the conversation partner (Misra, Cheng, Genevie, & Yuan, 2016; Przybylski & Weinstein, 2013). Additionally, two other studies found that the actual use of a smartphone during a conversation was negatively related to conversation quality among college students (Brown, Manago, & Trimble, 2016; vanden Abeele et al., 2016). For example, vanden Abeele and colleagues found that participants were less positive about the conversation and reported lower conversation quality when they had been instructed to use their mobile phone and send text messages during a conversation with a confederate peer.

This lower quality of conversations may in the long run adversely affect adolescents' relationships. It is thus not surprising that several previous studies have found that TIDOC

was associated with a lower quality of offline relationships (e.g., Halpern & Katz, 2017; Roberts & David, 2017; Wang et al., 2017; Xu et al., 2016). For example, Xu et al. (2016) found that among college students using media while having face-to-face interactions was negatively related to social success (i.e., the perception of having friends). In addition, studies that have investigated the role of TIDOC in romantic relationships found that TIDOC was adversely related to relationship satisfaction (Halpern & Katz, 2017; Roberts & David, 2017; Wang et al., 2017). High quality relationships, however, are crucial for adolescents' emotional well-being (Hartup, 1996; Hartup & Stevens, 1997), and may help to prevent emotional problems among adolescents. For example, adolescents with stronger social relationships reported higher levels of happiness (Hartup & Stevens, 1997). In addition, friendships can provide emotional support and therefore provide a buffer against stressors (e.g., Bukowski, 2001; Hartup, 1996; Hefner & Eisenberg, 2009). In sum, TIDOC might result in emotional problems as it negatively effects relationships with others.

With respect to the second mechanism, the cognitive demands resulting from TIDOC, may evoke stress (Reinecke et al., 2017). The transactional theory of stress (Lazarus & Folkman, 1987) posits that when activities are cognitively demanding, these activities are more likely to trigger stress responses (e.g., Lepp, Barkley, & Karpinski, 2014; Thomée, Härenstam, & Hagberg, 2011). In line with the assumption that TIDOC may be experienced as stressful, several studies already demonstrated that other types of media multitasking are positively associated with stress, assessed by both physiological and subjective measures (Mark, Gudith, & Klocke, 2008; Mark, Wang, & Niiya, 2014).

Stress has been positively related to several aspects of emotional problems, such as symptoms of depression, emotional distress, and a negative self-image (e.g., Dumont & Provost, 1999; Moksnes, Moljord, Espnes, & Byrne, 2010; Wiklund, Malmgren-Olsson, Ohman, Bergstrom, & Fjellman-Wiklund, 2012). In addition, stress predicted a rise in depressive symptoms over time (Carter, Garber, Ciesla, & Cole, 2006; Hankin, Mermelstein, & Roesch, 2007). Taken together, as TIDOC - similar to other forms of media multitasking - may be experienced as stressful, it is expected that TIDOC is positively related to adolescents' emotional problems and will positively predict their emotional problems over time.

Based on the above explanations, we expect that adolescents who report more TIDOC show more emotional problems (H3). Moreover, we predict that TIDOC is related to more emotional problems over time (H4). In addition, Roberts and David (2017) suggested that non-social TIDOC (e.g., television viewing) may be less disruptive than social TIDOC (e.g., interacting with friends). Thus, although our knowledge is limited, the relationship between TIDOC and emotional problems may differ for social and non-social TIDOC. Therefore, next to overall TIDOC, we will also examine the relationships of social and non-social TIDOC with emotional problems, resulting in the following research question (RQ3): Does

the relationship between TIDOC and emotional problems depend on the specific type of TIDOC (i.e., social and non-social TIDOC)?

Differences among boys and girls. Several researchers have argued that there may be differences between boys and girls in the relationship between TIDOC and emotional problems as well (Chotpitayasunondh & Douglas, 2016; McDaniel & Coyne, 2016a; Pea et al., 2012). Studies suggest that girls may be more susceptible for the impact of TIDOC on emotional problems. In general, girls more often experience emotional problems, such as depressive symptoms, than boys (Hankin & Abramson, 2001). Furthermore, researchers have argued that girls value their peer relationships more than boys (Thomas & Daubman, 2001). Therefore, girls may also be more emotionally affected when their peer relationships are disrupted by TIDOC. Based on these research findings, we expect that the concurrent and longitudinal relationships between TIDOC and emotional problems are stronger in girls than in boys (H5).

METHOD

Sample

This study was part of a three-wave longitudinal study with three-to-four month intervals (Wave 1: early November 2014, Wave 2: early March 2015, and Wave 3: end of June 2015). Adolescents where recruited at seven secondary schools in the Netherlands. Participants were excluded if they reported incorrect identification numbers or had missing values on all main variables (N_{Wave1} = 27; N_{Wave2} = 38; N_{Wave3} = 71). The total sample consisted of 1,441 adolescents who filled out the survey in at least one wave (M_{age} = 12.61, SD_{age} = 0.75; 51% boys). Because it was not possible to schedule the data collection for all classes in each wave, some classes did not participate in all three waves. Specifically, of the total sample, 904 participants (63%) filled out the survey in each of the three waves, 311 participants (22%) in two waves, and 226 participants (15%) in one wave. For the descriptive and cross-sectional findings, the participants of each wave were included (N_{Wave1} = 1,241; N_{Wave2} = 1,216; N_{Wave3} = 1,103), whereas for the longitudinal findings we used the data of the total sample (N = 1,441).

Procedure

We received approval from the ethical committee of the authors' institute. Thereafter, Dutch schools were contacted. Seven schools were willing to participate. Together with these schools, we selected the classes and retrieved passive informed consent of the participants' parents. Before the participants filled out the survey, informed assent was obtained. Specifically, we explained the content of the survey to the participants and assured that their participation was completely confidential and voluntary. The survey was filled out online during class, which took approximately 30 minutes. To thank the

participants for their participation, we handed out small incentives to the participants after filling out the survey in each wave.

Measurements

Technological interferences during offline conversations. To measure TIDOC, participants had to indicate how frequently they typically engage in the following eight types of media activities during a face-to-face conversation: (1) watching television, (2) listening to music, (3) talking on the phone, (4) sending messages via phone or computer, (5) using social network sites, (6) watching movies on the computer, (7) playing video games, and (8) other computer activities. Participants indicated their TIDOC behaviors on a five-point scale, with 0 = *never*, 1 = *almost never*, 2 = *sometimes*, 3 = *often*, and 4 = *very often*[2].

For overall TIDOC, we computed the average of the eight items into one mean for each wave (Wave 1: *M* = 1.14, *SD* = 0.79, Cronbach's alpha = .84; Wave 2: *M* = 1.14, *SD* = 0.82, Cronbach's alpha = .86; Wave 3: *M* = 1.16, *SD* = 0.84, Cronbach's alpha = .87). For social TIDOC, we calculated an average of the three items that included the use of technologies for social reasons, that is talking on the phone, sending messages via phone or computer, and using social network sites (Wave 1: *M* = 1.20, *SD* = 0.97, Cronbach's alpha = .73; Wave 2: *M* = 1.21, *SD* = 0.98, Cronbach's alpha = .76; Wave 3: *M* = 1.21, *SD* = 0.97, Cronbach's alpha = .75). For non-social TIDOC, we computed the average of the remaining five items that all reflected the use of technologies for non-social reasons (Wave 1: *M* = 1.10, *SD* = 0.81, Cronbach's alpha = .76; Wave 2: *M* = 1.11, *SD* = 0.85, Cronbach's alpha = .79; Wave 3: *M* = 1.13, *SD* = 0.98, Cronbach's alpha = .81). Higher scores indicated more frequent TIDOC.

Emotional problems. To measure emotional problems, we used the emotional problems scale of the Strengths and Difficulties Questionnaire (SDQ, Goodman, 1997). This measure has been successfully used in previous studies that have examined emotional problems and is highly correlated with other scale focused on measuring symptoms of depression and anxiety (Stone, Otten, Engels, Vermulst, & Janssens, 2010), The emotional problems scale consisted of five items and are rated on a three-point scale, 0 = *not true*, 1 = *somewhat true*, and 2 = *certainly true*. Example items are 'I worry a lot' and 'I am often unhappy, depressed or tearful'. We averaged the five items into one mean index (Wave 1: *M* = 0.55, *SD* = 0.45, Cronbach's alpha = .70; Wave 2: *M* = 0.54, *SD* = 0.46, Cronbach's alpha = .73; Wave 3: *M* = 0.58, *SD* = 0.48, Cronbach's alpha = .77). Higher scores on emotional problems scale implied more emotional problems.

[2] Reading was originally also included in this measure, but because the focus in of this paper is on media activities performed on technological devices and reading was rarely reported among adolescents, we excluded this item from this study.

Analyses

In SPSS, we examined the frequency and the specific types of media activities in Wave 1 (RQ1), we used Paired sampled *t*-tests to examine differences between social and non-social TIDOC (RQ2), and we used One-Way ANOVA's to investigate the possible differences between boys and girls in TIDOC (H1 & H2). Sex was coded as 0 = *boy* and 1 = *girl*. In addition, we used Pearson's *r* to examine the cross-sectional relationships between TIDOC and emotional problems (H3) and PROCESS to investigate if this relationship differs among boys and girls (H5). To examine the longitudinal relationships between TIDOC and emotional problems (H4) and the moderating role of sex (H5), we applied structural equation modeling. Specifically, we employed the random intercept cross-lagged panel model (RI-CLPM; Hamaker, Kuiper, & Grasman, 2015).

The RI-CLPM model is a recent adaptation of commonly used cross-lagged models in that it splits between-person variance from within-person variance (see Keijsers, 2016; Samek et al., 2017; te Poel, Baumgartner, Hartmann, & Tanis, 2016, for applications of this model). Thereby, the RI-CLPM provides insights in the stable between-person relationship and within-person relationships over time. Additionally, it controls for all stable confounders at the within-person level. However, to explore these within-person relationships, within-person variance is needed. Based on the intra-class correlations (ICC), we concluded that all variables showed sufficient within-person variance (overall TIDOC = 44%; social TIDOC = 43%; non-social TIDOC = 50% emotional problems = 42%), meaning that substantial parts of the variances were due to within-person changes over time.

For each of the three types of TIDOC (i.e., overall, social, and non-social TIDOC) we ran a RI-CLPM, resulting in three models. The RI-CLPMs were examined using the statistical program Mplus 7 (Muthén & Muthén, 2012). We carefully followed the procedures discussed by Hamaker and colleagues (2015); see Figure 1 for an illustration of the model. At the between-person level, the observed scores of TIDOC and emotional problems at all waves were the indicators of the two random intercept factors. These random intercept factors reflected the between-person variance of TIDOC and emotional problems. The factor loadings were constrained at 1. In addition, a covariance was added between the two random intercept factors, to control for the between-person correlation. This between-person correlation reflects the association between the stable rank order position of an individual in TIDOC and the stable rank order position of an individual's emotional problems across the school year.

At the within-person level, each observed variable was regressed on its own latent factor resulting in six within-person latent factors (TIDOC Wave 1 to Wave 3 and emotional problems Wave 1 to Wave 3), with each loading constrained to 1. These latent factors reflect the within-person variances. Between these six within-person latent factors, stability paths, cross-lagged paths, a covariance at Wave 1, and covariances between the

disturbances at Wave 2 and Wave 3 were added, see Figure 1. We also included the cross-lagged paths from emotional problems to subsequent TIDOC, to control for this direction of the relationship. Both the stability and the cross-lagged paths were constrained to be equal from Wave 1 to Wave 2 and from Wave 2 to Wave 3. We employed Full Information Maximum Likelihood (Muthén & Muthén, 2012) to deal with missing data across the three waves. We used multiple fit indices to examine the model fit of our models (e.g., Kline, 2004). The chi-square measure was used to examine exact fit of the model, with *p*-values below .05 indicating exact fit. RMSEA values below .05 and CFI values above .95 indicated good fit.

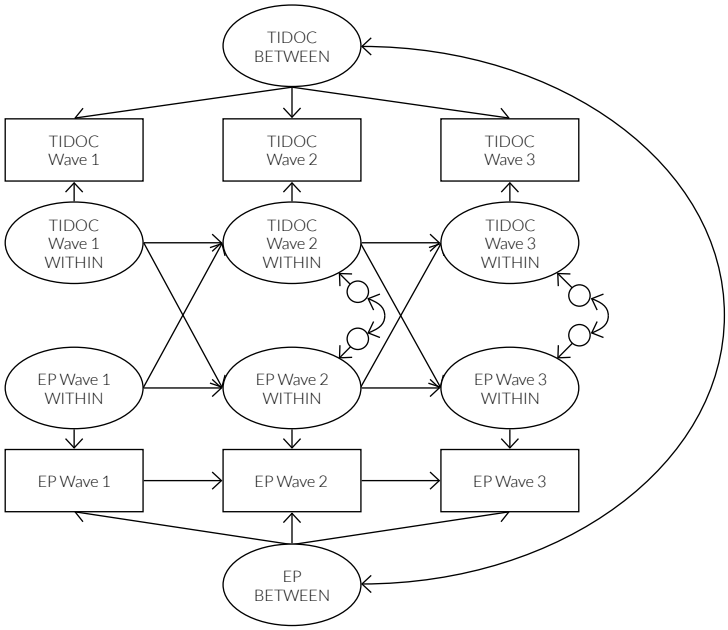

Figure 1. A depiction of a random intercept cross-lagged panel model including the relationships between technological interferences during offline conversations (TIDOC) and emotional problems (EP) across the three waves. The observed variables are represented in the squares. Of these observed variables, latent variables at both the between- and within level were constructed. These latent variables are displayed as ovals. The two random intercepts (TIDOC BETWEEN and EP BETWEEN) reflect the between-person variances. The six latent within-person variables (TIDOC WITHIN Wave1 –Wave 3 and EP WITHIN Wave 1-Wave 3) reflect the within-person variances. The within-person paths are illustrated by the modeling structure between the six latent within-person variables: two autoregressive paths from the latent factors of TIDOC WITHIN to TIDOC WITHIN and two autoregressive paths from the latent factors of EP WITHIN to EP WITHIN; two cross-lagged paths from the latent factors of TIDOC WITHIN to EP WITHIN and two cross-lagged paths from the latent factors of EP WITHIN to TIDOC WITHIN; correlation between TIDOC WITHIN and EP WITHIN at Wave 1, and between the residual correlations of TIDOC WITHIN and EP WITHIN at Waves 2 and 3.

RESULTS

TIDOC among Adolescents

To answer RQ1 we examined the TIDOC scale at item level. In Table 1, the means, standard deviations, and percentages for the items of the TIDOC scale at Wave 1 are presented. Adolescents most frequently engaged in texting (i.e., reading and sending text messages) during offline conversations, followed by watching television, listening to music, using social networking sites, and playing video games. Specifically, more than half of the adolescents reported that they at least sometimes engaged in reading or sending text messages during offline conversations. In addition, between approximately 35% and 50% of the adolescents reported that they at least sometimes watched television during offline conversations, listened to music, used social networking sites, and played video games. Although the other three media activities, watching online videos, doing other things on the computer, and calling during offline conversations, were less common, still 14 to 25% of the adolescents reported that they at least sometimes engaged in them.

Table 1. The Means, Standard Deviations and Percentages for the Eight Items of the TIDOC Scale.

			Percentages				
During conversations,	*M*	*SD*	0	1	2	3	4
... I read or send messages	1.75	1.30	22	22	28	17	12
... I watch television	1.49	1.14	23	28	29	15	5
... I listen to music	1.31	1.23	35	20	22	12	8
... I use social networking sites	1.30	1.30	39	20	22	11	8
... I play video games	1.16	1.23	42	21	21	11	5
... I watch movies on the internet	0.84	1.10	53	23	15	6	4
... I do other things on the computer/internet	0.72	1.00	57	23	14	4	2
... I call someone	0.56	1.00	68	17	8	3	3

Note: TIDOC = technological interferences during offline conversations; 0 = *Never*; 1 = *Almost never*; 2 = *Sometimes*; 3 = *Often*; 4 = *Always*.

To examine our second research question (RQ2), we tested whether there were differences in the prevalence of social and non-social TIDOC among adolescents. The means showed that social TIDOC (Wave 1: $M = 1.20$, $SD = 0.97$; Wave 2: $M = 1.21$, $SD = 0.98$; Wave 3: $M = 1.21$, $SD = 0.97$) was more prevalent among adolescents than non-social TIDOC (Wave 1: $M = 1.10$, $SD = 0.81$; Wave 2: $M = 1.11$, $SD = 0.84$; Wave 3: $M = 1.13$, $SD = 0.85$). Paired sampled *t*-tests showed that these differences were significant in all three waves (Wave 1: $t(1237) = 4.62$, $p < .001$; Wave 2: $t(1213) = 4.89$, $p < .001$; Wave 3: $t(1099) = 3.92$, $p < .001$).

Table 2. The Differences in Overall, Social, and Non-Social TIDOC in all Three Waves in Boys and Girls.

	Boys		Girls			
	M	*SD*	*M*	*SD*	*F*	*p*
Overall TIDOC W1	1.11	0.80	1.18	0.79	2.53	.112
Overall TIDOC W2	1.11	0.84	1.18	0.80	1.81	.178
Overall TIDOC W3	1.10	0.81	1.21	0.87	4.59	.032
Social TIDOC W1	1.02	0.94	1.39	0.98	44.38	<.001
Social TIDOC W2	1.07	0.98	1.36	0.96	27.18	<.001
Social TIDOC W3	1.04	0.91	1.38	1.01	35.28	<.001
Non-Social TIDOC W1	1.15	0.84	1.05	0.78	4.99	.026
Non-Social TIDOC W2	1.14	0.86	1.07	0.81	2.27	.132
Non-Social TIDOC W3	1.14	0.84	1.11	0.85	0.40	.525

Note: TIDOC = Technological interferences during offline conversations; W1 = Wave 1; W2 = Wave 2; W3 = Wave 3.

Demographic correlates. As for our first hypothesis (H1) and second hypothesis (H2), we examined if girls were more likely to engage in TIDOC than boys. In Table 2, the means for both sexes and the test statistics are provided. With respect to overall TIDOC, although the means in general indicated that girls more often engaged in TIDOC, the differences between boys and girls in Wave 1 and Wave 2 were not significant. However, in Wave 3 we found that girls reported more overall TIDOC compared to boys. For social TIDOC the differences between girls and boys were more consistent. Within all three waves, girls were more likely to engage in social TIDOC than boys. This is in line with H2. For non-social TIDOC, the means indicated that boys were more likely to engage in non-social TIDOC than girls. However, this difference was only significant in Wave 1.

TIDOC and Emotional Problems

Cross-sectional relationships. Overall, the different types of TIDOC were positively correlated with emotional problems in all waves, see Table 3. This means that adolescents who reported more TIDOC also reported more emotional problems. This is in line with H3.

Table 3. Zero-order Pearson Correlations, Means, and Standard Deviations for the Three Types of TIDOC (Overall, Social, and Non-Social) and Emotional Problems.

		1			2			3			4		
		W1	W2	W3	W1	W2	W3	W1	W2	W3	W1	W2	W3
1	Overall TIDOC	-	-	-									
2	Social TIDOC	.87**	.89**	.91**	-	-	-						
3	Non-Social TIDOC	.94**	.95**	.96**	.64**	.70**	.74**	-	-	-			
4	Emotional problems	.06†	.14**	.22**	.03	.11**	.21**	.06*	.15**	.21**	-	-	-
5	Sex (0 = *boy*)	.05	.04	.06*	.19**	.15**	.18**	-.06*	-.04	-.02	.18**	.21**	.16**
	M	1.14	1.14	1.16	1.20	1.21	1.21	1.10	1.11	1.13	0.55	0.54	0.58
	SD	0.79	0.82	0.84	0.97	0.98	0.97	0.81	0.85	0.98	0.45	0.46	0.48

Note: $^{**}p < .001$; $^{*}p < .05$; $^{\dagger}p < .06$. TIDOC = technological interferences during offline conversations; W1 = Wave 1; W2 = Wave 2; W3 = Wave 3.

Longitudinal relationships. We examined three models to test the longitudinal relationships between the three types of TIDOC (i.e., overall, social, and non-social TIDOC) and emotional problems. The three models showed good model fit (overall TIDOC: χ^2 (5) = 4.60, p = .466, RMSEA = .00 (90% CI [.00, .04]), and CFI = 1.00; social TIDOC: χ^2 (5) = 10.89, p = .054, RMSEA = .03 (90% CI [.00, .05]), and CFI = 1.00; non-social TIDOC: χ^2 (5) = 2.89, p = .717, RMSEA = .00 (90% CI [.00, .03]), and CFI = 1.00). For all three models, we found moderate between-person correlations between the random intercept factors of the specific types of TIDOC and emotional problems, see Table 4. These findings imply that adolescents who more often reported TIDOC, reported more emotional problems accross the school year.

Table 4 also provides an overview of the main within-person processes of the three models. The within-person processes reflect if changes in adolescents' TIDOC predict changes in their emotional problems, and if changes in adolescents' emotional problems predicts changes in their TIDOC. With respect to the cross-lagged relationships, all three types of TIDOC were not significantly related to subsequent emotional problems from Wave 1 to Wave 2 nor from Wave 2 to Wave 3. These findings do not support H4.

Demographic moderators. To examine H5, we also examined the possible moderating role of sex cross-sectionally and longitudinally. The Moderation Analysis via PROCESS (Model 1) showed that the cross-sectional relationships between the three different types of TIDOC and emotional problems did not differ among boys and girls (see Appendix B). Similarly, we examined the moderating role of sex using multiple group analyses in the RI-CLPM, and, again, we found no support for differences among boys and girls (see Appendix C).

Table 4. The Standardized Between-Person and Within-Person Correlations between the Three Types of TIDOC (Overall, Social, and Non-Social TIDOC) and Emotional Problems.

	Model 1 Overall TIDOC		Model 2 Social TIDOC		Model 3 Non-Social TIDOC	
Between-person correlation						
TIDOC & Emotional Problems	.20**		.21**		.18*	
Within person correlations	W1-W2	W2-W3	W1-W2	W2-W3	W1-W2	W2-W3
Stability paths						
TIDOC	.20**	.21*	.13*	.13*	.18**	.19*
Emotional Problems	.16*	.15*	.16*	.15*	.15*	.14
Cross-lagged paths						
TIDOC → Emotional Problems	.05	.05	.01	.01	.07	.07
Emotional Problems → TIDOC	-.01	-.01	-.05	-.05	.01	.01

Note: $^{**}p < .001$; $^{*}p < .05$. TIDOC = technological interferences during offline conversations; W1 = Wave 1; W2 = Wave 2; W3 = Wave 3.

DISCUSSION

Studies that examined technological interferences during offline conversations (TIDOC) and their relationship with emotional problems among adolescents were lacking. This is surprising because adolescents frequently engage in the simultaneous use of multiple media (Rideout et al., 2010), which is known to be closely related to TIDOC (Pea et al., 2012). Furthermore, examining the relationship between TIDOC and emotional problems may be particularly important during adolescence as emotional problems increase during this developmental stage (e.g., Costello et al., 20003). Therefore, the first aim of this study was to examine the frequency and types of TIDOC among adolescents and the possible differences among boys and girls. To do this, we examined specific media activities, and categorized these behaviors into social and non-social forms of TIDOC. In addition, we examined if TIDOC (overall, social, non-social) differed among boys and girls. Finally, we investigated the cross-sectional and longitudinal relationships between TIDOC (overall, social, non-social) and emotional problems, and the moderating role of sex.

Technological Interferences during Offline Conversations Among Adolescents

To further our insight in TIDOC during adolescence, we investigated eight specific TIDOC behaviors. Of these eight behaviors, five media activities were particularly prominent during offline conversations, namely text messaging, watching television, listening to music, using social networking sites, and playing video games. The finding that adolescents mainly engage in these five media activities during offline conversations is largely in line with a study on media multitasking among adolescents (Baumgartner, Lemmens, Weeda,

Huizinga, 2016). Specifically, Baumgartner and colleagues suggested that adolescent' media multitasking behaviors predominantly evolve around text messaging, watching television, listening to music, and using social networking sites. The current findings indicate that these media activities are also frequently used during offline conversations.

With respect to the five main types of media activities, the findings of our study indicate that adolescents commonly engaged in these behaviors during their offline conversations. Overall, the percentages of TIDOC in our study were somewhat higher than in the study of Fulkerson et al. (2016). This could be due to the different social settings of the studies. While this study focused on offline conversations in general, Fulkerson and colleagues focused specifically on media use during family mealtimes. This stresses the need to advance our understanding of TIDOC among adolescents in different social settings. In addition, we also distinguished between two types of TIDOC, namely social and non-social TIDOC. Adolescents more frequently engaged in social than non-social TIDOC. The higher prevalence of social TIDOC is supported by research that showed that media multitasking behavior among adolescents typically involves social media activities, for example, using social networking sites and sending text messages (Baumgartner et al., 2016; Pea et al., 2012). This finding supports the claims that particularly social media interrupt everyday activities (Roberts & David, 2016).

In line with our expectation (H2), we found that social TIDOC was particularly prevalent among girls. It has been previously argued that girls are particularly drawn to the social aspects of media activities (Sánchez-Martinez & Otero, 2009; van Deursen et al., 2015), and therefore they may be less likely to resist the urge to engage in these behaviors during offline conversations. For example, a previous study (Beyens, Frison, & Eggermont, 2016) indicated that adolescent girls generally report a higher fear of missing out than adolescent boys, which in turn was related to using Facebook more frequently. In contrast, boys seemed to engage more often in non-social TIDOC than girls. Although the difference between boys and girls in non-social TIDOC was only significant in Wave 1, it may be important to further examine this difference in the future. Studies have indicated that boys in general engage more often in non-social media activities, such as watching television and playing video games (e.g., Babey, Hastert, & Wolstein, 2013; Borgogna et al., 2015). Overall, the current findings support the notion that girls and boys differ in the specific types of media activities they engage in during offline conversations.

The Relationship between Technological Interferences and Emotional Problems

In line with previous studies (e.g., McDaniel & Coyne, 2016a; Wang et al., 2017), we found that TIDOC was positively related to emotional problems. As expected, adolescents who reported more frequent TIDOC, reported more emotional problems. These relationships were observed for overall, social, and non-social TIDOC. However, concerning the longitudinal relationship of TIDOC and emotional problems, we found no empirical

evidence for TIDOC further increasing emotional problems among adolescents. This suggests that TIDOC may not have a long-term effect on adolescents' emotional problems. In addition, we found no sex differences for both the cross-sectional and longitudinal relationships between the three types of TIDOC and emotional problems. Together, our results indicate that adolescents who reported more TIDOC also reported more emotional problems during the school year, but that engaging in TIDOC does not further increase these emotional problems. In contrast to previous expectations (e.g., McDaniel & Coyne, 2016a; Wang et al., 2017), the cross-sectional relationship between TIDOC and emotional problems may thus not mean that TIDOC increases emotional problems in the long run. The present findings might suggest that adolescents with emotional problems are more likely to engage in TIDOC, rather than emotional problems being a consequence of TIDOC.

Another explanation for the lack of support for the longitudinal effect of TIDOC on emotional problems is that adolescents may use media and communication technologies as facilitators of their conversations. Although the main assumption is that communication devices interrupt the offline conversations, they may actually facilitate them. When adolescents use these media and communication devices as facilitators for their offline conversations, this may not interrupt but rather extend or inspire the offline interaction. For example, adolescents may use their smartphone during offline conversations with peers to show pictures or search for information online.

Moreover, researchers have argued that TIDOC may have become socially acceptable behavior among young people, in particular (Sprecher, Hampton, Heinzel, & Felmee, 2016; Miller-Ott & Kelly, 2017; Xu et al., 2016). While paying full attention to offline conversations is traditionally seen as normative behavior, these social norms may be changing (Forgays, Hyman, & Schreiber, 2014), in response to the dramatic rise in the availability and role of media and communication devices in society (Sprecher et al., 2016). Specifically, Sprecher et al. (2016) argued that adolescents may find a way to use such devices without interrupting the conversation.

Besides these theoretical explanations for the absence of the longitudinal relationship between TIDOC and emotional problems in this study, there are also methodological explanations for this absence. For example, it could be that there are specific contextual factors that may affect the longitudinal relationship between TIDOC and emotional problems. For example, a recent study showed that smartphone use by the romantic partner was particularly perceived as negative within specific contexts, for example, when one of the partners expected more attention from the other (Kelly, Miller-Ott, & Duran, 2017). Additionally, although we have looked at sex as a moderator, this may still not capture the wide variability within adolescents. Thus, both contextual as well as individual differences may affect the relationship between TIDOC and emotional problems.

Suggestions for Future Research

The present study provided much needed evidence for TIDOC among adolescents. Future studies are advised to focus on the following three main directions. First, as this study is one of the first in its kind, it is valuable that future studies advance our knowledge on TIDOC among adolescents. Although we included a wide variety of media activities, we do not know why and with whom adolescents used these technologies. For example, it could be that adolescents sometimes use these technologies to facilitate their offline conversations, instead of disrupting them. Additionally, the frequency of TIDOC may depend on specific types of conversation partners, for example, family members, friends, or romantic partners. Similar to the existing studies on phubbing that focused on interactions with the romantic partner (e.g., McDaniel & Coyne, 2016a; Wang et al., 2017), it might be important to study TIDOC in a friend setting separately from TIDOC in a family setting, or a partner setting. Thus, future studies are advised to examine adolescents' motivations for TIDOC and the various contexts in which TIDOC occurs.

Second, future researchers are advised to examine if the norms for TIDOC are changing among adolescents. Although researchers generally assume that media and communication technologies interfere with offline conversations, adolescents may not perceive it like this. Therefore, when examining the impact of TIDOC on adolescents' emotional problems it is critical to examine whether adolescents view the use of media and communication technologies as problematic or impolite (Coyne et al., 2012). It could also be that adolescents differ in this perception, and this might explain possible individual differences in the relationship between TIDOC and emotional problems.

Lastly, particularly with respect to the relationship between TIDOC and emotional problems, future studies are advised to examine a wider range of outcome variables and examine underlying mechanisms. For example, we focused on one specific measure of emotional problems. Therefore, other studies could include broader measures of emotional functioning, for example, by focusing on both measures of emotional problems and emotional well-being, such as social anxiety and life satisfaction. With respect to the underlying mechanisms, future studies could focus on processes that may explain the relationship between TIDOC and adolescents' emotional problems, most notably quality of offline relationships and stress.

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CHAPTER 4

Media Multitasking and Sleep Problems: A Longitudinal Study among Adolescents

ABSTRACT

The rise in media multitasking among adolescents has led to serious concerns regarding its possible negative impact on sleep. Although cross-sectional studies have shown a link between media multitasking and sleep problems, knowledge about the causal direction is lacking. In a first step to understand causality, we investigated the longitudinal association between media multitasking and sleep problems among 1,443 adolescents (7th and 8th graders, 11-15 years, 51% boys), who completed a questionnaire three times at three-to-four month intervals. We employed random intercept cross-lagged panel models, which specifically examine cross-lagged correlations within (rather than between) individuals. The findings showed no cross-lagged correlations for the overall sample. However, the results indicated that, for 7th graders and girls, media multitasking was (marginally) related to more subsequent sleep problems. Our findings provide first evidence that media multitasking may affect the sleep of 7th graders and girls.

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Adolescents are growing up in technologically immersive environments. Due to the ongoing development of mobile media devices, young people have access to media 24/7. Consequently, along with the increased amount of time that adolescents spend using media, how they use media has changed dramatically (Rideout, Foehr, & Roberts, 2010). More than ever before, young people use multiple media devices simultaneously or switch rapidly between media on a single device – a behavior that is referred to as media multitasking. Over the past twenty years, the proportion of media time that eleven- to eighteen-year-olds spend media multitasking has expanded from 16% to 29% (Rideout et al., 2010). In the same period, concerns and research about the possible adverse consequences of media multitasking on adolescents' development have rapidly accumulated (van der Schuur, Baumgartner, Sumter, & Valkenburg, 2015).

Adolescence is a unique developmental phase, characterized by the continuing maturation of cognitive, emotional, and social domains of functioning (e.g., Burnett, Sebastian, Kadosh, & Blakemore, 2011). Growing evidence shows that sleep plays a crucial role in the healthy development of adolescents (Shochat, Cohen-Zion, & Tzischinsky, 2014). Sleep problems have been found to disrupt adolescents' functioning, such as their psychosocial health and academic performance (e.g., Owens, 2014). Sleep problems are multifaceted and include various aspects of sleep-related disturbances, such as shortness of sleep, night awakenings, and difficulties falling asleep (Cain & Gradisar, 2010). These sleep problems typically manifest themselves in increased feelings of sleepiness during the day, which may hinder adolescents' everyday functioning in multiple ways (Cain & Gradisar, 2010; van Maanen et al., 2014). Although the need for healthy sleep in adolescence is widely recognized, sleep problems are common in this phase of life (Gradisar, Gardner, & Dohnt, 2011), and have significantly increased in recent decades (e.g., Keyes, Maslowsky, Hamilton, & Schulenberg, 2015). Estimates of the prevalence of sleep problems among adolescents range from approximately 25% to 40% (Kilincaslan, Yilmaz, Batmaz Oflaz, & Aydin, 2014; Ohayon, Roberts, Zulley, Smirne, & Priest, 2000).

The simultaneous increase in media use and sleep problems among adolescents has captured the attention of researchers. A growing body of research has found that the use of screen-based media (e.g., the time spent watching television or playing videogames) has a negative influence on adolescents' sleep (e.g., Cain & Gradisar, 2010). Recently, researchers have suggested that media multitasking may also contribute to the high rates of sleep problems among adolescents (Calamaro, Mason, & Ratcliffe, 2009). However, only three studies have examined the relationship between media multitasking and sleep problems. These studies showed that media multitasking was related to shortened sleep (Calamaro et al., 2009; Mark, Wang, Niiya, & Reich, 2016; Pea et al., 2012), more difficulties in falling asleep, and daytime sleepiness (Calamaro et al., 2009).

Although these three studies have provided preliminary evidence for the relationship between media multitasking and sleep problems, two main shortcomings in the current literature on media multitasking warrant our attention. First, due to the cross-sectional nature of the available studies, there is as yet no evidence of the causal direction of the relationship between media multitasking and sleep problems. Second, although contemporary media effects theories (e.g., Slater, 2015; Valkenburg & Peter, 2013) have repeatedly pointed at the importance of examining individual differences in the susceptibility to media effects, most previous media multitasking studies have failed to assess the moderating influence of even the standard demographic factors like age and sex. Therefore, the present study employed a three-wave panel design in a first attempt to understand the causal direction of the relationship between media multitasking and sleep problems, and to examine the moderating role of age and sex.

The Causal Direction of the Relationship between Media Multitasking and Sleep Problems

Although researchers generally assume that media multitasking interferes with adolescents' healthy sleep, the relationship between media multitasking and sleep problems may be more complex than previously assumed. Most contemporary media effect theories posit that media effects are transactional (Bandura, 2001; Knobloch-Westerwick, 2014; Slater, 2015; Valkenburg, Peter, & Walther, 2016). These theories assume reciprocal causal relationships between media use and media outcomes, resulting in predictive paths both from media use to media outcomes and from these outcomes to media use (e.g., Bandura, 2001; Slater, 2015). Based on theories of transactional media effects, we anticipate that a reciprocal causal relationship also holds for the relationship between media multitasking and sleep problems. That is, media multitasking may positively predict sleep problems as most often assumed, while sleep problems may also positively predict media multitasking.

As studies have only examined the cross-sectional relationship between media multitasking and sleep problems (Calamaro et al., 2009; Mark et al., 2016; Pea et al., 2012), empirical evidence for a reciprocal relationship between media multitasking and sleep problems is lacking. However, several longitudinal studies on the relationship between screen-based media use and sleep problems have investigated reciprocal relationships, albeit with mixed results (e.g., Becker, Langberg, & Byars, 2015). Some studies found a reciprocal relationship between screen-based media use and sleep problems (Chen & Gau, 2016; Magee, Lee, & Vella, 2014), whereas other studies found that screen-based media use acted as either a predictor (e.g., Johnson, Cohen, Kasen, First, & Brook, 2004; van den Bulck, 2007) or a consequence of sleep problems (Tavernier & Willoughby, 2014). These mixed findings in the field of screen-based media use further emphasize the importance of examining the reciprocal causal direction of the relationship between media multitasking and sleep problems.

Existing studies mainly assume that media multitasking leads to sleep problems. This assumption is primarily based on the reasoning for the effect of screen-based media use on sleep problems (Calamaro et al., 2009; Pea et al., 2012). Three underlying mechanisms of the effect of screen-based media use on sleep problems have been proposed. First, screen-based media use may displace sleep (Cain & Gradisar, 2010). Second, exposure to bright screen light may lead to delayed sleep onset because of the suppressed secretion of melatonin, which is necessary to regulate the circadian timing system (e.g., Crowley, Cain, Burns, Acebo, & Carskadon, 2015). Third, screen-based media use may enhance physiological arousal (i.e., bodily sensations such as accelerated heart rate and breathing; Cain & Gradisar, 2010), which has been associated with sleep problems (Paavonen, Pennonen, Roine, Valkonen, & Lahikainen, 2006; van den Bulck, 2004).

These three explanations for the effects of screen-based media use on sleep problems may also explain the impact of media multitasking on sleep problems. Moreover, the effects of media multitasking on sleep problems may even be stronger than those of general time spent using screen-based media (Calamaro et al., 2009). Specifically, with respect to the displacement of sleep, media multitasking may result in more displacement than exposure to a single screen-based medium. To illustrate, when adolescents simultaneously engage in a video game and a social networking site on a laptop, it may take them longer to finish the video game or get to the next level - than when they would only focus on that video game. As for the exposure to bright screen lights, those adolescents who engage in media multitasking using multiple devices are exposed to more screen lights compared to their peers who use one screen at a time (Calamaro et al., 2009). Finally, because of the constant switching between media, media multitasking may constitute a more arousing activity than the use of a single medium. In fact, switching between media on a computer (e.g., e-mail and Facebook) has been shown to lead to temporarily increased physiological arousal (Yeykelis, Cummings, & Reeves, 2014).

Based on these explanations, we argue that media multitasking enhances sleep problems among adolescents. To better understand the causal relationship between media multitasking and sleep problems, we employ a three-wave longitudinal design. We assume that adolescents who show increased levels of media multitasking will experience more sleep problems three-to-four months later, resulting in the following hypothesis:

> Hypothesis 1: The frequency of media multitasking will be positively related to subsequent sleep problems among adolescents.

Although the main assumption is that media multitasking leads to sleep problems, there is also reason to hypothesize that sleep problems are related to an increase in subsequent media multitasking. Several studies have found support for the negative effect of sleep problems on adolescents' executive functions (e.g., Ferraro, Holfeld, Frankl, Frye, &

Halvorson, 2015; Gruber, Cassoff, Frenette, Wiebe, & Carrier, 2012; Warren, Riggs, & Pentz, 2017; Xanidis & Brignell, 2016). Executive functions are cognitive processes that regulate an individual's attention and behavior, including impulsivity and inhibition (e.g., Miyake et al., 2000). For example, compared to children whose sleep was extended, children whose sleep was restricted engaged in more restless impulsive behaviors after five nights (Gruber et al., 2012). Similarly, a longitudinal study demonstrated that sleep problems were associated with more deficits in subsequent inhibitory control (e.g., doing things without thinking first) among adolescents (Warren et al., 2017).

These studies are particularly relevant as executive functions are known to be key predictors of media multitasking (e.g., Sanbonmatsu, Strayer, Medeiros-Ward, & Watson, 2013; Yang & Zhu, 2015; Zhang, 2015). For example, college students who reported higher levels of impulsivity reported that they engaged more often in media multitasking (Sanbonmatsu et al., 2013). Additionally, deficits in inhibition were associated with more media multitasking among adolescents (Baumgartner, Weeda, van der Heijden, & Huizinga, 2014). Thus, it could be argued that adolescents who experience difficulties in their executive functions, due to sleep problems, find it more difficult to resist incoming streams of information (e.g., an incoming text message and social media alerts) that are not directly related to their main media activity (e.g., watching a television program; Yang & Zhu, 2015). Taken together, we hypothesize:

> Hypothesis 2: The level of sleep problems will be positively related to subsequent media multitasking among adolescents.

The Possible Moderating Role of Age and Biological Sex

It has become increasingly clear that media effects are not universal, indicating that some individuals may be more susceptible to such effects than others (Bandura, 2001; Slater, 2015; Valkenburg & Peter, 2013). Therefore, it is likely that the relationship between media multitasking and sleep problems is not the same for all adolescents. To increase our understanding of the relationship between media multitasking and sleep problems, we examined the moderating role of two well-known demographic predictors of media multitasking and sleep problems: age (e.g., Baumgartner et al., 2014; Dewald, Meijer, Oort, Kerkhof, & Bögels, 2010) and sex (e.g., Rideout et al., 2010; Dewald et al., 2010).

The current study focuses on the developmental period of early to middle adolescence. Along with developmental changes (e.g., Steinberg et al., 2008), this phase has been marked by crucial environmental changes, such as changes in adolescents' social network, school context, and family relationships (e.g., Eccles et al., 1993). One of the most important environmental changes at the onset of adolescence is the move from primary to secondary school in the Netherlands. Researchers have linked this transition to an increase in media use (e.g., Catherine & Michael, 2016) as well as to disruptions in adolescents' sleep patterns

(e.g., Quach, Hiscock, Canterford, & Wake, 2009). Thus, the transition from early to middle adolescence might be a critical window to study the relationship between adolescents' engagement in media multitasking and sleep problems. For these reasons, we examine the moderating role of age on the relationship between media multitasking and sleep problems, by proposing the following research question:

> Research question 1: Does age moderate the relationship between media multitasking and sleep problems?

Besides examining age differences, adolescence is also a crucial period to examine sex differences regarding the relationship between media multitasking and sleep problems. With respect to media multitasking, studies have repeatedly found that adolescent girls more frequently engage in media multitasking than boys (e.g., Rideout et al., 2010). Additionally, studies have found that adolescent girls reported more sleep problems than adolescent boys (e.g., Dewald et al., 2010). However, knowledge on possible sex differences in the longitudinal relationship between media multitasking and sleep problems is unknown. Therefore, we propose a second research question:

> Research question 2: Does sex moderate the relationship between media multitasking and sleep problems?

Understanding Causality: The Importance of Examining Within-Person Effects

Longitudinal data provide the opportunity to better understand the time ordering of variables, and thus provide initial evidence for the causality of a relationship (Curran & Bauer, 2011). To investigate reciprocal relationships using longitudinal data, researchers have typically used the cross-lagged panel model (CLPM; Adachi & Willoughby, 2016; Hamaker, Kuiper, & Grasman, 2015). The cross-lagged paths of the CLPM are commonly interpreted as causal effects between media use and the outcome variable of interest (Hamaker et al., 2015). Recently, researchers have expressed concerns regarding the use and interpretation of the CLPM (Curran & Bauer, 2011; Hamaker et al., 2015; Keijsers, 2015). One of the main disadvantages of the CLPM is that it does not disentangle between-person variance from within-person variance. Because the CLPM aggregates both sources of variance, it is thus unclear whether the cross-lagged paths reflect a between-person or within-person effect.

Being unable to disentangle within- and between-person variance is problematic, because from a theoretical standpoint we are particularly interested in effects that occur within individuals (Curran & Bauer, 2011). Specifically, we want to investigate whether a particular adolescent who frequently engages in media multitasking experiences more sleep problems over time. To address these shortcomings of the CLPM, the random intercept CLPM (RI-CLPM) has been recently introduced (for a full description of the model, see Hamaker et

al., 2015). The RI-CLPM splits between-person from within-person variance, by taking into account that the repeated measures are nested within individuals. In particular, the RI-CLPM controls for the stable between-person correlation, that is the correlation between the rank order position of an individual in media multitasking and the rank order position of an individual's sleep problems over time. As a result, the RI-CLPM allows us to specifically investigate the within-person cross-lagged correlations between media multitasking and sleep problems. In the present paper, we therefore employed the RI-CLPM instead of the common CLPM.

METHOD

Sample

This study involved a three-wave longitudinal study with three-to-four month intervals, conducted among a non-probability sample of adolescents from seven secondary schools in rural and urban areas in the Netherlands. In Wave 1 1,262 adolescents filled out the survey, 1,254 adolescents participated in Wave 2, and 1,174 adolescents participated in Wave 3. Participants were excluded if they reported incorrect identification numbers or had missing values on all main variables (N_{Wave1} = 27; N_{Wave2} = 38; N_{Wave3} = 71). In total, 1,441 adolescents (N_{Wave1} = 1,241; N_{Wave2} = 1,216; N_{Wave3} = 1,103) filled out the survey in at least one wave (M_{age} = 12.61, SD_{age} = 0.75; 51% boys). Of these participants, 904 adolescents (63%) participated in all three waves, 311 adolescents (22%) in two waves, and 226 adolescents (15%) in one wave. The attrition was mainly due to busy school schedules. At some schools, it was not possible to schedule data collection for all participating classes in each wave. Fifty-two percent (n = 414) were in their first year of secondary school (i.e., grade 7) and 48% (n = 388) were in their second year (i.e., grade 8). In the Netherlands, adolescents are typically 12 years old when they go to secondary school.

Procedure

After the ethical approval was obtained from the ethical committee of the authors' institute, the authors contacted multiple Dutch schools via e-mail. In total, seven schools responded and agreed to participate in this study. In consultation with these schools, the participating classes were selected based on the school class schedules and educational level. Of the participating classes, passive informed consent of the parents as well as informed assent of the adolescents was obtained before the start of the study. We collected the data around early November 2014, early March 2015, and the end of June 2015. The selected time points were all around the end of a school term (i.e., first-term, mid-term, and end-term). During a short introduction by the research team, we informed participants about the content of the questionnaire and assured that their participation was completely confidential and voluntary. Subsequently, the participants filled out an online survey during class under supervision of a member of the research team and/or the

teacher. It took participants approximately 30 minutes to complete the survey. After each wave, the participants received a small present (monetary value around $ 0.50) for their participation.

Measurements

Media multitasking. We measured media multitasking with the short media multitasking measure for adolescents (MMM-S) (Baumgartner, Lemmens, Weeda, & Huizinga, 2016), which is based on the media multitasking index (MMI) developed by Ophir, Nass, and Wagner (2009). The MMM-S is validated for adolescents and the items of this short scale correlate highly with the full scale (Baumgartner et al., 2016). The MMM-S consists of three main media activities: 1) watching TV, 2) sending messages via phone or computer (e.g., WhatsApp, Snapchat), and 3) using social networking sites (e.g., Facebook, Instagram). For each of the three main media activities, participants indicated how often they typically engage in that media activity simultaneously with each of the other two media activities as a secondary activity. Thus, media could be used on both multiple devices and on a single device. In addition, listening to music was included as a secondary activity for all three main activities. Listening to music is often not a primary media activity, but is included in most media multitasking measures (Ophir et al., 2009).

In total, the scale consists of nine items: (1) three items for watching TV ('While watching TV, how often do you [use social networking sites]/[send messages via phone or computer]/[listen to music] at the same time?'), (2) three items for using social networking sites, and (3) three items for sending messages via phone or computer. Participants indicated their engagement in media multitasking on a five-point scale, with 0 = *never*, 1 = *almost never*, 2 = *sometimes*, 3 = *often*, and 4 = *very often*. The nine items were averaged into one mean index (Wave 1: M = 1.93, SD = 1.01, Cronbach's alpha = .89; Wave 2: M = 1.88, SD = 1.02, Cronbach's alpha = .91; Wave 3: M = 1.85, SD = 1.03, Cronbach's alpha = .92). Higher scores on this scale indicate more frequent media multitasking.

Sleep problems. To measure sleep problems, we employed the Sleep Reduction Screening Questionnaire (SRSQ), which is a validated measure to screen for multifaceted symptoms of sleep problems in Dutch adolescents (van Maanen et al., 2014). When measuring subjective sleep problems among adolescents it is crucial to include a measure of daytime sleepiness, because that is how adolescents experience their sleep problems (Cain & Gradisar, 2010). Self-report measures similar to this scale have shown to correlate highly with objective sleep measures among adolescents (Wolfson et al., 2003). The SRSQ consists of nine items based on three domains: three items on sleepiness (e.g., 'I feel sleepy during the day'), three items on shortness of sleep (e.g., 'I am a person who does not get enough sleep'), and three items on loss of energy (e.g., 'I have enough energy during the day to do everything [reversed]'). The items are rated on a five-point scale, 0 = *never*, 1 = *almost*

never, 2 = *sometimes*, 3 = *often*, and 4 = *very often*. The nine items were averaged into one mean index; A higher score indicates more sleep problems. Cronbach's alpha for the scale with nine items was .79 (*M* = 1.44, *SD* = 0.68) in the first wave, .79 (*M* = 1.50, *SD* = 0.69) in the second wave, and .77 (*M* = 1.56, *SD* = 0.67) in the third wave.

Data Analysis

Structural equation modeling was applied to analyze the longitudinal relationship between media multitasking and sleep problems. The RI-CLPMs were tested using the statistical program Mplus 7 (Muthén & Muthén, 2012). All models were estimated using Full Information Maximum Likelihood, to cope with missing data across waves (Muthén & Muthén, 2012). To increase the parsimony of the models, stability and cross-lagged paths were constrained to be equal in all models. Model fit was evaluated with the chi-square measure of exact fit, the Root Mean Square Error of Approximation (RMSEA) and its 95% confidence interval, and the Comparative Fit Index (CFI). Close fit of the model was indicated by RMSEA values below .05 and CFI values above .95. Finally, RMSEA values between .05 and .08 and CFI values between .90 and .95 indicate satisfactory fit.

The RI-CLPM controls for past levels of the outcome variables, sleep problems and media multitasking. Although previous studies have shown that both media multitasking (Wang & Tchernev, 2012) and sleep problems (Tavernier & Willoughby, 2014) are stable over time, high stability does not preclude maturation or change at the individual level. Thus, particularly in a transition period such as early to middle adolescence, both media multitasking and sleep problems may change over time at the individual level. Before running the RI-CLPM, we examined the amount of between-person and within-person variance by calculating the intra-class correlations (ICC). For media multitasking, the ICC was .72, indicating that 72% of the variance was explained by between-person variance and that 28% of the variance was explained by within-person variance. For sleep problems, the ICC was .65. This demonstrated that 65% of the variance was explained by between-person variance, whereas 35% of the variance was explained by within-person variance. This implies that a substantial part of the variance was due to within-person changes over time.

In the RI-CLPM (see Figure 1), the CLPM is extended following the procedures described by Hamaker et al. (2015). First, to examine the within-person processes, each observed variable was regressed on its own latent factor, each loading constrained at 1. This resulted in six within-person latent factors, reflecting the within-person variance. Between these six within-person latent factors we added stability paths, cross-lagged paths, a covariance between media multitasking and sleep problems at Wave 1, and covariances between the disturbances of media multitasking and sleep problems at Wave 2 and Wave 3. In addition, we added random intercept factors for media multitasking and sleep problems to control for the stable between-person variance. The indicators of these random intercept factors

were the observed scores of all three waves and the factor loadings were constrained at 1. Finally, between these two random factors we added a covariance to the model. The moderating role of age and sex was examined by applying multiple group analyses.

RESULTS

Descriptive Statistics

Table 1 displays the means, standard deviations, and correlations for media multitasking and sleep problems at each assessment point. Although the means of media multitasking were slightly below two (i.e., 'sometimes') (Wave 1: *M* = 1.93, *SD* = 1.01; Wave 2: *M* = 1.88, *SD* = 1.02; Wave 3: *M* = 1.85, *SD* = 1.03), the findings indicate that media multitasking was common among adolescents. In Wave 1, 33% of the participating adolescents reported that they sometimes engage in media multitasking (Wave 2 = 32%; Wave 3 = 32%). In addition, 17% indicated that they engage often or very often in media multitasking (Wave 2 = 16%; Wave 3 = 15%). The means of sleep problems were also below two (i.e., 'sometimes') (Wave 1: *M* = 1.44, *SD* = 0.68; Wave 2: *M* = 1.50, *SD* = 0.69; Wave 3: *M* = 1.56, *SD* = 0.67). In Wave 1, 20% of the participating adolescents indicated that they sometimes experienced sleep problems (Wave 2 = 24%; Wave 3 = 31%), and 2% reported that they often experienced sleep problems (Wave 2 = 3%; Wave 3 = 2%).

Table 1. Zero-order Pearson Correlations, Means, and Standard Deviations for Media Multitasking, Sleep Problems, Age, and Sex.

Measure		1	2	3	4	5	6	10
1	MM W1	-						
2	MM W2	.73**						
3	MM W3	.67**	.75**					
4	SP W1	.24**	.23**	.24**				
5	SP W2	.27**	.26**	.24**	.66**			
6	SP W3	.27**	.25**	.29**	.61**	.65**		
7	Age	.10**	.06	.08*	.12**	.09*	.13**	
8	Sex (0 = *boy*)	.24**	.27**	.32**	.07*	.02	.04	-.01
	M	1.93	1.88	1.85	1.44	1.50	1.56	12.61
	SD	1.01	1.02	1.03	0.68	0.69	0.67	0.75

Note. * $p < .05$; ** $p < .001$. MM = Media multitasking; SP = Sleep problems; W1 = Wave 1; W2 = Wave 2; W3 = Wave 3.

As Table 1 shows, all correlation coefficients between media multitasking and sleep problems were significant and positive in each wave. Adolescents engaging in higher levels of media multitasking reported more sleep problems. General media use was positively related to

both media multitasking and sleep problems. In addition, girls reported significantly more media multitasking than boys. Eighth graders engaged more often in media multitasking and reported more sleep problems than 7th graders.

Longitudinal Relationships

The RI-CLPM model showed an exact fit, χ^2 (5) = 3.54, p = .618, RMSEA = .00 (90% CI [.00, .03]), and CFI = 1.00. There was a moderately strong between-person correlation between the random intercept factors of media multitasking and sleep problems (b^* = .38, p < .001). This implies that adolescents who engage in media multitasking more frequently, reported more sleep problems across the three waves. In addition, both media multitasking (b^* = .37 and .39, both p < .001) and sleep problems (b^* = .18, p = .001 and b^* = .20, p = .004) displayed a significant wihtin-person stability over time.

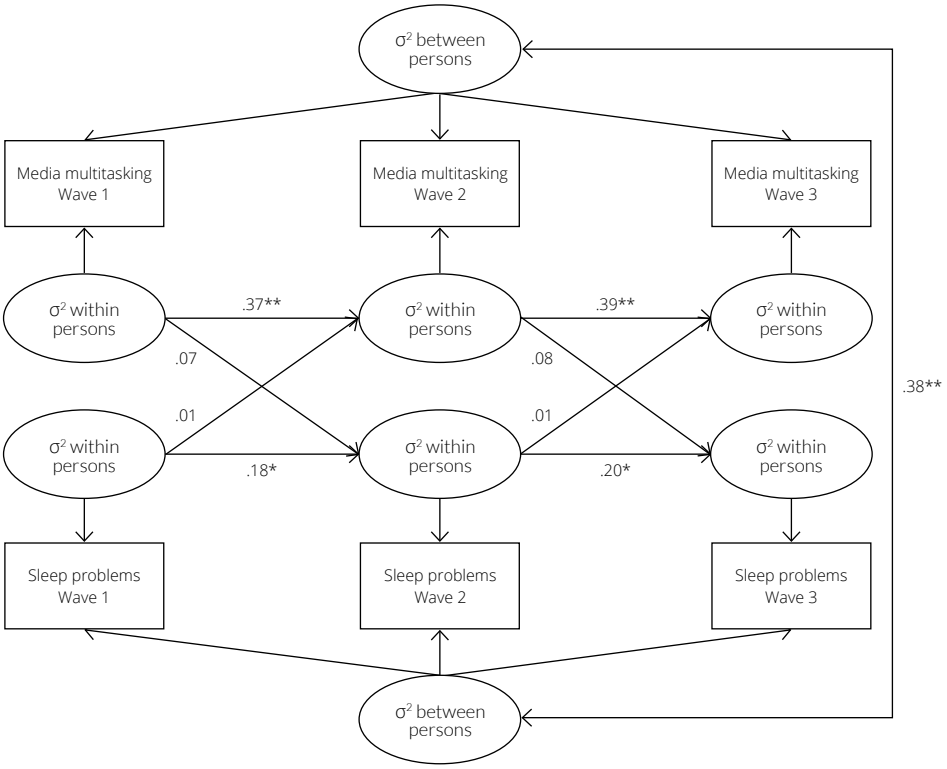

Figure 1. Simplified RI-CLPM with the standardized maximum likelihood parameter estimates for the within-person relationship between media multitasking and sleep problems.
Note. * p < .05; ** p <.001.

As displayed in Figure 1, the within-person correlation between media multitasking and subsequent sleep problems was not significant from Wave 1 to Wave 2 (b^* = .07, p = .176)

nor from Wave 2 to Wave 3 (b^* = .08, p = .178). Similarly, there was no significant within-person correlation between sleep problems and subsequent media multitasking from Wave 1 to Wave 2 (b^* = .01, p = .910) nor from Wave 2 to Wave 3 (b^* = .01, p = .910). These findings do not support Hypotheses 1 and 2.

The moderating role of age. The model showed an exact fit, χ^2 (10) = 9.71, p = 466, RMSEA = .00 (90% CI [.00, .04]), and CFI = 1.00. The model revealed a moderately strong between-person correlation between the random intercept factors of media multitasking and sleep problems for both age groups (grade 7: b^* = .33, p < .001; grade 8: b^* = .39, p < .001).

For adolescents in grade 7, the within-person stability paths of media multitasking (b^* = .43 and .45, both p < .001) and sleep problems (b^* = .26 and .30, both p < .001) were significant. The within-person correlation between media multitasking and subsequent sleep problems approached significance from Wave 1 to Wave 2 (b^* = .13, p = .055) and from Wave 2 to Wave 3 (b^* = .13, p = .051). The within-person correlations between sleep problems and subsequent media multitasking were not significant (b^* = .03, p = .535 and b^* = .04, p = .536).

For adolescents in grade 8, the within-person stability paths were significant for media multitasking (b^* = .33 and .36, both p < .001), but not significant for sleep problems (b^* = .12, p = .144; b^* = .13 p = .179). The within-person correlations between media multitasking and subsequent sleep problems (both b^* = .01, p = .906) and the within-person correlations between sleep problems and subsequent media multitasking (b^* = .04, p = .562 and b^* = .05, p = .563) were not significant.

The moderating role of sex. For sex, the model showed an exact fit, χ^2 (10) = 7.76, p = .652, RMSEA = .00 (90% CI [.00, .03]), and CFI = 1.00. For both girls and boys, there was a moderately strong between-person correlation between the random intercept factors of media multitasking and sleep problems (girls: b^* = .43, p < .001; boys: b^* = .32, p = .001).

For girls, the within-person stability paths were significant for media multitasking (b^* = .30 and .36, both p < .001), but not significant for sleep problems (b^* = .12, p = .142; b^* = .13, p = .184). The within-person correlation between media multitasking and subsequent sleep problems was (marginally) significant from Wave 1 to Wave 2 (b^* = .14, p = .053) and from Wave 2 to Wave 3 (b^* = .16, p = .049). In contrast, the reverse within-person correlations between sleep problems and subsequent media multitasking were not significant (both b^* = .07, p = .292 and p = .296).

For boys, the within-person stability paths were significant for media multitasking (b^* = .45 and .42, both p < .001) and sleep problems (b^* = .22, p = .003 and b^* =.24, p = .005). However, both the within-person correlations between media multitasking and subsequent sleep

problems (both $b^* = .06$, $p = .444$ and $p = .446$) and the within-person correlations between sleep problems and subsequent media multitasking were not significant for boys (both $b^* = -.03$, $p = .659$ and $p = .658$).

DISCUSSION

The considerable increase in media multitasking in recent decades has raised concerns regarding the possible negative impact of media multitasking on sleep problems. Although cross-sectional studies demonstrated that media multitasking is related to sleep problems (e.g., Calamaro et al., 2009; Mark et al., 2016), evidence for the direction of this relationship has been lacking. Such evidence is pivotal because media multitasking could be conceptualized as both a cause and a consequence of sleep problems. To take a first step in understanding the causal relationship between media multitasking and sleep problems, we conducted a three-wave longitudinal study among adolescents.

Consistent with previous cross-sectional studies that demonstrated that media multitasking was associated with sleep problems (e.g., Calamaro et al., 2009; Mark et al., 2016), our findings showed a near to medium positive relationship between media multitasking and sleep problems in each of the three waves. Adolescents who engaged in higher levels of media multitasking reported more sleep problems. Moreover, in line with these cross-sectional findings, the RI-CLPM demonstrated a stable moderate between-person relationship between media multitasking and sleep problems. Thus, as expected media multitasking and sleep problems are positively related among adolescents.

To explore the longitudinal relationship between media multitasking and sleep problems, we were especially interested in within-person processes over time. More specifically, we examined whether an increase in an adolescent's media multitasking behavior was linked to an increase in sleep problems three-to-four months later. In contrast to our expectations (see Hypothesis 1 and Hypothesis 2), media multitasking was not related to an increase in subsequent sleep problems, nor were sleep problems positively related to subsequent media multitasking for the overall sample. This suggests that media multitasking and sleep problems do not influence each other. However, our findings indicated that there might be a small relationship between media multitasking and subsequent sleep problems among 7th graders and girls. For 7th graders and girls, media multitasking was (marginally) associated with more subsequent sleep problems.

Although the relationship between media multitasking and subsequent sleep problems was small among 7th graders and girls, these findings should not be interpreted as trivial (Adachi & Willoughby, 2015). To understand why 7th graders and girls are especially susceptible to the negative effects of media multitasking on sleep, it might be important

to consider the role of psychological stress (i.e., the perceived inability to cope with the demands of everyday life) that results from media multitasking. Several studies have shown that individuals who experience daily stressors are more likely to report sleep problems (Doane & Thurston, 2014; Galambos, Howard, & Maggs, 2011). As young people perceive the current media multitasking environment as stressful (Bardhi et al., 2010; Mark, Wang, & Niiya, 2014), it is expected that the elevated levels of psychological stress resulting from daily media multitasking might be disrupting adolescents' sleep.

In the current study, the 7th graders just transitioned from elementary to secondary school, which means that they experience multiple environmental changes (e.g., Eccles et al., 1993). For example, they have to get used to a new school and new teachers, build new friendships, and become more independent from their parents (e.g., Eccles et al., 1993). Along with these changes, adolescents experience changes in their media environment. For example, after transitioning schools, adolescents watch television more frequently (e.g., Gebremariam et al., 2012), and use more social media (Catherine & Michael, 2016). As media use increases, adolescents are also more likely to engage in media multitasking (Rideout et al., 2010). It might thus be assumed that adolescents experience a multitude of stressors during this period. The cumulative stress theory (Simmons, Burgeson, Carlton-Ford, & Blyth, 1987) posits that when changes occur simultaneously, adolescents may find it difficult to cope with these changes. Because 7th graders experience several transition-related changes during this period, they may find it difficult to also cope with the changes in their media environment and thus perceive media multitasking as particularly stressful.

With respect to the sex differences, girls are known to be particularly vulnerable to stress (e.g., Gunnar, Wewerka, Frenn, Long, & Griggs, 2009) and often deal insufficiently with stress (e.g., Nolen-Hoeksema, 2001). It has been shown that girls perceive higher levels of stress than boys when exposed to similar situations (e.g., Beyens, Frison, & Eggermont, 2016; Gunnar et al., 2009; Östberg et al., 2015; Thomée, Eklöf, Gustafsson, Nilsson, & Hagberg, 2007). For example, girls were more stressed about not being popular on Facebook than boys (Beyens et al., 2016). In addition, compared to boys, girls more often cope with stress by ruminating (i.e., focusing on their own concerns), instead of searching for solutions that decrease levels of stress (Nolen-Hoeksema, 2001). In sum, because girls may be more likely to experience psychological stress and insufficiently cope with stress resulting from media multitasking than boys, girls may be particularly susceptible to the possible negative effects of media multitasking on sleep.

Inconsistent with our second hypothesis, we found no support for the impact of sleep problems on subsequent media multitasking frequency. However, sleep problems may still affect media multitasking if shorter time intervals are considered. When adolescents experience sleep problems this may lead to deficits in executive functions shortly after (Gruber et al., 2012). Subsequently, these deficits in executive functions may lead to an

increase in media multitasking (e.g., Baumgartner et al., 2014; Yang & Zhu, 2015). In line with this, Mark and colleagues (2016) found that adolescents who experienced more sleep problems reported more media multitasking the next day. These findings suggest that sleep problems have a proximal effect on media multitasking, but that this effect may not be visible anymore three-to-four months later.

Because our findings indicate that media multitasking may result in more sleep problems among 7th graders and girls, it could be important to inform adolescents about the possible negative consequences of media multitasking on their sleep. As the present study shows, media multitasking is common and rather stable over time, suggesting that it has become a habit for many adolescents. This may be problematic because habits, once formed, are difficult to change. To prevent habituation to media multitasking, adolescents may need to learn to inhibit their responses to internal (e.g., boredom) and external triggers (e.g., incoming text messages) that may result in media multitasking. An effective way in which parents and teachers can prevent habitual media multitasking is by setting clear and consistent rules about media and smartphone use (Valkenburg, Piotrowski, Hermanns, & Leeuw, 2013).

Shortcomings and Future Research

Our study should be regarded as a first step in providing knowledge on the long-term effects of media multitasking on sleep problems. However, we acknowledge that our study has shortcomings that should be addressed in future research. First, although the RI-CLPM automatically controls for all stable differences among individuals (Hamaker et al., 2015), it is still possible that other factors play a confounding role in the relationship between media multitasking and sleep problems. Therefore, both longitudinal and experimental studies are needed to confirm our findings.

Second, future studies are needed to understand when and for whom media multitasking is particularly disruptive. Future studies that examine the impact of media multitasking on sleep should further distinguish between *which* media adolescents use (i.e., device, content), *how* they use media (i.e., single-tasking, multitasking using a single device, multitasking using multiple devices), and *when* they use media (i.e., day, evening, night). Furthermore, this study suggests that the relationship between media multitasking and sleep problems may not be universal. Although examining the moderating role of age and sex was an important first step, this should be extended by examining wider age ranges, and by considering the cultural background with respect to the moderating role of gender. For example, the cultural background has been shown to be important for explaining differences in media multitasking (Kononova, Zasorina, Diveeva, Kokoeva, & Chelokyan, 2014; Voorveld, Segijn, Ketelaar, & Smit, 2014).

Third, longitudinal and experimental studies are needed to examine possible processes

underlying both directions of the relationship between media multitasking and sleep problems. For the influence of media multitasking on sleep problems, we have discussed several possible underlying mechanisms that may explain this relationship, such as exposure to bright screens, heightened levels of arousal, and elevated levels of psychological stress. Examining these underlying mechanisms will help us to understand why media multitasking and sleep problems are related.

Fourth, findings in the current study may have been affected by the length of the time intervals used in this study (three-to-four month intervals). Therefore, future studies should include varying time intervals to fully understand how the longitudinal relationship between media multitasking and sleep problems develops over time. For example, time series data consisting of multiple time sample points within shorter time intervals might provide crucial information on the immediate effects of media multitasking on sleep problems and vice versa (e.g., Wang & Tchernev, 2012).

Finally, although the media multitasking and sleep problem instruments that we used have both been validated among adolescents, this study included only subjective self-reports. Future studies are advised to measure media multitasking and sleep problems in multiple ways to compare the reliability and validity of the different measures used. Ultimately, such studies should combine subjective measures (e.g., self-report, teacher reports, parent reports) and objective measures (e.g., automated tracking devices to measure media multitasking and sleep).

Conclusion

The findings of the present study suggest that current concerns about the possible negative impact of media multitasking on sleep problems are only partly justified. Although we found no support for a longitudinal relationship between media multitasking and sleep problems for the overall sample, our findings do indicate that media multitasking was (marginally) related to increased sleep problems three-to-four months later among 7th graders and girls. While more research is needed, media multitasking among 7th graders and girls may warrant attention because sleep is essential for adolescents' healthy development. If media multitasking interferes with adolescents' sleep, other aspects of their development that are related to sleep problems (Becker et al., 2015; Shochat et al., 2014), such as their socioemotional functioning (Owens, 2014) and academic performance (Dewald et al., 2010), may be affected.

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General Discussion

Concerns regarding the adverse impact of media multitasking on adolescent development have become increasingly prevalent in today's society (e.g., Wallis, 2010). Consequently, empirical research on this topic has grown rapidly over the past twenty years (e.g., Becker, Alzahabi, & Hopwood, 2013; Junco & Cotten, 2012; Ophir, Nass, Wagner, 2009). However, clear evidence of the actual impact of media multitasking on adolescent development remained limited, due to two main gaps in the current literature. First, the media multitasking literature was largely fragmented (e.g., Kazakova, Cauberghe, Pandelaere, & de Pelsmacker, 2015), which hindered the possibility to draw a clear picture of the relationship between media multitasking and adolescent development. Second, evidence for the longitudinal relationship between media multitasking and adolescent development was lacking.

The present dissertation set out to address these gaps in the current literature. The first main aim was to investigate the state of the art in the media multitasking literature, with respect to the possible negative consequences of media multitasking for adolescent development. To examine this, we conducted a review of the scientific media multitasking literature (Chapter 1). The second main aim was to investigate the longitudinal relationships between media multitasking and multiple domains of adolescent development. Therefore, Chapters 2 to 4 are based on a three-wave longitudinal study among 1,440 Dutch adolescents (11-15 years old). By focusing on these two aims, this dissertation clarifies and extends our current knowledge of the possible consequences of media multitasking for adolescent development. Furthermore, the findings of this dissertation have important practical implications and provide critical directions for future research.

The State of the Art: Cross-sectional Relationships between Media Multitasking and Adolescent Development

Chapter 1 demonstrated that the extant literature has largely focused on the impact of media multitasking on three developmental domains, that is cognitive control, academic performance, and socioemotional functioning. Although the findings were partly mixed, the majority of the studies published between 1994 and 2014 provided support for a small to moderate cross-sectional association between media multitasking and the three developmental domains. Specifically, research demonstrated that media multitasking was negatively associated with cognitive control (e.g., Baumgartner, Weeda, van der Heijden, & Huizinga, 2014; Ophir et al, 2009), academic performance (e.g., Junco & Cotten, 2012; Rosen, Carrier, & Cheever, 2013), and socioemotional functioning (e.g., Becker et al., 2013; Pea et al., 2012).

Although these studies have provided first insights regarding the cross-sectional relationship between media multitasking and various developmental domains, the review in Chapter 1 also underscored the need for research on adolescent media multitasking. Previous studies have primarily used convenience and college student samples (Becker et al., 2013; Junco & Cotten, 2012; Ophir et al, 2009). Only a few studies had specifically

focused on adolescents (e.g., Baumgartner et al., 2014; Calamaro, Mason, & Ratcliffe, 2009; Pool, van der Voort, Beentjes, & Koolstra, 2000), which is surprising because media multitasking is especially prevalent among adolescents (e.g., Carrier, Cheever, Rosen, Benitez, & Chang, 2009; Voorveld & van der Goot, 2013). Consequently, evidence regarding the cross-sectional link between media multitasking and these developmental domains among adolescents was lacking. Therefore, it was important to also examine whether these cross-sectional relationships observed in student samples could also be observed in a representative adolescent sample.

In line with the main findings of Chapter 1, Chapters 2 to 4 showed that media multitasking had a small to moderate relationship with adolescents' development. First, Chapter 2 showed that academic-media multitasking (i.e., media use during homework and while attending class) was positively associated with academic attention problems and negatively associated with academic achievement scores. In other words, adolescents who frequently used media during academic activities reported more academic attention problems and had lower academic achievement scores, compared to adolescents who engaged less frequently in academic-media multitasking. Second, Chapter 3 demonstrated that technological interferences during offline conversations (TIDOC) were negatively related to adolescents' emotional problems. Specifically, more frequent media use during offline conversations was related to more emotional problems. Finally, Chapter 4 illustrated that media-media multitasking (i.e., the simultaneous use of multiple media) was related to more sleep problems among adolescents. Together, the findings of this dissertation clearly show that media multitasking and adolescent development are cross-sectionally related.

Unchartered Territories: Longitudinal Relationships between Media Multitasking and Adolescent Development

As demonstrated by Chapter 1, research on the possible impact of media multitasking on developmental domains was mostly cross-sectional. Therefore, evidence for the causality between media multitasking and the three developmental domains was lacking. This is problematic because societal concerns typically evolve around the idea that media multitasking is the cause of an unhealthy development. For example, researchers have assumed that media multitasking during academic activities leads to lower academic achievement scores. However, cross-sectional relationships do not allow researchers to make such conclusions. A cross-sectional relationship merely supports the idea that the two variables are related. Thus, it could, for example, also be that media multitasking does not deteriorate students' academic achievement but that students with lower grades are more prone to engage in media multitasking. Therefore, in Chapters 2 to 4 took an important first step towards understanding the causal relationships between media multitasking and adolescent development by investigating the relationships longitudinally. Specifically, these chapters examined longitudinal relationships between media multitasking and three aspects of adolescent development; their academic achievement, their emotional

problems, and their sleep problems.

1 **At the between-person level, media multitasking and the three aspects of adolescent development were negatively related**.

The relationship at the between-person level represents the correlation between the stable rank order position of an individual on media multitasking and the stable rank order of that individual on adolescent development across the school year. These between-person relationships are comparable with the correlations between media multitasking and adolescent development examined in cross-sectional studies, because these correlations are based on the rank order positions of each variable at one specific time point. However, these relationships at the between-person level reflect a more reliable estimate of this relationship, as it entails the correlation between the stable position of an adolescent on media multitasking and the stable position of an adolescent on the outcome variable across the three assessment points during one school year.

The findings of Chapters 2 to 4 showed that media multitasking and the developmental domains were negatively related across the school year. These relationships were small to moderate. Chapter 2 showed that academic-media multitasking was related to both more academic attention problems and lower academic achievement scores. Chapter 3 demonstrated that TIDOC was positively related to emotional problems. Chapter 4 showed that media-media multitasking was positively associated with sleep problems. Thus, similar to the cross-sectional relationships among adults found in previous studies, these results demonstrate that adolescents who more frequently engage in media multitasking show more problems in certain aspects of their development compared to adolescents who less often report media multitasking.

2 **At the within-person level, media multitasking sometimes, but not always, negatively predicted adolescent development**.

As the concerns about media multitasking specifically focus on the impact of media multitasking on adolescent development, researchers have been mainly interested in the within-person impact of media multitasking on adolescents' development. This means that we want to know if a rise in media multitasking of a specific adolescent predicts more difficulties in certain developmental domains over time of this specific adolescent. For example, if an adolescent uses more media during academic activities, does this adversely affect his/her academic achievement?

The findings of this dissertation showed that media multitasking sometimes, but not always, predicted adolescent development at the within-person level. In contrast to the expectations, this dissertation showed that academic-media multitasking was not related

to academic achievement scores over time (Chapter 2) and that TIDOC was not related to adolescents' emotional problems over time (Chapter 3). This means that an increase in these two types of media multitasking behaviors did not further impair adolescents' academic achievement scores nor their emotional problems. However, we did find evidence for small longitudinal relationships between media multitasking and subsequent adolescent development on two other developmental domains. First, an increase in academic-media multitasking did predict more academic attention problems over time (Chapter 2). This indicates that if an adolescent more often used media during academic activities this further deteriorated his/her ability to pay attention during academic activities. Second, Chapter 4 demonstrated that when early adolescents and girls more often used multiple media simultaneously this predicted an increase in their sleep problems.

3 **At the within-person level, the three aspects of adolescent development did not predict an increase in media multitasking**.

Although the common assumption is that media multitasking hinders adolescent development (e.g., Wallis, 2010), some researchers have argued that this relationship could also be reversed (e.g., Becker et al., 2013; Junco & Cotton, 2012). This means that problems in adolescent development may result in more media multitasking over time. For example, as discussed in Chapter 1, adolescents with lower academic achievement scores may be less motivated at school and when doing homework (Richardson, Abraham, & Bond, 2012). This could result in more frequent media use during academic activities because these adolescents may be less motivated to refrain from using media during these activities. Similarly, when adolescents experience sleep problems they could be more prone to engage in media multitasking. Sleep problems may hinder adolescents' executive functions, which are cognitive processes that help individuals to control their attention and behavior (e.g., Ferraro, Holfeld, Frankl, Frye, & Halvorson, 2015; Gruber, Cassoff, Frenette, Wiebe, & Carrier, 2012). Difficulties in these executive functions are in turn known to positively predict media multitasking (e.g., Sanbonmatsu, Strayer, Medeiros-Ward, & Watson, 2013; Yang & Zhu, 2016). Therefore, in this dissertation we also investigated the reversed relationships. However, difficulties in the developmental domains studied in this dissertation (i.e., academic attention problems, academic achievement scores, emotional problems, and sleep problems) did not predict an increase in media multitasking over time.

What do these Findings Mean?

All chapters of this dissertation clearly show that media multitasking and adolescent development are related at the between-person level, indicating that adolescents who more often engage in media multitasking also show more difficulties in the different developmental domains. However, findings at the within-person level, related to the general assumption that media multitasking actually hinders adolescent development over time are more nuanced. Specifically, we found that specific types of media multitasking

predicted an increase in academic attention problems and sleep problems, but not academic achievement scores and emotional problems. This means that although media multitasking is consistently related to all of these developmental domains, more frequently engaging in media multitasking seems to only further deteriorate adolescents' academic attention problems and sleep problems.

The reason for why this dissertation only shows support for the effects of media multitasking on some of the developmental domains could be that media multitasking only plays a small part in adolescent development. As Bronfenbrenner (1979) argued, multiple environmental factors are likely to influence the development of children and adolescents. Media multitasking in this respect is only one aspect of a wide array of environmental factors that play a role in adolescent development. Therefore, media multitasking effects are expected to be small and could be overflowed by other factors that are more important for adolescent development. Considering the developmental outcomes in this dissertation, both academic achievement and emotional problems are quite extreme measures of adolescent development and are likely influenced by multiple other factors that are more important than media multitasking. Academic attention problems and sleep problems may be seen as less extreme measures of adolescent development, and therefore could be more amendable for effects of media multitasking.

The nuanced findings of the impact of media multitasking on adolescent development also point to the role of individual differences in this relationship. Specifically, communication researchers have repeatedly stressed that individuals differ in their susceptibility to media effects (e.g., Bandura, 2001; Slater, 2015; Valkenburg & Peter, 2013). Therefore, it is likely that the relationships between media multitasking and the developmental domains differ among adolescents as well. This could explain why the overall relationships between media multitasking and adolescent development are generally small, or even absent. Whereas some adolescents may be particularly susceptible for media multitasking effects, others may experience no effects of media multitasking. Chapter 4 provided first evidence for the differences among adolescents, as this chapter showed that media multitasking only predicted sleep problems among early adolescents and girls. However, this has only been a first step in understanding the wide variability in the impact of media multitasking on adolescent development.

Together, the findings of this dissertation suggest that although there might be no reason to panic, the findings do suggest that there is a reason for caution regarding the impact of media multitasking on adolescent development. As adolescent development is dependent on many factors, media multitasking can still play a role. Specifically, our findings suggest that media multitasking may interfere with academic attention problems and sleep problems, which are both highly important for the healthy development of adolescents (e.g., Eisenberg, Hofer, & Vaughan, 2007; Shochat, Cohen-Zion, & Tzischinsky, 2014). However,

considering the small or even absent relationships, it is likely that media multitasking is not disruptive for all adolescents, but some adolescents may be particularly susceptible for media multitasking effects.

A Theoretical Framework on the Underlying Mechanisms

While this dissertation focused on examining the consequences of media multitasking for adolescent development, the chapters also took first steps in extending the theoretical reasoning regarding this relationship. Chapter 1 showed that explanations on the effects of media multitasking on the developmental domains often remained vague. Therefore, in this dissertation we theoretically delineated potential underlying mechanisms that may explain media multitasking effects. Focusing on the possible underlying mechanisms of the relationship between media multitasking and adolescent development has yielded important insights regarding a theoretical framework of media multitasking effects. Together, the chapters of this dissertation point towards two underlying pathways that may explain the possible impact of media multitasking on adolescent development (see Figure 1). Both pathways are based on theoretical explanations discussed throughout this dissertation and therefore need to be tested in future research.

The 1st pathway: The displacement hypothesis and disruption hypothesis. The first pathway includes the impact of specific types of media multitasking on specific aspects of adolescent development. This dissertation shows that researchers are advised to distinguish between specific types of media multitasking, such as academic-media multitasking, media use during offline conversations, and media-media multitasking. These types of media multitasking have specific characteristic that can explain the effects of media multitasking on specific aspects of adolescent development. More specifically, this dissertation emphasized that the specific types of media multitasking may affect specific aspects of adolescent development, through *displacement* and/or *disruption of* a specific activity.

The displacement hypothesis assumes that the time spent on media and communication devices, displaces the time spent on specific activities (e.g., Fox, Rosen, & Crawford, 2009; McDaniel & Coyne, 2016). In the case of media multitasking, using media may directly displace an activity that could be beneficial for adolescent development. For example, as discussed in Chapter 2, media use during homework could displace the time spent on the particular homework task (e.g., Fox et al, 2009), which subsequently may hinder adolescents' academic achievement. Similarly, media use during an offline conversation with friends may displace the time spent on the conversation (McDaniel & Coyne, 2016), which in turn may hinder the development of friendships.

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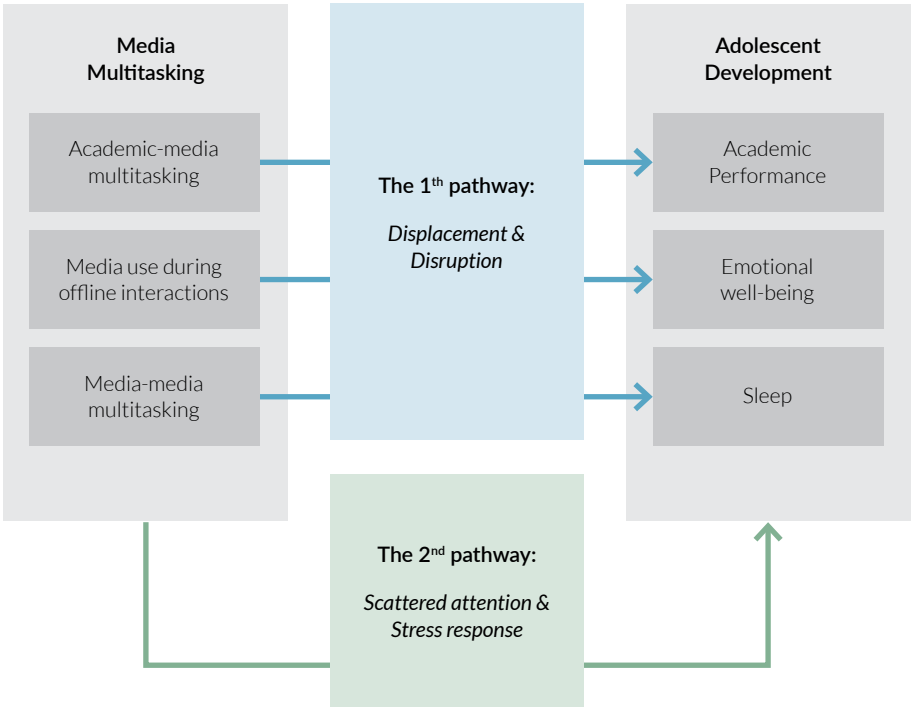

Figure 1. A representation of the two pathways to explain the possible consequences of media multitasking for adolescent development.

The *disruption* hypothesis posits that specific types of media multitasking disrupt specific activities that are beneficial for adolescent development. For example, it is widely acknowledged that people have limited cognitive capacities (e.g., Lang, 2000, 2006), which means that when people are exposed to multiple streams of information they may not process this information sufficiently. Therefore, when adolescents use media during non-media activities, which is the case for academic-media multitasking and TIDOC, this may disrupt processing the information of these non-media activities (i.e., academic activity and offline conversation). For example, with respect to media use during offline conversations, adolescents who use media during an offline interaction have to process both the content

of the media (e.g., reading a text message) and the content of the offline interaction. Consequently, adolescent may insufficiently process information of the conversation partner, which is likely to disrupt the offline interaction. However, such positive offline conversations are needed for a healthy emotional development as discussed in Chapter 3.

The 2nd pathway: The scattered attention hypothesis and stress response hypothesis. The second pathway focuses on how the common characteristics of media multitasking, rather than the specific types of media multitasking, can influence adolescent development. Independent of the relationship between specific types of media multitasking and the specific aspects of adolescent development, the common characteristics of media multitasking may also hinder adolescent development. There are two common characteristics that were discussed throughout this dissertation. First, we repeatedly argued, that the different types of media multitasking are all characterized by the rapid switching between tasks. Second, another common characteristic is that the constant switching between tasks is assumed to be cognitively demanding. In this dissertation, the two common characteristics of media multitasking have been linked to different underlying mechanisms. The constant switching between activities may result in more attention problems (i.e., *scattered attention* hypothesis), whereas the cognitive demanding nature of media multitasking may enhance adolescents' stress levels (i.e., *stress response* hypothesis).

In Chapter 1 and 2, the *scattered attention* hypothesis was introduced. This hypothesis posits that frequently engaging in media multitasking may lead to attention problems (Baumgartner et al., 2014; Baumgartner, van der Schuur, Lemmens, & te Poel, 2017; Ophir et al., 2009). Adolescents who repeatedly engage in media multitasking may eventually get habituated to respond to ongoing distractions in everyday situations. For example, these adolescents may experience more problems in ignoring irrelevant information and sustaining attention on the primary activity, because they are accustomed to respond to ongoing distractions (Ophir et al., 2009). These deficits in attention due to media multitasking may interfere with adolescents' ability to sustain attention on an academic activity (e.g., Ophir et al., 2009; Wallis, 2010), or to regulate their emotions (Eisenberg et al., 2007).

In Chapter 3 and 4, the *stress response* hypothesis was included to explain the impact of media-media multitasking on sleep and the impact of TIDOC on emotional problems. The different types of media multitasking may all elicit stress. Stress encompasses the extent to which individuals perceive that they are unable to cope with everyday life situations (Cohen, Kamarck, & Mermelstein, 1983). The transactional theory of stress (Lazarus & Folkman, 1987) assumes that cognitively demanding activities are more likely to evoke stress responses because it is more difficult to cope with these demands. As media multitasking is cognitively demanding due to multiple incoming streams of information (Lang, 2000, 2006), media multitasking is likely to result in stress. Research on media-media multitasking

has already shown that using multiple media simultaneously is positively associated with stress, including both physiological and subjective measures (Mark, Wang, & Niiya, 2014). Therefore, independent of the type of media multitasking adolescents engage in, it may be assumed that the common characteristics of media multitasking deteriorate adolescents' attentional processes and increases their stress levels.

Both attention and stress have, however, an important impact on different aspects of adolescent development (e.g., Galambos, Howard, & Maggs, 2011; Hankin, Wetter, & Flory, 2012; Polderman, Boomsma, Bartels, Verhulst, & Huizink, 2010; Wiklund, Malmgren-Olsson, Öhman, Bergström, & Fjellman-Wiklund, 2012), and may thus hinder their healthy development. Together, this may explain why the common characteristics of the specific types of media multitasking may hinder adolescent development.

Practical Implications

Media and communication devices will become increasingly integrated into adolescents' lives. For example, it is likely that there will be more mobile devices and more Wi-Fi spots in the future. This will even further enhance adolescents' possibilities to engage in media multitasking. Therefore, it is expected that media multitasking will continue to rise among adolescents. Consequently, the question of how adolescents should deal with the omnipresence of media and communication devices becomes increasingly important in the upcoming years.

Although the first reaction of people may be to restrict the use of media and communication devices, researchers have already argued that the banning of these devices is not the best answer for two main reasons. First, many media and communication technologies play a positive role in adolescents' lives. For today's adolescents, the use of media and communication devices has become an important part of their daily life. For example, they use search engines to make homework and keep in touch with friends via social media. Studies have demonstrated that using media and communication devices can be beneficial for adolescent development (e.g., Reinecke, Vorderer, & Knop, 2014; Valkenburg & Peter, 2011). For example, using social media can be beneficial for adolescents' emotional well-being (Reinecke et al., 2014). Second, studies have shown that when taking the devices 'out of sight' they may not be 'out of mind' (Cheever, Rosen, Carrier, & Chavez, 2014; Clayton, Leshner, & Almond, 2015). Specifically, Cheever and colleagues showed that when mobile devices were taken away from college students, they reported higher levels of anxiety, than when adolescents were allowed to use these devices. Similarly, another study showed that when college students were separated from their smartphones, not being able to answer their ringing phone resulted in higher levels of anxiety and lower performance on a cognitive task (Clayton et al., 2015). Thus, even when devices are taken away from young people, they may still be preoccupied with these devices.

As simply restricting the use of media and communication devices is likely not the answer, it may be more important to focus on developing evidence-based programs that teach adolescents to cope with the omnipresence of these devices. Such programs could, for example, focus on both individual skills as well as the direct environment of the adolescents. With respect to the individual skills, particularly two skills may be particularly important. First, adolescents may benefit from increased awareness of their media use. Researchers have shown that media multitasking is often habitual, and that adolescents are often not aware of their media multitasking behaviors (LaRose, Lin, & Eastin, 2003). To change these behaviors, adolescents first need to be aware of their usage. Second, it may be helpful to increase adolescents' self-control. Self-control refers to an individual's ability to inhibit desires that may stand in the way of a specific goal (Hofmann, Baumeister, Förster, & Vohs, 2012; Hofmann & Kotabe, 2012). A lack in self-regulation has been associated with more media multitasking (Sanbonmatsu et al., 2013; Wei, Wang, & Klausner, 2012; Zhang, 2015). Therefore, enhancing adolescents' self-control may help adolescents to deal with ongoing media distractions. Taken together, both skills may help adolescents to use media and communication devices in a more beneficial way.

As for the direct environment of adolescents, it may be beneficial for adolescents when their environment supports adolescents' in coping with the omnipresence of media and communication devices. Although adolescents become increasingly independent during this developmental stage, parent and teachers still pay a critical role in their lives (Dishion & McMahon, 1998). Particularly because adolescents continue to develop critical aspects of their self-control skills (Crone & Dahl, 2012), parents and teachers play an important role in guiding adolescents to cope with the saturated media environment. For example, parents are advised to set clear and consistent rules about media use, whereby they should take into account their child's perspective and needs (Valkenburg, Piotrowski, Hermanns, & Leeuw, 2013). In addition, researchers suggest that parents could be important role models for adolescents' media use (Vaala & Bleakley, 2015). Therefore, it may be important that parents and teachers set the right example by, for example, not using their smartphones during family meals or when talking with others.

Future Directions for Researchers

This dissertation clearly showed that media multitasking and adolescents' development are cross-sectionally related. Although support for the impact of media multitasking on adolescent development was less conclusive, this dissertation provided first evidence for the negative effect of media multitasking on some aspects of adolescent development, that is their academic attention problems and sleep problems. Future studies are necessary to further understand the consequences of media multitasking for adolescent development. As communication researchers increasingly acknowledge that media effects are highly complex, attention for advanced theoretical models is growing (e.g., Hepp, Hjarvard, & Lundby, 2015; Valkenburg & Peter, 2013). In the media multitasking field, a clear theoretical

framework is often lacking and the complexity of media multitasking effects may not be fully captured by the way we are currently collecting and analyzing our data. There are three main directions that researchers could pursue to enhance our theoretical understanding of media multitasking effects and grasp its complexity: examining underling mechanisms, taking time into account, and investigating individual differences.

First, future studies should advance our understanding of the underlying mechanisms of media multitasking on adolescent development by empirically testing these mechanisms. This dissertation focused on examining the consequences of media multitasking for adolescent development. However, the chapters also extended the reasoning regarding the underlying mechanism of the possible effects of media multitasking on adolescent development as displayed in Figure 1. Researchers are advised to test these underlying mechanisms. Specifically, to date, we do not know which of the underlying mechanisms is most important, or if multiple underlying mechanisms play a role.

Second, researchers are advised to pay more attention to the time in which media multitasking effects occur. Although changes in individuals typically occur continuously, researchers have to depend on "snapshots" of these changes (Voelkle, Oud, Davidov, & Schmidt, 2012). Presently, communication researchers mainly turn to experimental or panel designs to answer questions of causality. While experimental designs typically examine the immediate effects, panel designs often include times spans of over 6 months or more. However, the time frame in which an effect occurs is probably dependent on the type of media use and the outcome that is examined. For example, Chapter 4 showed no support for the impact of sleep problems on media multitasking, while Mark, Wang, Niiya, and Reich (2016) found that adolescents who experienced more sleep problems reported more media multitasking the next day. This may suggest that sleep problems have an immediate effect on media multitasking, instead of a more long-term effect. In addition, while experimental studies showed that academic-media multitasking can hinder academic achievement directly after the academic activity, Chapter 2 showed no support for a long-term relationship. Therefore, to examine the impact of media multitasking on adolescent development it may be important to take time into account in future studies. This also calls for different data collections methods, such as experience sampling studies, and advanced statistical techniques, such as continuous time sampling and time series (Voelkle et al., 2012).

Third, researchers are advised to further examine individual differences. Communication researchers have repeatedly emphasized the need for examining individual differences when investigating media effects (Bandura, 2001; Slater, 2015; Valkenburg & Peter, 2013). This has resulted in more attention to these individual differences. However, in the field of media multitasking, attention for individual differences is limited. To take a first step in examining individual differences, this dissertation examined possible demographic

moderators, specifically age and biological sex. This dissertation showed that age and sex indeed moderated the relationship between media multitasking and sleep problems. However, examining single or a few moderators are likely to only grasp a small part of the individual differences. Therefore, to really understand the complexity of individual differences, it may be important to consider a bottom-up approach. For example, researchers could identify adolescents that show negative relationships between media multitiasking and adolescent development and examine the characteristic of these adolescents. For example, by investigating if common demographic, personal, and contextual factors that may explain the negative patterns found among this subgroup of adolescents do differ.

CONCLUSION

As a consequence of the growing concerns that media multitasking hinders adolescent development, the overarching goal of this dissertation was to enhance our knowledge of the relationship between media multitasking and adolescent development. This dissertation suggests that the concerns about the potential detrimental impact of media multitasking may be exaggerated. Although the studies consistently found support for a link between media multitasking and adolescent development, evidence for the actual impact of media multitasking on adolescent development is less conclusive. Specifically, the results showed that media multitasking may hinder some, but not all, aspects of adolescent development. However, examining the consequences of media multitasking for adolescent development in the future stays important. As the role of media and communication devices is expected to grow even further, it will be increasingly important to understand its impact on adolescent development and teach adolescents how to cope with the omnipresence of these devices.

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Appendices

APPENDIX A

Search Strategy

Databases
PsycINFO, ERIC, and Communication & Mass Media Complete

Results Prior to July 14, 2014
PsycINFO: 3.024 peer reviewed articles
ERIC: 4.747 peer reviewed articles
Communication & Mass Media Complete: 677 peer reviewed articles

Search Terms PsycINFO

#1 Media
audiotapes/ OR audiovisual communications media/ OR audiovisual.ti,ab,id. OR avatar.ti,ab,id. OR blog*.ti,ab,id. OR books/ OR cell phones.ti,ab,id. OR cellular phones/ OR chat*.ti,ab,id. OR cinema.ti,ab,id. OR computer based task*.ti,ab,id. OR computer applications/ OR computer mediated communication/ OR computer usage/ OR digital computers/ OR digital devices.ti,ab,id. OR digital video/ OR electronic communication/ OR electronic mail.ti,ab,id. OR email*.ti,ab,id. OR facebook.ti,ab,id. OR films/ OR film*.ti,ab,id. OR google.ti,ab,id. OR handheld*.ti,ab,id. OR human computer interaction/ OR hypermedia/ OR hypermedia.ti,ab,id. OR information technology/ OR internet/ OR internet usage/ OR iphone*.ti,ab,id. OR ipod*.ti,ab,id. OR laptop*.ti,ab,id. OR magazines/ OR mass media/ OR mass media usage.ti,ab,id. OR media content.ti,ab,id. OR media exposure/ OR media exposure.ti,ab,id. OR media adj3 multi*.ti,ab,id. OR microcomputers/ OR mobile devices/ OR mobile devices.ti,ab,id. OR mobile phones.ti,ab,id. OR motion pictures.ti,ab,id. OR movies.ti,ab,id. OR mp3.ti,ab,id. OR multimedia/ OR multimedia.ti,ab,id. OR music/ OR music.ti,ab,id. OR myspace.ti,ab,id. OR news media/ OR newspapers/ OR newspapers.ti,ab,id. OR nonprint media.ti,ab,id. OR online social networks/ OR online systems.ti,ab,id. OR OSN*.ti,ab,id. OR PDA*.ti,ab,id. OR personal digital assistant*.ti,ab,id. OR photographs/ OR printed communications media/ OR radio/ OR radio.ti,ab,id. OR second life.ti,ab,id. OR smart device*.ti,ab,id. OR smart phone*.ti,ab,id. OR SNS*.ti,ab,id. OR social media/ OR social media.ti,ab,id. OR social networks/ OR social network* adj3 online.ti,ab,id. OR social network* adj3 site*.ti,ab,id. OR tablet*.ti,ab,id. OR tagged.ti,ab,id. OR telecommunications media/ OR telephone systems/ OR television/ OR television.ti,ab,id. OR television advertising/ OR television viewing/ OR text messag*.ti,ab,id. OR texting.ti,ab,id. OR twitter.ti,ab,id. OR video display units/ OR video*.ti,ab,id. OR videotapes/ OR webcam*.ti,ab,id. OR website*.ti,ab,id. OR websites/ OR youtube.ti,ab,id.
Results: 186.092 (July 14, 2014)

#2 Multitasking

multitasking/ OR multitask*.ti,ab,id. OR task analysis/ OR task analysis.ti,ab,id. OR task complexity/ OR task complexity.ti,ab,id.

Results: 12.204 (July 14, 2014)

#3 Academic performance

academic achievement/ OR academic achievement.ti,ab,id. OR academic assignment*.ti,ab,id. OR academic effects.ti,ab,id. OR academic performance.ti,ab,id. OR gradepoint.ti,ab,id. OR grade point average.ti,ab,id. OR GPA.ti,ab,id. OR homework/ OR homework*.ti,ab,id. OR learning strategies/ OR learning strategies.ti,ab,id. OR reading achievement/ OR reading achievement.ti,ab,id. OR reading assignments.ti,ab,id. OR reading comprehension/ OR reading comprehension.ti,ab,id. OR scholastic achievement.ti,ab,id. OR school achievement.ti,ab,id. OR school assignment*.ti,ab,id. OR school performance.ti,ab,id. OR writing assignment*.ti,ab,id.

Results: 85.753 (July 14, 2014)

#4 Adolescents and emerging adults

kid.ti,ab,id. OR kids.ti,ab,id. OR prepubescen*.ti,ab,id. OR prepuberty*.ti,ab,id. OR teen*.ti,ab,id. OR young*.ti,ab,id. OR youth*.ti,ab,id. OR minors*.ti,ab,id. OR under ag*.ti,ab,id. OR underag*.ti,ab,id. OR juvenile*.ti,ab,id. OR girl*.ti,ab,id. OR boy*.ti,ab,id. OR preadolesc*.ti,ab,id. OR (adolescence 13 17 yrs OR young adulthood 18 29 yrs).ag. OR adolesc*.ti,ab,id. OR elementary schools/ OR elementary education/ OR elementary school students/ OR elementary education.ti,ab,id. OR primary school students/ OR primary education.ti,ab,id. OR K12*. ti,ab,id. OR K12.ti,ab,id. OR public school education/ OR middle schools/ OR middle school education/ OR middle school students/ OR secondary education/ OR secondary education.ti,ab,id. OR junior high schools/ OR junior high school students/ OR junior high*.ti,ab,id. OR high schools/ OR high school students/ OR high school education/ OR highschool*.ti,ab,id. OR junior college students/ OR college students/ OR colleges/ OR college*.ti,ab,id. OR higher education/ or graduate education/ OR graduate schools/ OR undergraduate education/ OR undergrad*.ti,ab,id. OR tertiary education.ti,ab,id. OR postsecondary education.ti,ab,id. OR universit*.ti,ab,id. OR students/ OR student*.ti,ab,id. OR school*.ti,ab,id. OR classroom*.ti,ab,id.

Results: 1.301.349 (July 14, 2014)

1 AND [2 OR (3 AND 4)]: 3.024 peer reviewed (July 14, 2014)

Search Terms ERIC

#1 Media

audio books/ OR audiotapes.ti,ab. OR audiovisual.ti,ab. OR avatar.ti,ab. OR blog*.ti,ab. OR books/ OR cell phones.ti,ab. OR cellular phones.ti,ab. OR chat*.ti,ab. OR cinema.ti,ab.

OR computer based task*.ti,ab. OR computer applications.ti,ab. OR computer mediated communication/ OR computer usage.ti,ab. OR computers/ OR digital devices.ti,ab. OR digital video.ti,ab. OR discussion groups/ OR electronic communication.ti,ab. OR electronic equipment/ OR electronic journals/ OR electronic mail/ OR electronic mail.ti,ab. OR email*.ti,ab. OR facebook.ti,ab. OR films/ OR film*.ti,ab. OR google.ti,ab. OR handheld devices/ OR human computer interaction.ti,ab. OR hypermedia/ OR information networks/ OR information technology/ OR internet/ OR internet us*.ti,ab. OR iphone*.ti,ab. OR ipod*.ti,ab. OR laptop computers/ OR laptop*.ti,ab. OR magazines.ti,ab. OR mass media/ OR mass media effects/ OR mass media use/ OR media content.ti,ab. OR media exposure.ti,ab. OR media adj3 multi*.ti,ab. OR microcomputers.ti,ab. OR mobile devices.ti,ab. OR mobile phones.ti,ab. OR motion pictures.ti,ab. OR movies.ti,ab. OR multimedia materials/ OR multimedia.ti,ab. OR music/ OR music.ti,ab. OR myspace.ti,ab. OR news media/ OR newspapers/ OR newspapers.ti,ab. OR nonprint media/ OR online systems/ OR OSN*.ti,ab. OR PDA*.ti,ab. OR periodicals/ OR personal digital assistant*.ti,ab. OR photographs.ti,ab. OR photography/ OR radio/ OR radio.ti,ab. OR second life.ti,ab. OR smart device*.ti,ab. OR smart phone*.ti,ab. OR SNS*.ti,ab. OR social media.ti,ab. OR social networks/ OR social network* adj3 online.ti,ab. OR social network* adj3 site*.ti,ab. OR tablet*.ti,ab. OR tagged.ti,ab. OR telecommunications/ OR telephone systems.ti,ab. OR television/ OR television.ti,ab. OR television advertising.ti,ab. OR television commercials/ OR television viewing/ OR text messag*.ti,ab. OR texting.ti,ab. OR twitter.ti,ab. OR video*.ti,ab. OR videotape cassettes/ OR videotape recorders/ OR web 2.0 technologies/ OR web browsers/ OR web sites/ OR webcam*.ti,ab. OR website*.ti,ab. OR youtube.ti,ab. OR

Results: 177.983 (July 14, 2014)

#2 Multitasking

multitask*.ti,ab. OR task analysis/ OR task analysis.ti,ab. OR task complexity.ti,ab.

Results: 9.156 (July 14, 2014)

#3 Academic performance

academic achievement/ OR academic achievement.ti,ab. OR academic assignment*.ti,ab. OR academic effects.ti,ab. OR academic performance.ti,ab. OR assignments/ OR gradepoint.ti,ab. OR grade point average/ OR grades (scholastic)/ OR GPA.ti,ab. OR homework/ OR homework*.ti,ab. OR learning strategies/ OR learning strategies.ti,ab. OR reading achievement/ OR reading achievement.ti,ab. OR reading assignments/ OR reading comprehension/ OR reading comprehension.ti,ab. OR research papers (students)/ OR scholastic achievement.ti,ab. OR school achievement.ti,ab. OR school assignment*.ti,ab. OR school performance.ti,ab. OR writing assignments/

Results: 127.260 (July 14, 2014)

#4 Adolescents and emerging adults

kid.ti,ab. OR kids.ti,ab. OR prepubescen*.ti,ab. OR prepuberty*.ti,ab. OR teen*.ti,ab.

OR young*.ti,ab. OR youth/ OR youth*.ti,ab. OR girl*.ti,ab. OR boy*.ti,ab. OR minors*.ti,ab. OR under ag*.ti,ab. OR underag*.ti,ab. OR juvenile*.ti,ab. OR preadolescents/ OR preadolesc*.ti,ab. OR adolescent development/ OR adolescents/ OR adolesc*.ti,ab. OR early adolescents/ OR late adolescents/ OR (elementary secondary education).el. OR elementary secondary education/ OR K12*.ti,ab. OR K12.ti,ab. OR (elementary education OR primary education OR grade 1 OR grade 2 OR grade 3 OR grade 4 OR grade 5 OR grade 6 OR grade 7 OR intermediate grades).el. OR grade 1/ OR grade 2/ OR grade 3/ OR grade 4/ OR grade 5/ OR grade 6/ OR grade 7/ OR elementary schools/ OR elementary education/ OR elementary school students/ OR elementary education.ti,ab. OR primary education/ OR primary education.ti,ab. OR public schools/ OR (secondary education OR junior high schools OR middle schools OR grade 8 OR grade 9 OR high schools OR grade 10 OR grade 11 OR grade 12).el. OR grade 8/ OR grade 9/ OR grade 10/ OR grade 11/ OR grade 12/ OR secondary schools/ OR secondary school students/ OR secondary education/ OR secondary education.ti,ab. OR middle schools/ OR middle school students/ OR junior high schools/ OR junior high school students/ OR junior high*.ti,ab. OR high schools/ OR high school students/ OR highschool*.ti,ab. OR (higher education OR postsecondary education OR two year colleges).el. OR higher education/ OR tertiary education.ti,ab. OR postsecondary education.ti,ab. OR college students/ OR colleges/ OR two year college students/ OR college*.ti,ab. OR two year college students/ OR undergraduate students/ OR undergraduate study/ OR undergrad*.ti,ab. OR graduate students/ OR graduate study/ OR universities/ OR universit*.ti,ab. OR students/ OR student*.ti,ab. OR school*.ti,ab. OR classroom*.ti,ab.

Results: 1.125.627 (July 14, 2014)

1 AND [2 OR (3 AND 4)]: 4.747 peer reviewed (July 14, 2014)

Search Terms Communication and Mass Media Complete

#1 Media

AB (audiotape* OR audiovisual OR avatar OR blog* OR book* OR "cell* phones" OR chat* OR cinema OR computer* OR device* OR digital OR electronic* OR email* OR facebook OR film* OR google OR internet OR iphone* OR ipod* OR laptop* OR magazine* OR media OR micro* OR mobile OR "motion pictures" OR movie* OR multimedia OR music OR myspace OR network* OR newspaper* OR online OR photo* OR radio* OR "second life" OR SNS* OR site* OR software OR tablet* OR tagged OR telecom* OR telephone* OR television OR "text messag*" OR texting OR tv OR twitter OR video* OR web* OR youtube) OR KW (audiotape* OR audiovisual OR avatar OR blog* OR book* OR "cell* phones" OR chat* OR cinema OR computer* OR device* OR digital OR electronic* OR email* OR facebook OR film* OR google OR internet OR iphone* OR ipod* OR laptop* OR magazine* OR media OR micro* OR mobile OR "motion pictures" OR movie* OR multimedia OR music OR myspace OR network* OR newspaper* OR online OR photo* OR radio* OR "second life" OR SNS*

OR site* OR software OR tablet* OR tagged OR telecom* OR telephone* OR television OR "text messag*" OR texting OR tv OR twitter OR video* OR web* OR youtube) OR SU (audiotape* OR audiovisual OR avatar OR blog* OR book* OR "cell* phones" OR chat* OR cinema OR computer* OR device* OR digital OR electronic* OR email* OR facebook OR film* OR google OR internet OR iphone* OR ipod* OR laptop* OR magazine* OR media OR micro* OR mobile OR "motion pictures" OR movie* OR multimedia OR music OR myspace OR network* OR newspaper* OR online OR photo* OR radio* OR "second life" OR SNS* OR site* OR software OR tablet* OR tagged OR telecom* OR telephone* OR television OR "text messag*" OR texting OR tv OR twitter OR video* OR web* OR youtube) OR TI (audiotape* OR audiovisual OR avatar OR blog* OR book* OR "cell* phones" OR chat* OR cinema OR computer* OR device* OR digital OR electronic* OR email* OR facebook OR film* OR google OR internet OR iphone* OR ipod* OR laptop* OR magazine* OR media OR micro* OR mobile OR "motion pictures" OR movie* OR multimedia OR music OR myspace OR network* OR newspaper* OR online OR photo* OR radio* OR "second life" OR SNS* OR site* OR software OR tablet* OR tagged OR telecom* OR telephone* OR television OR "text messag*" OR texting OR tv OR twitter OR video* OR web* OR youtube)
Results: 413.708 (July 14, 2014)

#2 Multitasking
AB (multitask* OR "task analysis" OR "task complexity") OR KW (multitask* OR "task analysis" OR "task complexity") OR SU (multitask* OR "task analysis" OR "task complexity") OR TI (multitask* OR "task analysis" OR "task complexity")
Results: 279 (July 14, 2014)

#3 Academic performance
AB ("academic achievement*" OR "academic assignment*" OR "academic effect*" OR "academic performance" OR gradepoint OR "grade point" OR GPA OR homework* OR "learning strateg*" OR "reading achievement*" OR "reading comprehension" OR "scholastic achievement*" OR "school achievement*" OR "school assignment*" OR "school performance") OR KW ("academic achievement*" OR "academic assignment*" OR "academic effect*" OR "academic performance" OR gradepoint OR "grade point" OR GPA OR homework* OR "learning strateg*" OR "reading achievement*" OR "reading comprehension" OR "scholastic achievement*" OR "school achievement*" OR "school assignment*" OR "school performance") OR SU ("academic achievement*" OR "academic assignment*" OR "academic effect*" OR "academic performance" OR gradepoint OR "grade point" OR GPA OR homework* OR "learning strateg*" OR "reading achievement*" OR "reading comprehension" OR "scholastic achievement*" OR "school achievement*" OR "school assignment*" OR "school performance") OR TI ("academic achievement*" OR "academic assignment*" OR "academic effect*" OR "academic performance" OR gradepoint OR "grade point" OR GPA OR homework* OR "learning strateg*" OR "reading achievement*" OR "reading comprehension" OR "scholastic achievement*" OR "school

achievement*" OR "school assignment*" OR "school performance")
Results: 2.647 (July 14, 2014)

#4 Adolescents and emerging adults
Results: n/a

1 AND (2 OR 3): 677 peer reviewed (July 14, 2014)

APPENDIX B

This table includes the findings regarding the moderating role of sex in the cross-sectional relationships between TIDOC (overall, social, non-social) and emotional problems.

	Beta	SE	*t*	*p*
Overall TIDOC*Sex				
W1	.02	.03	0.54	.588
W2	-.00	.03	-0.13	.899
W3	.00	.04	0.09	.925
Social TIDOC*Sex				
W1	.02	.03	0.88	.377
W2	.01	.03	0.42	.678
W3	-.02	.03	-0.66	.511
Non-Social TIDOC*Sex				
W1	.01	.03	0.34	.732
W2	-.02	.03	-0.52	.605
W3	.03	.03	0.76	.449

Note: TIDOC = technological interferences during offline conversations; W1 = Wave 1; W2 = Wave 2; W3 = Wave 3.

APPENDIX C

This table includes the main findings regarding the moderating role of sex in the longitudinal relationships between TIDOC (overall, social, non-social) and emotional problems.

	Model 1 Overall TIDOC				Model 2 Social TIDOC				Model 3 Non-Social TIDOC			
	Boys		Girls		Boys		Girls		Boys		Girls	
Between-person correlation												
TIDOC & Emotional Problems	.20*		17*		.18		.14*		.20		.19*	
Within person correlations	W1-W2	W2-W3	W1-W2	W2-W3	W1-W2	W2-W3	W1-W2	W2-W3	W1-W2	W2-W3	W1-W2	W2-W3
Stability paths												
TIDOC	.27**	.30**	.09	.09	.22*	.26*	.05	.04	.24**	.25*	.11	.12
Emotional Problems	.05	.04	.28**	.31**	.05	.04	.29**	.32**	.03	.02	.28**	.30*
Cross-lagged paths												
TIDOC → Emotional Problems	.05	.04	.08	.09	-.03	.03	.07	.07	.10	.08	.06	.07
Emotional Problems → TIDOC	-.04	-.04	.01	.01	-.09	-.10	.00	.00	-.00	-.00	.01	.01

Note: $^{**}p < .001$; $^{*}p < .05$. TIDOC = technological interferences during offline conversations; W1

English Summary

JUGGLING WITH MEDIA: THE CONSEQUENCES OF MEDIA MULTITASKING FOR ADOLESCENT DEVELOPMENT

Presently, adolescents have the opportunity to use media and communication devices 24/7. The ubiquitousness of these devices has led to a dramatic rise in media multitasking among adolescents (e.g., Rideout, Foehr, & Roberts, 2010; Wallis, 2010). Specifically, adolescents frequently use multiple media simultaneously, such sending text messages to their friends while watching a movie, and use media during non-media activities, such as listening to music while doing homework. Although this rise in media multitasking among adolescents is almost inevitable, it could be problematic for their development (Wallis, 2010). Researchers have expressed concerns that media multitasking may be harmful for several aspects of adolescent development, such as attention, academic achievement, socioemotional functioning, and sleep (e.g., Carrier, Rosen, Cheever, & Lim, 2015; Ophir, Nass, Wagner, 2009; Pea et al., 2012).

Despite these concerns, empirical evidence regarding potential negative consequences of media multitasking on adolescent development was limited and largely fragmented. Therefore, this dissertation had two main aims. The first main aim of this dissertation was to provide a comprehensive overview of our current knowledge of the possible consequences of media multitasking on developmental domains. To reach this aim, we carefully reviewed and integrated the scientific literature (Chapter 1). Largely based on this review, the second main aim of this dissertation was to investigate the longitudinal relationships between media multitasking and adolescent development. To examine these longitudinal relationships a three-wave study was conducted among approximately 1,440 adolescents from seven schools across the Netherlands. Based on analyses of these data, chapters 2 to 4 focused on improving our understanding of the actual impact of media multitasking on several aspects of adolescent development, namely academic achievement, emotional functioning, and sleep.

The State of the Art: Cross-sectional Relationships between Media Multitasking and Adolescent Development

A review of the media multitasking literature (Chapter 1) demonstrated that media multitasking had been studied in relation to three main developmental domains, namely cognitive control, academic performance, and socioemotional functioning. Although some of the results were mixed within each of the three domains, the majority of studies provided support for small to moderate relationships between media multitasking and the respective developmental domain. Higher levels of media multitasking were typically related to lower cognitive control, academic performance, and socioemotional functioning.

Besides integrating the results of existing scientific literature on media multitasking

and important aspects of adolescent development, Chapter 1 also identified important directions for future research. Most importantly, the reviewed studies primarily relied on convenience and college student samples (e.g., Becker et al., 2013; Junco & Cotten, 2012; Ophir et al, 2009), whereas only a few studies specifically focused on adolescents (e.g., Baumgartner et al., 2014; Calamaro, Mason, & Ratcliffe, 2009; Pool, van der Voort, Beentjes, & Koolstra, 2000). This is surprising, as scholars particularly focus on adolescents when expressing concerns about potentially detrimental effects of media multitasking on development (e.g., Carrier, Cheever, Rosen, Benitez, & Chang, 2009; Voorveld & van der Goot, 2013).

As a consequence of this research gap, evidence regarding the cross-sectional relationships between media multitasking and the three developmental domains among adolescents was limited. Therefore, it was important to examine whether the cross-sectional relationships reported in the literature would also hold among adolescents. In with line the cross-sectional findings of the review, the following chapters (chapters 2 to 4) showed that media multitasking was, indeed, associated with lower academic performance (i.e., more academic attention problems and lower academic achievement scores), more emotional problems, and more sleep-related problems among adolescents.

Unchartered Territories: Longitudinal Relationships between Media Multitasking and Adolescent Development

Chapter 1 further revealed that it is yet unknown whether media multitasking actually causes problems in adolescent development. Accordingly, in order to enhance our knowledge of the causal relationship between media multitasking on adolescent development, the following chapters in this dissertation examined the longitudinal relationship between media multitasking and adolescent development. This longitudinal approach has resulted in three main findings.

1 **Media multitasking and adolescent development were negatively related across the school year**. The findings of this dissertation indicate the media multitasking was related to more problems in several developmental domains among adolescents. In line with previous cross-sectional studies, adolescents who reported more frequent media multitasking reported to have lower academic achievement, more academic attention problems, more sleep problems, and more emotional problems across the school year.

2 **Media multitasking sometimes, but not always, negatively predicted adolescent development**. Although media multitasking was negatively related with the specific domains of adolescent development, we found limited evidence for a long-term effect of media multitasking on adolescent development. More specifically, academic-media multitasking did not predict academic achievement scores over

time (Chapter 2), and media use during offline conversations did not predict emotional problems over time (Chapter 3). However, we did find support for a small longitudinal relationship between media multitasking and adolescent development over time in two other domains. Specifically, Chapter 2 showed that academic-media multitasking positively predicted adolescents' academic attention problems over time, and Chapter 4 demonstrated that media-media multitasking positively predicted sleep-related problems over time among early adolescents and girls.

3 **There was no evidence for the reversed relationship, difficulties in adolescent development did not predict adolescents' media multitasking frequency**. Although the common assumption is that media multitasking hinders adolescent development, Chapter 1 indicated that some researchers have argued that the relationship could also be reversed. Therefore, in chapters 2 to 3 it was examined if difficulties in adolescent development positively predicted media multitasking. However, the findings showed no support for the reversed relationships. Academic achievement (Chapter 2), academic attention problems (Chapter 2), emotional problems (Chapter 3), and sleep-related problems (Chapter 4), did not predict more frequent engagement in media multitasking over time.

Conclusions and Societal Implications

All chapters of this dissertation clearly show that media multitasking and adolescent development are cross-sectionally related. However, findings that media multitasking actually hinders adolescent development are more nuanced. Given the fact that this dissertation has solely yielded small relationships between media multitasking on some aspects of adolescent development, the conclusion might be that media multitasking is less problematic for adolescent development than it often assumed. Together, the findings of this dissertation do indeed suggest that there is no reason for panic regarding the impact of media multitasking on adolescent development. However, at the same time, findings do emphasize that there is still reason for caution regarding specific developmental aspects. Specifically, our findings suggest that media multitasking may interfere with attention problems and sleep-related problems. Both attention and sleep are highly important in the healthy development of adolescents (e.g., Eisenberg, Hofer, & Vaughan, 2007; Shochat, Cohen-Zion, & Tzischinsky, 2014). Considering that media and communication devices will become increasingly integrated into adolescents' lives, it is expected that media multitasking will continue to rise among adolescents. Therefore, the question on how adolescents should deal with the omnipresence of media and communication devices becomes even more important in the upcoming years.

As simply restricting the use of media and communication devices is likely not the best answer (Cheever, Rosen, Carrier, & Chavez, 2014; Clayton, Leshner, & Almond, 2015), future programs are advised to teach adolescents to cope with the omnipresence of

these devices. Such programs could, for example, focus on both individual skills as well as the direct environment of the adolescents. With respect to individual skills, programs may focus on enhancing adolescents' awareness and self-control of their media use. By increasing awareness and self-control adolescents may be more able to control their use of media and communication devices. As for the direct environment of the adolescents, it may be beneficial when their environment supports them to cope with the ubiquitousness of media. Specifically, parents and teachers play an important role in guiding adolescents to cope with the saturated media environment. For example, parents are advised to set clear and consistent rules about media use, whereby they take into account their child's perspective and needs (Valkenburg, Piotrowski, Hermanns, & Leeuw, 2013).

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Nederlandse Samenvatting

[DUTCH SUMMARY]

JONGLEREN MET MEDIA: DE GEVOLGEN VAN MEDIA MULTITASKING OP DE ONTWIKKELING VAN ADOLESCENTEN

Door de snelle ontwikkeling van media- en communicatietechnologieën hebben jongeren tegenwoordig 24 uur per dag en 7 dagen in de week toegang tot media. Dit gaat gepaard met een sterke toename in *media multitasking* onder adolescenten (bijv. Rideout, Foehr & Roberts, 2010; Wallis, 2010). Ten eerste gebruiken adolescenten steeds vaker meerdere media tegelijkertijd, tijdens het televisie kijken sturen ze bijvoorbeeld berichtjes naar vrienden. Ten tweede gebruiken adolescenten vaak media tijdens school- en sociale activiteiten. Zo kijken ze bijvoorbeeld YouTube filmpjes tijdens het maken van huiswerk en gebruiken ze sociale media tijdens gesprekken met vrienden. Ouders, leerkrachten en onderzoekers maken zich steeds vaker zorgen over de mogelijke negatieve gevolgen van media multitasking op de ontwikkeling van adolescenten (Wallis, 2010). Desondanks blijft wetenschappelijk bewijs voor deze negatieve gevolgen beperkt en gefragmenteerd.

Dit proefschrift richt zich daarom op het onderzoeken van de gevolgen van media multitasking op de ontwikkeling van adolescenten. Het eerste doel van dit proefschrift is inzicht te krijgen in de huidige kennis over de gevolgen van media multitasking op verschillende ontwikkelingsdomeinen. Om dit doel te bereiken is de wetenschappelijke literatuur zorgvuldig onderzocht en geïntegreerd. Dit literatuuronderzoek wordt beschreven in Hoofdstuk 1. Het tweede doel van het proefschrift is gebaseerd op bevindingen van het literatuuronderzoek, namelijk het onderzoeken van de longitudinale relaties tussen media multitasking en de ontwikkeling van adolescenten. Om deze relaties te onderzoeken hebben ongeveer 1,440 Nederlandse middelbare scholieren op drie momenten tijdens één schooljaar een vragenlijst ingevuld. De resultaten van dit onderzoek worden beschreven in Hoofstuk 2, 3 en 4.

De stand van zaken: cross-sectionele relaties tussen media multitasking en de ontwikkeling van adolescenten

Hoofdstuk 1 geeft een overzicht van de stand van zaken in de wetenschappelijke media multitasking literatuur. Dit overzicht laat zien dat de literatuur onder te verdelen is aan de hand van drie belangrijke ontwikkelingsdomeinen, namelijk cognitieve controle, schoolprestaties en sociaal-emotioneel functioneren. Hoewel de bevindingen van de studies binnen de drie ontwikkelingsdomeinen soms verschillen, blijkt over het algemeen dat er een verband is tussen media multitasking en de verschillende ontwikkelingsdomeinen. Adolescenten die vaker jongleren met media hebben minder cognitieve controle, slechtere schoolprestaties en meer problemen op het gebied van sociaal-emotioneel functioneren.

Naast het in kaart brengen van het huidige onderzoeksveld, geeft Hoofdstuk 1 inzicht in de tekortkomingen in de bestaande wetenschappelijke literatuur en biedt het handvatten voor

toekomstig wetenschappelijk onderzoek. Tot nu toe maakten onderzoekers voornamelijk gebruik van relatief kleine en willekeurige steekproeven bestaande uit universitaire studenten (bijv. Becker et al., 2013; Junco & Cotten, 2012; Ophir, Nass, & Wagner, 2009), slechts een beperkt aantal studies richtten zich expliciet op adolescenten (bijv. Baumgartner, Weeda, van der Heijden, & Huizinga, 2014; Calamaro, Mason, & Ratcliffe, 2009; Pool, van der Voort, Beentjes, & Koolstra, 2000). Dit is verrassend, omdat media multitasking voornamelijk voorkomt onder adolescenten (bijv. Carrier, Cheever, Rosen, Benitez, & Chang, 2009; Voorveld & van der Goot, 2013).

In de laatste drie hoofdstukken van dit proefschrift wordt beschreven of de cross-sectionele relaties uit eerder onderzoek ook terug te zien zijn onder adolescenten. Deze hoofdstukken laten zien dat ook bij deze leeftijdsgroep media multitasking gerelateerd is aan verschillende aspecten van de ontwikkeling. Zo wordt in Hoofdstuk 2, 3 en 4 beschreven dat adolescenten die vaker multitasken met media lagere schoolprestaties hadden en meer aandachtsproblemen op school, emotionele problemen en slaap-gerelateerde problemen rapporteerden.

Onbekend terrein: longitudinale relaties tussen media multitasking en de ontwikkeling van adolescenten

In Hoofdstuk 1 wordt benadrukt dat cross-sectionele studies geen bewijs leveren voor de causale processen tussen media multitasking en de verschillende ontwikkelingsdomeinen van adolescenten. Cross-sectionele studies tonen aan dat er een relatie is tussen media multitasking en de verschillende ontwikkelingsdomeinen, maar geven geen inzicht in de daadwerkelijke invloed van media multitasking op de verschillende ontwikkelingsdomeinen. Het is bijvoorbeeld ook mogelijk dat de relatie omgekeerd is, dus dat de aanwezigheid van verschillende problemen in de ontwikkeling van een adolescent zou kunnen leiden tot een toename in media multitasking. De zorgen over media multitasking gaan echter specifiek over de gevolgen van media multitasking op de ontwikkeling van adolescenten. Over het algemeen wordt verwacht dat wanneer een adolescent vaak meerdere media tegelijkertijd gebruikt of media gebruikt tijdens school- of sociale activiteiten, dit een negatieve invloed zal hebben op de verschillende ontwikkelingsdomeinen. Om de eerder gevonden verbanden beter te kunnen begrijpen, gaan Hoofdstuk 2, 3 en 4 van dit proefschrift voornamelijk in op het onderzoeken van de *longitudinale* relaties tussen media multitasking en de ontwikkeling van adolescenten. Met deze longitudinale benadering wordt een eerste stap gezet om de causale processen beter te begrijpen (bijv. Curran & Bauer, 2011; Hamaker, Kuiper, & Grasman, 2015). Dit resulteerde in drie belangrijke bevindingen.

1 **Gedurende het schooljaar was media multitasking negatief gerelateerd aan de verschillende ontwikkelingsdomeinen**. Het is mogelijk dat gedurende het schooljaar de scores voor media multitasking en de verschillende ontwikkelingsdomeinen redelijk stabiel blijven onder de adolescenten. Sommige adolescenten zullen

immers over het algemeen meer geneigd zijn om te multitasken met media ten opzichte van andere adolescenten. In de longitudinale modellen is zichtbaar of deze stabiele scores voor media multitasking en de stabiele scores op de verschillende ontwikkelingsdomeinen aan elkaar gerelateerd zijn. Deze modellen lieten zien dat in navolging van de eerder gevonden cross-sectionele bevindingen, adolescenten met een stabiele hogere score voor media multitasking meer problemen vertoonden op de verschillende ontwikkelingsdomeinen dan adolescenten met een stabiele lagere score voor media multitasking. In het kort betekent dit dat adolescenten die meer multitasken met media gedurende het schooljaar lagere schoolpresentaties, meer aandachtsproblemen op school (Hoofdstuk 2), meer emotionele problemen (Hoofdstuk 3) en vaker slaap-gerelateerde problemen (Hoofdstuk 4) rapporteerden dan adolescenten die minder vaak multitasken met media.

2 **Media multitasking voorspelde soms, maar niet altijd, negatieve veranderingen in de verschillende ontwikkelingsdomeinen**. Om de causale relaties tussen media multitasking en de verschillende ontwikkelingsdomeinen te begrijpen, was het belangrijkste doel het toetsen van de mogelijke invloed van media multitasking op de verschillende ontwikkelingsdomeinen van adolescenten. De studie beschreven in Hoofdstuk 2 laat zien dat multitasking met media tijdens schoolactiviteiten, zoals het maken van huiswerk, over een periode van drie tot vier maanden niet gerelateerd is aan lagere schoolprestaties. De resultaten die worden beschreven in Hoofdstuk 3 laten zien dat mediagebruik tijdens offline gesprekken drie tot vier maanden later niet gerelateerd is aan meer emotionele problemen. Er werd echter wel bewijs gevonden voor kleine longitudinale relaties tussen media multitasking en de ontwikkeling van adolescenten op twee andere domeinen. Multitasking met media tijdens schoolactiviteiten voorspelt over een periode van drie tot vier maanden meer aandachtsproblemen op school (Hoofdstuk 2), en multitasking met media in het algemeen voorspelt meer slaap-gerelateerde problemen voor meisjes en brugklassers (Hoofdstuk 4).

3 **Er is geen bewijs gevonden voor de invloed van problemen in de ontwikkeling van adolescenten op de frequentie van media multitasking**. Alhoewel onderzoekers over het algemeen verwachtten dat cross-sectionele relaties een indicatie zijn voor een mogelijk effect van media multitasking op de ontwikkeling van adolescenten, wordt in Hoofdstuk 1 van dit proefschrift beargumenteerd dat de relatie ook andersom zou kunnen zijn. Dit betekent dat de aanwezigheid van verschillende problemen in de ontwikkeling van een adolescent zou kunnen leiden tot een toename in media multitasking. In Hoofdstuk 2,3 en 4 werd echter geen bewijs gevonden voor de mogelijke invloed van de ontwikkelingsdomeinen op de frequentie van media multitasking.

Conclusie en maatschappelijke implicaties

In dit proefschrift wordt beschreven dat media multitasking en de verschillende ontwikkelingsdomeinen tijdens de adolescentie aan elkaar gerelateerd zijn. De assumpties dat media multitasking daadwerkelijk negatieve gevolgen heeft op de ontwikkeling van adolescenten lijken te moeten worden genuanceerd. Omdat dit proefschrift alleen kleine longitudinale relaties laat zien tussen media multitasking en sommige ontwikkelingsdomeinen ontstaat de vraag of media multitasking eigenlijk wel problematisch is voor de ontwikkeling van adolescenten. Hoewel dit proefschrift laat zien dat de gevolgen van media multitasking wellicht minder groot zijn dan vaak wordt verondersteld, blijft het belangrijk om waakzaam te zijn voor negatieve gevolgen. De resultaten suggereren immers ook dat media multitasking de aandacht en slaap van adolescenten kan verstoren. Zowel aandacht als slaap zijn cruciaal voor de gezonde ontwikkeling van adolescenten (e.g., Eisenberg, Hofer, & Vaughan, 2007; Shochat, Cohen-Zion, & Tzischinsky, 2014). Rekening houdend met een steeds verdere integratie van media- en communicatietechnologieën in de levens van adolescenten, is het te verwachten dat media multitasking onder adolescenten blijft toenemen. Daarom wordt de vraag hoe adolescenten om moeten gaan met deze alom aanwezige technologieën de komende jaren steeds belangrijker.

Omdat het verbieden van het gebruik van media- en communicatietechnologieën niet de oplossing is (bijv. Cheever, Rosen, Carrier, & Chavez, 2014; Clayton, Leshner, & Almond, 2015), is het belangrijk om aandacht te besteden aan het ontwikkelen van wetenschappelijk onderbouwde programma's die adolescenten leren omgaan met de hoeveelheid aan media en technologieën. Deze programma's kunnen zich bijvoorbeeld richten op het ontwikkelen van individuele vaardigheden, bijvoorbeeld het versterken van het bewustzijn en de zelfcontrole met betrekking tot het mediagebruik van adolescenten. Door het bewustzijn en de zelfcontrole te vergroten, zijn adolescenten mogelijk meer in staat om bewuster om te gaan met media. Daarnaast zouden programma's zich kunnen richten op creëren van een omgeving die het bewust gebruiken van media door jongeren actief ondersteunt. Ouders en leerklachten spelen hierin een belangrijke rol. Zo zouden ouders bijvoorbeeld moeten worden geadviseerd om duidelijke en consistente regels op te stellen over mediagebruik, waarbij ze het perspectief en de behoeften van het kind meenemen (Valkenburg, Piotrowski, Hermanns, & Leeuw, 2013). Door adolescenten bewust te leren omgaan met media- en communicatietechnologieën ontstaat er hopelijk een optimale balans waarin de negatieve effecten van media multitasking worden beperkt en de positieve effecten van het gebruiken van media worden ondersteund.

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Authorship Contributions

Chapter 1: The Consequences of Media Multitasking for Youth: A Review
Researchers involved (with Initials): Winneke van der Schuur (WS), Susanne Baumgartner (SB), Sindy Sumter (SS), & Patti Valkenburg (PV)

Author Contributions	Contribution	Substantial Contribution
Conceptualization (Main idea, Theory)		WS, SB, SS, PV
Methodology (Design, Operationalization)		WS, SB, SS, PV
Data Collection	SB, SS	WS
(Statistical) Analysis	SB, SS, PV	WS
Writing (original draft preparation)		WS
Writing (review and editing)		WS, SB, SS, PV

Chapter 2: Exploring the Long-Term Effects of Academic-Media Multitasking on Adolescents' Academic Achievement
Researchers involved (with Initials): Winneke van der Schuur (WS), Susanne Baumgartner (SB), Sindy Sumter (SS), & Patti Valkenburg (PV)

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Methodology (Design, Operationalization)		WS, SB, SS, PV
Data Collection		WS
(Statistical) Analysis	SB, SS	WS
Writing (original draft preparation)		WS
Writing (review and editing)		WS, SB, SS, PV

Chapter 3: Technological Interferences During Offline Conversations Among Adolescents and its Relationship With Their Emotional Problems

Researchers involved (with Initials): Winneke van der Schuur (WS), Sindy Sumter (SS), Susanne Baumgartner (SB), & Patti Valkenburg (PV)

Author Contributions	Contribution	Substantial Contribution
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Methodology (Design, Operationalization)		WS, SB, SS, PV
Data Collection		WS
(Statistical) Analysis	SB, SS	WS
Writing (original draft preparation)		WS
Writing (review and editing)		WS, SB, SS, PV

Chapter 4: Media Multitasking and Sleep Problems: A Longitudinal Study Among Adolescents

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Methodology (Design, Operationalization)		WS, SB, SS, PV
Data Collection		WS
(Statistical) Analysis	SB, SS	WS
Writing (original draft preparation)		WS
Writing (review and editing)		WS, SB, SS, PV

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About the Author

Winneke A. van der Schuur (June 6, 1988) started as a bachelor student in Pedagogical Sciences at the University of Amsterdam in September 2008. She received her bachelor degree in 2011. Thereafter, she was admitted to the research master in Educational Sciences at the University of Amsterdam, where she continued developing her interests in research on child development and education. After receiving her Master of Science degree in 2013, she started as a PhD student at the Amsterdam School of Communication Science at the University of Amsterdam, under supervision of her advisor prof. dr. Valkenburg and co-advisors dr. Baumgartner and dr. Sumter. During the four years of Winneke's PhD project, she focused on examining the possible consequences of media multitasking for adolescent development. Since September 2017, Winneke has been working as an assistant professor in Child and Family studies at the Erasmus University Rotterdam. In the upcoming years, Winneke aims to enhance the current knowledge of the impact of media use on adolescent development and find ways in which adolescents can learn how to cope with the omnipresence of media in their lives.

More than ever, adolescents juggle with media. They use multiple media simultaneously, for example, they send text messages to their friends while watching a movie. In addition, they use media during academic and social activities, such as watching YouTube videos while doing homework. Although this rise in media multitasking among adolescents is almost inevitable, researchers have expressed concerns that media multitasking may be harmful for several aspects of adolescent development, such as attention, academic achievement, socioemotional functioning, and sleep. Despite these concerns, empirical evidence regarding potential negative consequences of media multitasking on adolescent development was limited. All chapters of this dissertation show that media multitasking and adolescent development are cross-sectionally related. However, findings on the actual impact of media multitasking on adolescent development are more nuanced. This dissertation has solely yielded small longitudinal relationships between media multitasking and some aspects of adolescent development. Although the conclusion might be that media multitasking is less problematic for adolescent development than often assumed, the findings do emphasize that there is still reason for caution regarding specific developmental domains, such as attention and sleep. Considering that media and communication devices will become increasingly integrated into adolescents' lives, it is expected that media multitasking will continue to rise among adolescents. Therefore, the question on how adolescents should deal with the omnipresence of media and communication devices becomes even more important in the upcoming years.