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The Relationship Between Media Multitasking and Attention Problems in Adolescents: Results of Two Longitudinal Studies

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The increased prevalence of media multitasking among adolescents has raised concerns that media multitasking may cause attention problems. Despite cross-sectional evidence of the relationship between media multitasking and attention problems, no study has yet investigated this relationship longitudinally. It is therefore unclear how these two variables are related. Two 3-wave longitudinal studies with 3- and 6-month time lags were conducted. In total, 2,390 adolescents aged 11–16 provided data on media multitasking and attention problems. Findings from random intercept autoregressive cross-lagged models suggest that media multitasking and attention problems were strongly related between individuals. Empirical evidence for a potential detrimental long-term effect of media multitasking on attention problems was only found among early adolescents but not among middle adolescents.

Keywords: Media Multitasking, Attention Problems, Adolescents, Media Effects, Reinforcing Effects, Spiral Models.

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The prevalence of media multitasking—the simultaneous engagement in two or more media activities—has strongly increased in recent years. Media multitasking has become a popular form of media use particularly among adolescents (Foehr, 2006; Rideout, Foehr, & Roberts, 2010). Research has indicated that adolescents' time spent multitasking has doubled within a decade: from 16% in 1999 to a third of their time 10 years later (Rideout et al., 2010). The increased prevalence of media multitasking among adolescents has raised concerns that frequent media multitasking may be detrimental to adolescents' cognitive control processes, such

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as their ability to focus and maintain attention (Bowman, Waite, & Levine, 2015; Ophir, Nass, & Wagner, 2009; Wallis, 2010).

The potential negative consequences of media multitasking on cognitive control processes have received increasing research attention in the past few years. Since a seminal study by Ophir et al. (2009), several studies have examined the relationship between media multitasking and cognitive control processes (for a review, see van der Schuur, Baumgartner, Sumter, & Valkenburg, 2015). The majority of these studies found a small negative relationship between the amount of media multitasking and cognitive control. For example, (Ophir et al. 2009) showed that heavy media multitaskers were more likely to be distracted by irrelevant information than light media multitaskers. Similarly, Baumgartner, Weeda, van der Heijden, and Huizinga (2014) found that adolescents who media multitasked frequently reported more difficulties focusing attention in their everyday lives. Moreover, frequent media multitasking has been shown to be related to self-reported attention problems (Ralph, Thomson, Cheyne, & Smilek, 2013).

Scholars have frequently interpreted the findings of these studies as providing evidence for a unidirectional relationship between media multitasking and attention problems, in which engagement in media multitasking leads to increased attention problems. However, such a conclusion appears premature for at least three reasons. First, although several researchers propose potential mechanisms for such effects (Ophir et al., 2009; Ralph et al., 2013), a comprehensive theoretical framework to explain these effects is still missing. Furthermore, because of the cross-sectional nature of the existing studies, it is not known whether there is indeed a causal relationship between media multitasking and attention problems and whether this relationship is unidirectional. Based on recent media effects theories (Slater, Henry, Swaim, & Anderson, 2003; Valkenburg & Peter, 2013), one may assume that the relationship is more complex, taking the form of a reciprocal, dynamic relationship, with media multitasking and attention problems influencing each other over time. A final shortcoming of previous studies is that they have largely ignored boundary conditions for the relationship between media multitasking on attention problems. Therefore, we do not know for whom and under what conditions a relationship between media multitasking and attention problems may exist.

Considering these three shortcomings, the present article has three main aims. First, we will provide a comprehensive framework for the relationship between media multitasking and attention problems and delineate how and why the two variables may influence each other. Second, the article aims to further elucidate the causal nature of the relationship between media multitasking and attention problems. Third, we will test initial boundary conditions to investigate for whom potential effects may exist. Establishing the nature of the relationship between media multitasking and attention problems and its boundary conditions is the most important step in the development of a comprehensive theory of media multitasking effects. To provide a complete picture of the causal relationship between media multitasking and attention problems, we investigated the relationship in two longitudinal studies with different time lags (3 and 6 months), we examined potential moderators (i.e., age and biological gender), and disentangled between-subject effects from within-subject effects.

The relationship between media multitasking and attention problems

Attention problems refer to the inability of an individual to regulate and guide attention efficiently. Adolescents with attention problems have difficulties maintaining focus on one task and become more easily bored with a task. Moreover, they commonly have difficulty ignoring irrelevant information and are more easily distracted (APA, 2013). Attentional deficits are one of the two main symptoms of attention-deficit hyperactivity disorder (ADHD) (with impulsive-hyperactive behavior being the second); however, attentional deficits can also occur solely (Barkley, 1997). Attentional processes, more generally, are oftentimes subsumed under the term "executive functions" (Anderson, 2002). Executive functions have been conceptualized as multiple interrelated control systems that are responsible for goal-related behavior. Attentional processes are one of these subdomains, and a deficit in attentional processes may have consequences for various aspects of adolescent functioning (Anderson, 2002).

There are at least three possibilities how media multitasking and attention problems might be related. The first—and most widely assumed—possibility is that media multitasking leads to attention problems in adolescents. Another, no less plausible possibility, however, is that attention problems lead to increased engagement in media multitasking. Finally, media multitasking and attention problems may also be reciprocally related. All three relational patterns and their theoretical underpinnings are described below.

Theoretical explanations for an effect of media multitasking on attention problems

Most studies that investigated the relationship between media multitasking and cognitive processes implicitly or explicitly state that media multitasking leads to attention problems (Ophir et al., 2009; Ralph et al., 2013). However, theoretical explanations for such an effect are either not provided or based on plausibility assumptions. It is thus unknown *how* and *why* media multitasking would increase attention problems. However, to understand potential effects of media multitasking on attention problems, it is important to delineate potential theory-based explanations that may drive such an effect. We therefore suggest three potential explanations that might explain this effect: (a) habituation to high arousal levels, (b) heightened sensitivity for irrelevant information, and (c) deterioration of attentional control processes.

First, media multitasking may lead to attentional problems because individuals habituate to increasing arousal levels. In a media multitasking situation, individuals encounter two or more streams of information simultaneously. Because information processing capacities are limited, individuals have to constantly switch their attention from one media content (e.g., TV program) to another (e.g., incoming text messages). Interestingly, switching between one media content and another has been shown to be arousing (Yeykelis, Cummings, & Reeves, 2014). Because of this arousing character of media multitasking, previous scholarship (Nikkelen, Valkenburg, Huizinga, & Bushman, 2014; Wallis, 2010) has argued that adolescents who frequently multitask with media may habituate to these heightened arousal levels. Adolescents who are used to elevated arousal levels might have difficulties staying focused in other nonmedia situations that are not arousing (e.g., in class). This habituation may lead to impatience during boring situations and the expectation of instant and continuous gratifications. In the long run, the habituation to highly arousing media multitasking may thereby lead to problems sustaining attention during less engaging situations that require focused attention.

Second, frequent media multitasking may lead to difficulties in filtering out irrelevant information. Ophir et al. (2009) argues that heavy media multitaskers are more easily distracted by irrelevant information because they are accustomed to focusing on several media in their environment. If adolescents get used to allocating their attention to several media concurrently, they may have difficulty focusing their attention in situations that require longer periods of attention (e.g., doing homework; see, e.g., Junco & Cotten, 2011; Rosen, Carrier, & Cheever, 2013). Using a small sample of university students, Ophir et al. (2009) showed that light and heavy media multitaskers differed in the way they processed information. Heavy media multitaskers showed a breadth-biased processing style, indicating that they had greater difficulty filtering out irrelevant information from the environment than low media multitaskers (Ophir et al., 2009). The inability to filter out irrelevant information leads to a heightened distractibility, which is an important component of attention problems. Accordingly, research by Ophir et al. (2009) suggests that media multitasking may have detrimental effects on attention because it results in a reduced ability to ignore irrelevant information. Similarly, Kazakova, Cauberghe, Pandelaere, and de Pelsmacker (2015) have shown experimentally that a media multitasking situation leads to differences in processing style immediately following this situation.

A third explanation for potential detrimental effects of media multitasking on attention is that media multitasking deteriorates attentional control processes. For example, according to Ralph et al.'s (2013) deficit-producing hypothesis, "over-reliance on external [...] stimulation (i.e., media stimulation) may cause deficits in one's ability to internally [...] sustain the focus of attention" (p. 6). Specifically, they argue that individuals lose their ability to regulate their attention internally because the media frequently externally guides their attention. This is in line with what has previously been argued for the effects of fast-paced TV content (i.e., TV content that includes rapidly changing events). For example, Lillard and Peterson (2011) argued that fast-paced TV may capture attention in a bottom–up fashion, which means the properties of the TV content, not volitional attention processes, automatically guide attention. Fast-paced TV content may therefore inhibit the development of "internally-controlled (prefrontal) attention" processes (Lillard & Peterson, 2011, p. 645). Watching fast-paced TV and engaging in media multitasking may be similar because both imply fast and frequent attentional switches. Accordingly, one can assume that media multitasking may also deteriorate the ability to internally control attention processes.

In sum, all three mechanisms provide theoretical explanations for potential effects of media multitasking on attention problems. Although it is yet unknown, based on the existing studies, which of these mechanisms may contribute to attention problems, all three mechanisms suggest that media multitasking disrupts adolescents' ability to sustain and focus attention in the long run.

A dynamic perspective: Reciprocal relationships between media multitasking and attention problems over Time

Based on recent media effects models, it may be assumed that the relationship between media multitasking and attention problems is more complex than a simple cause-and-effect relationship (Bandura, 2009; Slater, 2007; Valkenburg & Peter, 2013). According to the Reinforcing Spiral Model (RSM) of media effects (Slater et al., 2003; Slater, 2007, 2015), media use and attitudes can be reciprocally related and mutually reinforcing. The RSM originally postulated reinforcing effects between *attitudes* and the use of specific media *content*. However, this focus on media content and attitudes (and later behavior; see Slater, Henry, Swaim, & Cardador, 2004) may represent an artificial boundary constraint to the model. We argue that the explanatory power of this framework can be expanded to also explain the relationship between specific *types* of media use (i.e., media multitasking) and individual difference factors (i.e., attention problems).

One of the main premises of the RSM is that individuals choose specific media content that is in line with their prevailing *attitudes,* which in turn may reinforce these *attitudes*. Within the specific context of media multitasking and attention problems, the question remains whether we can expect similar selection effects to occur for individual factors (instead of attitudes). Based on previous research, one may assume that individuals with specific personality traits are more likely to seek out media multitasking situations (Hwang, Kim, & Jeong, 2014; Jeong & Fishbein, 2007; Wang & Tchernev, 2012). Adolescents with attention problems may be more likely to engage in media multitasking because they prefer the distraction provided by several media simultaneously (Sanbonmatsu, Strayer, Medeiros-Ward, & Watson, 2013). Thus, adolescents who have difficulties focusing their attention in their everyday lives may be less able to sustain attention on one singular medium (e.g., on a TV show) and may be more likely to multitask if they have the possibility to use other media simultaneously.

Preliminary evidence that attentional problems lead to increased multitasking has been provided by Sanbonmatsu et al. (2013) who have shown that specific personality traits, such as impulsivity, are related to media multitasking. More specifically, they showed that attentional impulsiveness is related to frequent engagement in media multitasking. Attentional impulsiveness is a concept that is very similar to attention problems. Attentional impulsiveness describes the inability to concentrate and focus attention. Sanbonmatsu et al. (2013) argue that because of the rewarding nature of media multitasking, individuals with higher attentional impulsiveness are less able to block tempting media distractions. Moreover, Magen (2017) recently indicated that inattention was related to increased media multitasking. Thus, adolescents who show attention problems may be more likely to engage in media multitasking because they have difficulties in sustaining their attention on one media content in the presence of other media distractors.

As outlined above, frequent engagement in media multitasking may increase initial attention problems because media multitasking may (a) cause habituation to increased arousal levels, (b) increase difficulties to filter out irrelevant information, and (c) deteriorate attentional control processes. These increased attention problems may, in turn, augment the willingness to engage in media multitasking. Over time, this reciprocal relation could develop into a downward spiral in which media multitasking and attention problems are mutually reinforcing. First, evidence for a dynamic and reciprocal relationship in the context of media multitasking has been provided by Wang and Tchernev (2012). Using experience sampling data, they found that media multitasking, needs, and gratifications reciprocally and dynamically influence each other. Most importantly, they found that media multitasking is driven by cognitive needs and that media multitasking in turn increases emotional gratifications, which may dynamically change needs.

In sum, based on the above reasoning and previous studies on media multitasking and attention problems, there are several theoretical explanations for a reciprocal relationship between attention problems and media multitasking. We therefore hypothesize:

> **H1:** Media multitasking and attention problems influence each other reciprocally over time.

Age and biological gender as potential moderators

Prior research (e.g., van der Schuur et al., 2015) has pointed out that ignoring individual differences is a crucial shortcoming in existing research on the effects of media multitasking. Moderators are particularly important within the RSM framework because they may indicate for whom the spiraling effects are particularly pronounced (Slater, 2007). Moreover, moderators may point toward restraining factors that potentially inhibit the reinforcing effects. A likely assumption is that the reinforcing nature of media use and effects does not spiral up endlessly but that there are circumstances in which these effects are dampened (see Slater, 2015). It is therefore important to identify potential factors that may constrain or reinforce these effects.

Based on theoretical considerations, we identified two individual factors that may play important moderating roles: age and biological gender. Age is an important moderator because, Valkenburg & Peter, 2013 have argued that developmental changes during the lifespan may make some individuals more susceptible to media effects than others. In particular, the transition from early to middle adolescence is a period of substantial developmental changes in the cognitive, emotional, and social domain (Steinberg, 2008). More specifically, it has been shown that during adolescence, important self-regulatory processes are still developing (Gestsdottir & Lerner, 2008). Early adolescents thus frequently have deficits in self-regulatory skills (Huizinga, Dolan, & van der Molen, 2006). Self-regulation may be an important determinant of media multitasking. Individuals with lower self-regulatory skills may be more likely to engage in media multitasking because they have less ability to regulate impulses to multitask. Thus, it is a likely assumption that younger adolescents are more likely to engage in media multitasking.

In addition to the increased likelihood of young adolescents to multitask, the effects of media multitasking on attention problems may also be stronger among early adolescents than among older adolescents. From a developmental neuroscience perspective, the onset of puberty is seen as a period of substantial restructuring in the adolescent brain (Anderson, 2002; Blakemore & Choudhury, 2006; Steinberg, 2008). Blakemore & Choudhury (2006, p. 307) have argued that during early adolescence, individuals are particularly sensitive to "experiential input at this period of time in the realm of executive functioning." This suggests that if adolescents engage in frequent media multitasking during this developmentally sensitive period, this indeed may lead to a deterioration of attentional control processes because the brain is particularly vulnerable during this period. Older adolescents may be less sensitive to these effects because their brain development has already progressed.

It may also be that adolescents habituate to potentially adverse media multitasking effects over time. In early adolescence, both smartphone ownership and media multitasking substantially increase (Rideout et al., 2010). It may thus be that during early adolescence, when media multitasking initially increases, this behavior may indeed affect their attention problems. However, after some time, adolescents may adjust to these new cognitive challenges. They may learn to process the multiple streams of incoming information and get better at handling these media distractions (Prenksy, 2001). Therefore, older adolescents may not be as vulnerable to media multitasking effects anymore.

A final explanation for stronger effects of media multitasking in early adolescents than in older adolescents can be found in developmental changes in self-control that occur during this period. During adolescence, individuals typically become better in self-control (Steinberg, 2008) and make developmental progress in executive functioning (Huizinga et al., 2006). These developments may help to diminish adolescents' attention problems and thereby may counteract potential negative effects of media multitasking on attention problems. This reasoning is in line with the idea that habituation and maturation may moderate spiral effects (Slater, 2007). We therefore assume:

> **H2:** The reciprocal relationship between media multitasking and attention problems is stronger among early adolescents than middle adolescents.

Apart from developmental differences, several studies have shown that media multitasking, particularly media multitasking with social media, is more prevalent among females than among males (Baumgartner, Lemmens, Weeda, & Huizinga, 2016; Foehr, 2006; Rideout et al., 2010). Social media multitasking has been shown to be particularly detrimental for some outcome variables, such as academic performance (Junco & Cotten, 2011; Rosen et al., 2013). It may be argued that social media multitasking has stronger effects on attention processes because of the highly disruptive nature of these media types (Pea et al., 2012). It may be that media multitasking with social media leads to stronger habituation, to higher arousal levels, or that this type of media multitasking is particularly detrimental for cognitive control processes. Because biological gender is a consistent predictor of media multitasking frequency, we investigate its potential moderating role in the relationship between media multitasking and attention problems. However, because there is no prior evidence of differences in the effects of media multitasking on males or females, we pose the following research questions:

RQ: Does biological gender moderate the relationship between media multitasking and attention problems?

The current studies

Despite cross-sectional evidence of a relationship between media multitasking and attention problems, the exact nature of this relationship remains unclear. To further disentangle the nature of this relationship, we conducted two longitudinal survey studies among large samples of adolescents. Study 1 was a three-wave study with 3-month time lags. Study 2 was a three-wave study with 6-month time lags. We chose two different time lags because these are the first longitudinal studies on the potential effects of media multitasking on attention problems, and we have no prior knowledge on the timeframe in which these effects should occur. It has been argued that examining one specific time lag can never provide a full picture of a variable's effect, and therefore, it has been advised to examine several different time intervals (Gollob & Reichardt, 1987). Choosing several time lags may be particularly important if no prior research exists because it allows comparing of effects and provides recommendations for future studies (Selig & Preacher, 2009).

Research on the development of attention problems indicates that attention problems are moderately stable during childhood and adolescence (Rietveld, Hudziak, Bartels, Beijsterveldt, & Boomsma, 2004). This indicates that next to genetic variables, environmental influences come into play when explaining attention problems. However, it is unknown how long a specific media exposure must occur to cause an effect on attention problems. Because of a lack in longitudinal studies, it is difficult to estimate how long adolescents need to multitask before they habituate to heightened arousal levels or before their processing styles may change. Previous studies on more general effects of media use have found effects on attention problems using a variety of different time lags, ranging from 3 months (Swing, Gentile, Anderson, & Walsh, 2010) to 1 year (Gentile, Swing, Lim, & Khoo, 2012) or even 2 years (Stevens, Barnard-Brak, & To, 2009).

Accordingly, in the current study, we compare two different time intervals in two independent samples. Time lags of 3 and 6 months are typical in longitudinal studies on media effects (see, e.g., Anderson et al., 2008). We chose these two relatively short time intervals because during adolescence, developmental changes occur rather quickly (Forbes & Dahl, 2010). Moreover, Collins and Graham (2002) argue for using shorter time intervals in order to capture causal effects. Shorter time intervals should particularly be chosen if no prior studies on a specific effect exist (Cole & Maxwell, 2009).

Data analytical approach: Disentangling between-person versus within-person change

Autoregressive cross-lagged panel models (CLPM) are commonly used statistical approaches in communication science and related disciplines to examine long-term effects of one variable on another. The basic idea of these models is that a specific variable X at Time 2 is predicted by this variable's previous score (autoregressive path) as well as by variable Y at Time 1. If a cross-lagged effect from variable Y on variable X is found, this is considered initial evidence for a causal relationship between those variables (or at least temporary precedence). However, CLPM have been strongly criticized in the past (Hamaker, Kuiper, & Grasman, 2015; Selig & Little, 2012; Slater et al., 2003). The major critique is that these models do not disaggregate between-person differences from within-person changes over time. Therefore, common CLPM do not allow one to draw conclusions about individual change over time. If a cross-lagged path is found in a traditional CLPM, it is thus not clear whether this effect is due to longitudinal changes on the individual level, due to changes on the between-person level, or due to both types of effects.

For media effects studies, this limitation of the CLPM is very problematic because in media effects research we are mainly interested in interindividual changes. For example, when considering the relationship between media multitasking and attention problems longitudinally, we are primarily interested in whether interindividual change in one variable over time leads to interindividual change in the other variable. More specifically, we expect that if a person increases his or her level of media multitasking, this person's level of attention problems increases as well. Similarly, we assume that if a person's attention problems increase over time, this person's media multitasking will also increase. Hypothesis 1, which posits a reciprocal relationship of media multitasking and attention problems over time, therefore clearly assumes effects on the individual level (within persons).

To account for interindividual changes, we will employ an adapted version of the CLPM based on a multilevel logic—the random intercept cross-lagged panel model (RI-CLPM) (Hamaker et al., 2015). The RI-CLPM allows distinguishing between within-person and between-person variation. Using this model will allow us to draw more accurate conclusions about how media multitasking and attention problems are related on the between-person level as well as on the individual level.

Study 1

Sample and procedure

Study 1 was a three-wave longitudinal panel study with 3-month time intervals within one school year. After approval was obtained from the ethical board of the university, respondents were recruited from seven secondary schools throughout the Netherlands. These schools provided active informed consent. Thereafter, we acquired passive informed consent from the parents and informed consent from the adolescents. Subsequently, respondents filled in an online survey. All surveys were filled in during school hours. Respondents were assured that their answers were handled confidentially and that teachers, parents, or fellow pupils would not be informed of any individual results. It took respondents approximately 25 minutes to complete the survey, after which they were thanked for their participation and received a small incentive (with a value of less than €1).

In Wave 1, 1,262 adolescents participated. In Wave 2, 1,254 adolescents participated; in Wave 3, 1,174 students participated. In each wave, all students participated who were present during the days of data collection. We excluded 27 respondents from Wave 1, 38 respondents from Wave 2, and 71 respondents from Wave 3. These respondents were excluded because of incorrect identification numbers ($N_{Wave1} = 17$; $N_{Wave2} = 25$; $N_{Wave3} = 60$) or missing values on all main variables ($N_{Wave1} = 10$; $N_{Wave2} = 13$; $N_{Wave3} = 11$). The final sample consisted of 1,441 participants ($N_{Wave1} =$ 1,241; $N_{Wave2} =$ 1,216; $N_{Wave3} =$ 1,103) who filled out the survey in at least one wave (51% boys, age range 11–15 years, $M_{age} = 12.61$, $SD_{age} = 0.75$).

Of these participants, 904 participants (63%) had filled out the survey in all three waves, 311 participants (22%) had filled out the survey in two waves, and 226 participants (15%) had filled out the survey in one wave. The attrition across the three waves is mainly because of illness and some classes that could not participate in one of the waves because of busy school schedules during assessment periods. The sample consisted of 834 early adolescents attending the first grade of secondary school (age range in the first wave, 11–13 years, $M_{age} = 12.17$, $SD_{age} = 0.53$) and 607 middle adolescents attending the second grade of secondary school (age range 13–15 years, $M_{age} = 13.20$, $SD_{age} = 0.53$).

Measures

Attention problems

To assess the extent to which respondents displayed symptoms of attention problems, we adapted nine symptoms for “Inattentiveness” from the DSM-5 criteria for ADHD (APA, 2013) into scale items. The DSM-5 criteria for “Inattentiveness” reflect the attention deficit dimension of ADHD. As proposed by Kessler et al. (2005), we asked respondents to indicate how often particular situations are applicable to themselves on a 5-point scale, ranging from 1 (*never*) to 5 (*very often*). Example items were “I am easily distracted” and “I have difficulty sustaining attention.” Cronbach’s alpha was .86 for the first wave ($M = 2.42$, $SD = 0.69$), .87 for the second wave ($M = 2.45$, $SD = 0.70$), and .90 for the third wave ($M = 2.50$, $SD = 0.76$)[1]. The average score on the scale was used as a manifest variable in the analyses.

Media multitasking

We measured media multitasking with the 9-item short media multitasking measure for adolescents (MMM-S; Baumgartner et al., 2016). This measure is a shortened and validated version of the media multitasking index (MMI, Ophir et al., 2009; Pea et al., 2012) and is based on the most prevalent media multitasking behaviors among adolescents. The items of the MMM-S assess four different media use activities: watching TV, sending messages via phone or computer, listening to music, and using social network sites. For each of these activities, participants indicated how frequently they use the other activities simultaneously. For example, participants were asked, “While watching TV, how often do you use social network sites at the same time”? Because listening to music is mainly a secondary activity, we did not assess it as primary activity. Participants rated the items on a 5-point scale, ranging from 1 (*never*) to 5 (*very often*). We changed the response categories of the original scale from 4- to 5-point Likert scales to keep response categories equal among different questions in the survey. Cronbach’s alpha for this 9-item index was .90 in the first wave ($M = 2.93$, $SD = 1.01$), .90 in the second wave ($M = 2.88$, $SD = 1.02$), and .91 in the third wave ($M = 2.85$, $SD = 1.03$). Higher values indicated more frequent media multitasking. We used the average score on the media multitasking scale as a manifest variable in the analyses.

Data analysis: The random intercept cross-lagged panel model

We examined the relationship between media multitasking and attention problems using an RI-CLPM (using Mplus 7 with full-information maximum likelihood and a maximum likelihood estimator). We thereby closely followed the modeling strategy of Hamaker et al. (2015); see also Keijsers, 2015). Autoregressive and cross-lagged paths were constrained to be equal across waves to increase parsimony of the models (see Hamaker et al., 2015). Figure 1 depicts the RI-CLPM. We regressed the manifest variables attention problems and media multitasking on their own latent factors and constrained the loadings at one (paths A and B in Figure 1). To allow the latent factor structure to capture both within- and between-person variance, we constrained the variances of the manifest variables to zero. Moreover, we added a random intercept for attention problems as well as a random intercept for media multitasking to the model (factor loadings constrained at one; paths C and D in Figure 1) to represent the stable differences between individuals. These random intercepts separate the differences between individuals from the within-person

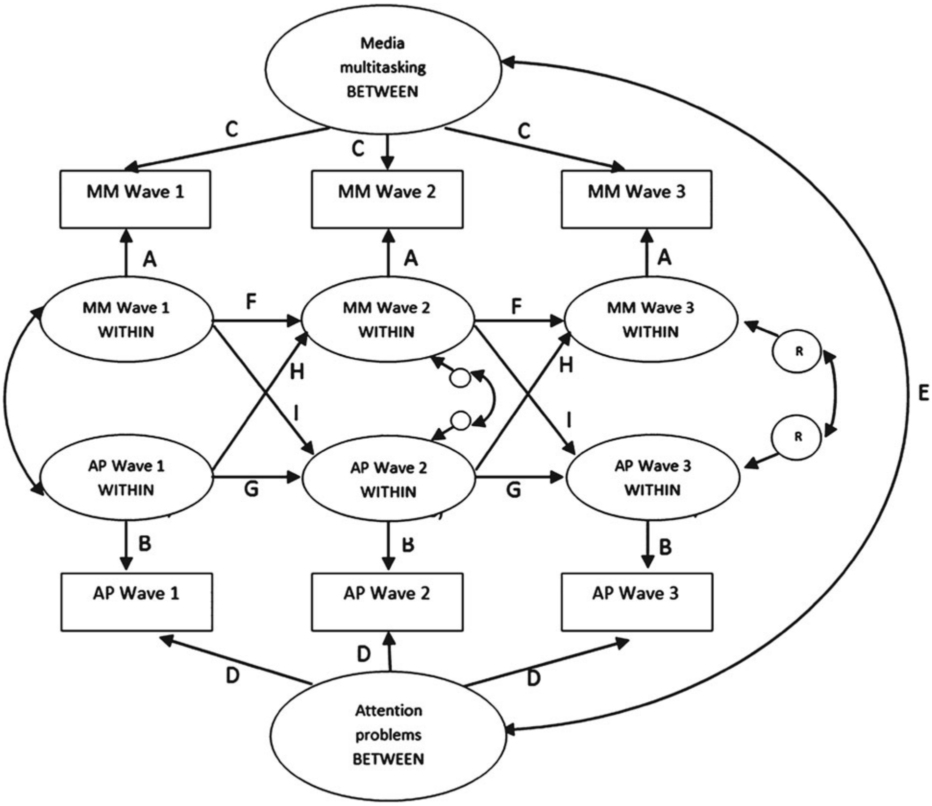

Figure 1 Random intercept cross-lagged panel model representing the relationships between media multitasking (MM) and attention problems (AP) across three waves. The squares represent manifest variables, and the ovals represent latent factors. The two random intercepts (Media multitasking BETWEEN and Attention problems BETWEEN) reflect between-person differences. Within-person processes are reflected by the latent modeling structure: the autoregressive paths between the latent factors of MM across waves and the latent factors of AP across waves; cross-paths between the latent factors of both MM and AP indicate the reciprocal relationship between both constructs; correlation at Wave 1, and residual correlations at Waves 2 and 3.

processes, and the correlation between them reflects how stable differences in attention problems between individuals are linked with stable differences in media multitasking between individuals (Path E in Figure 1).

As a result, the autoregressive paths (paths F and G) represent the extent to which individual deviations in attention problems and media multitasking predict individual deviations in attention problems and media multitasking relative to that individual's own expected score. Most importantly, the cross-lagged paths (paths H and I) reflect to what extent a deviation from an individual's own expected score on media multitasking predicts a deviation from that adolescent's own expected score on attention problems one wave later (and vice versa). These cross-lagged paths (H and I) thus test the reciprocal relationship between media multitasking and attention problems as posed in H1. Finally, the correlated residuals at Wave 2 and Wave 3 indicate how far the two variables simultaneously increase or decrease based on other unobserved factors.

The goodness of fit for the RI-CLPM was evaluated using the Comparative Fit Index (CFI), Tucker Lewis index (TLI), the Root Mean Square Error of Approximation (RMSEA), and the Standardized Root Mean Square Residual (SRMR). A good model fit is expressed by a CFI greater than .95, a TLI greater than .95, a RMSEA value lower than .06, and a SRMR value lower than .08 (e.g., Byrne, 2001).

In a first step, we calculated the overall model. In a second step, we calculated multigroup models to test for age differences and differences in biological gender, that is, to investigate potential moderating effects of age and gender. The multigroup analyses consisted of two steps. First, models were calculated with no constraints between groups (baseline models for age and gender, respectively). Secondly, models were calculated in which the cross-lagged paths were constrained to be equal among the groups (i.e., among early and middle adolescents and among males and females, respectively). Subsequently, chi-square difference tests were run. A significant chi-square difference between the baseline model and the constrained model indicated that the baseline model (with less constrained parameters) had better fit with the data. Hence, significant chi-square differences indicated an interaction between the predictor and age or gender, respectively. For all analyses, p-values lower than .05 are considered significant.

Results of Study 1

All cross-sectional correlations can be found in Table S1, Supporting Information. As expected, in all three waves, media multitasking and attention problems were positively correlated.

Random intercept cross-lagged panel model

The overall model (see Table 1 for parameter estimates) revealed excellent model fit, $\chi^2(5) = 5.26$, $p = 0.385$, RMSEA = 0.01, (90% CI: 0.00/0.04), CFI = 1.00, TLI = 1.00, and SRMR = 0.014. The overall model suggests that there are no cross-lagged effects from attention problems on media multitasking over time on the within-person level. Moreover, there were only marginally significant effects from media multitasking on attention problems over time (p = .06/.07; paths I in Figure 1). There was, however, a significant between-person correlation (path E), indicating that media multitasking and attention problems are related rather between persons than within persons.

The first multigroup analysis investigated differences between early and middle adolescents. Both the baseline and the constrained model showed excellent model fit (all CFIs $\geq$ .99; all TLIs = 1.00; all RMSEA $\leq$ .12, all ps > .90; all SRMR = .02). The baseline model revealed significant cross-lagged effects from media multitasking on attention problems (paths I) for early adolescents but not for middle adolescents. This

Table 1 Standardized Estimates for the RI-CLPM of Study 1

	All (*N* = 1,441)			Females (*N* = 707)			Males (*N* = 734)			Early Adolescents (*N* = 834)			Middle Adolescents (*N* = 607)		
	*b**	*SE b**	*p*	*b**	*SE b**	*p*	*b**	*SE b**	*p*	*b**	*SE b**	*p*	*b**	*SE b**	*p*
MM Wave 1 → MM Wave 2	.353	.059	.000	.284	.076	.000	.420	.089	.000	.384	.078	.000	.322	.083	.000
MM Wave 2 → MM Wave 3	.370	.075	.000	.338	.110	.002	.395	.102	.000	.402	.094	.000	.352	.110	.001
AP Wave 1 → AP Wave 2	.123	.067	.065	.203	.075	.006	.030	.111	.784	.054	.089	.546	.246	.090	.006
AP Wave 2 → AP Wave 3	.115	.069	.098	.212	.086	.014	.025	.093	.791	.049	.084	.565	.257	.111	.020
MM Wave 1 → AP Wave 2	.116	.062	.061	.118	.069	.090	.106	.103	.304	.188	.083	.023	.063	.078	.419
MM Wave 2 → AP Wave 3	.105	.058	.071	.115	.070	.099	.085	.085	.320	.155	.071	.029	.069	.088	.429
AP Wave 1 → MM Wave 2	.039	.047	.403	.008	.059	.891	.069	.065	.284	.076	.054	.158	.006	.075	.938
AP Wave 2 → MM Wave 3	.042	.051	.409	.010	.076	.891	.066	.063	.298	.087	.063	.167	.006	.078	.938
Correlation Wave 1	.229	.059	.000	.153	.084	.070	.281	.083	.001	.270	.079	.001	.183	.095	.054
Residual correlation Wave 2	.069	.067	.307	.057	.083	.494	.084	.098	.393	.158	.080	.048	-.022	.096	.823
Residual correlation Wave 3	.159	.042	.000	.161	.059	.007	.147	.060	.014	.132	.056	.019	.244	.061	.000
Between-person correlation	.266	.050	.000	.448	.055	.000	.231	.088	.009	.224	.074	.002	.276	.070	.000

AP = Attention problems; MM = Media multitasking.

indicates that early adolescents who engaged in media multitasking indeed showed increases in attention problems 3 months later. A chi-square difference test did not indicate a significant difference in cross-lagged paths between early and middle adolescents. Based on a baseline model of $\chi^2(10) = 10.98$ and a constrained model of $\chi^2(12) = 11.82$, the $\Delta\ \chi^2(2)$ was not significant, $p = .657$. However, when constraining the cross-lagged paths to be equal among groups, the paths from media multitasking on attention problems were significant for both groups (all $b^* > .11$, all $p < = .028$). This effect is likely be driven by the paths being significant for the early adolescents.

No reversed effects from attention problems on media multitasking over time were found for either age group (paths H). The between-person correlations between media multitasking and attention problems were significant for both age groups, indicating that adolescents with more attention problems were more likely to engage in media multitasking irrespective of age (path E). In all models, residuals at Wave 3 correlated significantly. These correlated residuals indicate that an increase in media multitasking accompanied a simultaneous increase in attention problems during this time period.

Overall, the multigroup analysis for age shows that although the constrained and unconstrained models did not differ significantly, the cross-lagged effects of media multitasking on attention problems appear to be stronger for early adolescents. Hypothesis 2, which posited that the reciprocal relationship between media multitasking and attention problems are stronger among early adolescents than middle adolescents, can only be partly supported.

The second multigroup analysis for biological gender also revealed excellent model fits for both the baseline and the constrained model (all CFIs $\geq .99$; all TLIs = 1.00; all RMSEA $\leq .008$, all *p*s $> .90$; all SRMR $\leq .021$). The $\Delta\ \chi^2(2)$ between the models was not significant, $p = .394$, baseline model: $\chi^2(10) = 10.50$; constrained model, cross-path constrained: $\chi^2\ (12) = 12.36$. The models for males and females looked similar. There were no significant within-person cross-lagged effects of attention problems on media multitasking for either group. Similarly, the cross-lagged paths from media multitasking on attention problems were also not significant. However, the between-person correlation (path E) for females was almost twice as large as the one for males ($b^* = .45$, $SE = .01$, $p < .001$ for females; $b^* = .23$, $SE = .09$, $p < .01$ for males).

Overall, the findings clearly showed that there were between-person relationships between media multitasking and attention problems. Hypothesis 1, which posited reciprocal within-person relationships between media multitasking and attention problems, was not supported. However, the findings indicate that media multitasking may indeed have long-term effects on attention problems among early adolescents.

Study 2

The aim of Study 2 was to investigate the relationship between media multitasking and attention problems with a larger time lag of 6 months.

Sample and procedure

Study 2 was part of a larger, three-wave longitudinal panel study among adolescents from five secondary schools[2] across the Netherlands. After acquiring active consent from the schools and teachers, and passive consent from adolescents' parents, respondents filled in a paper-and-pencil survey during school hours. Completing the survey took about 30 minutes, and participants received a small incentive. In the first wave, 1,083 adolescents participated (55% girls). Age ranged from 11 through 16 (M_{age} = 13.35, SD_{age} = 1.17). We fielded the second wave 6 months later, in which 1,056 adolescents participated. Between waves, 949 respondents were matched based on corresponding student numbers, but 10 participants had to be removed because of missing information on their age (N_{final} = 939; M_{age} = 13.74, SD_{age} = 1.18). This sample included 531 early adolescents (age range 11–13 years, M_{age} = 12.44, SD_{age} = 0.55) and 408 middle adolescents (age range 14–16 years, M_{age} = 14.42, SD_{age} = 0.60). Attrition of 134 respondents (12%) was because of the final examination, graduation period, illness, unavailability of supervising teachers, or because of discrepancies in respondents' student numbers. Six months later, we fielded the third wave among the same five schools. However, because of many pupils having either graduated or chosen a different type of secondary education in their second or third year, we could not reach many pupils. Only 439 pupils (59% girls, M_{age} = 14.37, SD_{age} = 1.17) could be matched across all three waves (46% of the original sample).

As a result of the large amount of missing data, we decided to include only participants who had data for at least two data waves (N = 949). Independent samples t-tests indicated no significant differences in relevant variables (multitasking, attention problems, age, or biological between) between the 949 matched respondents and the 134 respondents who were lost because of attrition between waves 1 and 2. However, t-tests did indicate that those respondents who provided data in all three waves showed somewhat higher scores in multitasking (M = 2.37, SD = 0.71) than those who dropped out (M = 2.20, SD = 0.69), $t(942) = -3.63$, $p < .001$. Matched respondents showed slightly less signs of attention problems (M = 2.38, SD = 0.68) compared with those who dropped out during Wave 3 (M = 2.48, SD = 0.65), $t(936) = 2.22$, $p = .028$. Furthermore, the sample of matched respondents consisted of slightly more females (59%) than the group that dropped out (54%). However, the correlations between media multitasking and attention problems in Wave 1 were similar within the group that dropped out ($n = 504$, $r = .29$, $p < .001$) and the respondents that were included in the third wave ($n = 434$, $r = .23$, $p < .001$) (Fisher's r to z transformation showed that these correlations did not differ significantly, $z = .98$, $p = .327$). Although the differences between groups were rather small, the attrition may have systematically affected the longitudinal relations between multitasking and attention problems. Nevertheless, we decided to include these data because the sample was still sufficiently large, and cross-sectional correlations were highly similar to those of Study 1.

Measures

We assessed attention problems and media multitasking with measures identical to Study 1. The only difference was that the response categories for media multitasking ranged on a 4-point scale from 1 (*never*) to 4 (*very often*), in line with Baumgartner et al. (2016). Cronbach's alpha for the 9-item media multitasking measure was .88 in the first wave ($M = 2.28$, $SD = 0.70$), .89 in the second wave ($M = 2.28$, $SD = 0.69$), and .81 in the third wave ($M = 2.41$, $SD = 0.73$). Higher values indicated more frequent media multitasking. For attention problems, Cronbach's alpha was .86 ($M = 2.44$, $SD = 0.67$) for the first wave, .89 ($M = 2.52$, $SD = 0.73$) for the second wave, and .89 ($M = 2.45$, $SD = 0.72$) for the third wave.

Results

All cross-sectional correlations can be found in the online supplement. Similar to Study 1, media multitasking and attention problems were significantly and positively correlated within each wave.

Random intercept cross-lagged panel model

The overall model revealed excellent model fit, $\chi^2(5) = 4.749$, $p = .447$, $RMSEA = .00$, $p = .901$ (CI = .000–.058), CFI = 1,00 TLI = 1.00 and $SRMR$ = .039. It revealed no cross-lagged effects, neither from media multitasking on attention problems (all $ps = .894$) nor for attention problems on media multitasking (all $ps \geq .419$). However, similar to the findings of Study 1, a significant between-person effect was revealed, $b^* = .43$, $SE = .08$, $p < .001$.

In a second step, we calculated multigroup models for age and biological gender. All models revealed excellent model fit (all CFIs ≥ .99; all TLIs ≥ .99; all RMSEA ≤ .12, all $ps > .78$; all SRMR ≤ .045). The models for early and middle adolescents and males and females looked similar and did not reveal any significant cross-lagged effects. Furthermore, Chi-square difference tests showed no differences between the models for early and middle adolescents, $\Delta\,\chi^2(2) = 3.19$, $p = .203$, and between the models for males and females, $\Delta\,\chi^2(2) = 0.72$, $p = .697$. However, similar to the findings of Study 1, the between-person correlation between media multitasking and attention problems was particularly strong for females in comparison to males (for females: $b^* = .43$, $SE = .07$, $p < .001$; for males: $b^* = .18$, $SE = .09$, $p = .051$).[3] The findings of the RI-CLPM suggest that there were no cross-lagged effects on the within-person level during 6-month time intervals. Hence, these findings neither support Hypothesis 1 nor Hypothesis 2.

Discussion

Although several previous studies have found a cross-sectional relationship between media multitasking and attention problems, the exact nature of this relationship was yet unknown. The present findings substantially increase our theoretical understanding of the relationship between media multitasking and attention problems, thereby providing an important first step for the development of a media multitasking effects theory.

The findings provide strong support for a between-subject relationship between media multitasking and attention problems. This indicates that adolescents with attention problems engage in media multitasking more frequently than adolescents without attentional deficits. It appears that these adolescents are more easily distracted by media and may find it difficult to focus their attention in the presence of media distractors. This finding is in line with previous cross-sectional studies (Baumgartner et al., 2014; Ophir et al., 2009; Ralph et al., 2013). These findings imply that, particularly for adolescents with attention problems, the omnipresence of media may be distracting. This is also in line with a recent observational study showing that children with attention problems find it particularly difficult to focus their attention on a computer task in the presence of other appealing computer activities (Baumgartner & Sumter, 2017).

Interestingly, however, this between-subject relationship was particularly strong for adolescent girls in both studies. Although this between-subject relationship was also significant for males, it appears that males with attention problems engage in media multitasking to a lesser degree. These gender differences may be because of differing preferences or motivations for media choices among boys and girls (Van den Eijnden, Lemmens, & Valkenburg, 2016). Girls are typically more socially oriented and may therefore be more distracted by social media applications that play a key role in media multitasking. Media multitasking as measured in the present studies was based on the most popular media multitasking combinations among adolescents, which are highly driven by social media and messaging (Baumgartner et al., 2016). Females in the two current studies engaged in these types of media multitasking generally more frequently than males. Similarly, recent studies have shown that adolescent females are more involved in social media and texting than are males (Lenhart, 2015). Therefore, it may be that females with attention problems might find it particularly challenging to resist social media distractions. For females, media multitasking with social media may, thus, be one behavioral manifestation of their attention problems. In contrast, males with attention problems may be distracted in different ways and during different activities. Their attentional problems may manifest themselves differently, for example, through trouble focusing on school work or by engaging in other types of media multitasking, such as multitasking while gaming.

Next to these between-subject correlations, the present study provides initial evidence for a long-term effect of media multitasking on attention problems for early adolescents (aged 11–13). These findings partly support theoretical considerations about the potential effects of media multitasking (Carrier, Rosen, Cheever, & Lim, 2015; Ophir et al., 2009; Ralph et al., 2013; Wallis, 2010). It appears that for younger adolescents, engaging in media multitasking more frequently may lead to—or worsen—attention problems over time. We delineated three theoretical explanations for such an effect. It might be that early adolescents who frequently engage in media multitasking habituate to heightened arousal levels, which in turn makes it more difficult for them to focus attention in less arousing situations. Another possibility is that their multitasking behavior makes them more sensitive to irrelevant information. Finally, it may be that their media multitasking behavior deteriorates attentional control processes because these processes are not trained through media multitasking. Future studies should examine which of these processes play a role in explaining the effects of media multitasking on attention problems for young adolescents.

Contrary to our expectations, the present studies did not find support for an effect of attention problems on media multitasking over time. Attention problems at a specific point in time did not increase the frequency of media multitasking 3 or 6 months later. Therefore, H1—which assumed a reciprocal relationship between media multitasking and attention problems—was not supported. This may indicate that attention problems are a consequence, but not a cause, of media multitasking. However, these findings can still be interpreted in terms of the RSM. It might be that the time lags for attention problems causing media multitasking are different than those for the effect of media multitasking on attention problems. For example, it could be that attention problems have an immediate effect on the engagement in media multitasking, but that media multitasking needs some time to exert an influence on attention problems. In line with Slater et al. (2003), the findings may then cautiously be interpreted in terms of an *asymmetric* spiral model. The strong cross-sectional correlation between media multitasking and attention problems among all adolescents might indicate that adolescents who have more attention problems are more likely to engage in media multitasking at any point in time. In the long run, however, media multitasking may increase these attention problems among early adolescents.

The finding that there were no long-term effects for middle adolescents may support the notion that there are factors that dampen mutual influence processes and that media use and effects therefore lead to homeostasis rather than to extreme outcomes (Slater, 2007, 2015). Although such dampening influences have been theoretically assumed, they have not yet been empirically established. The present finding may provide first evidence for such boundary constraints for the reinforcing effects postulated by the RSM. Although middle adolescents with attention problems were more likely to multitask cross-sectionally than adolescents without attention problems, we found no cross-lagged effects over time from media multitasking to attention problems. This finding is of crucial importance. It indicates that although middle adolescents with attention problems are equally likely to engage in media multitasking as early adolescents, middle adolescents' engagement in media multitasking does not worsen or increase attention problems over time. This might imply that media multitasking has adverse effects on attention problems only during specific developmental periods and that it is important to identify factors that dampen the effects of media multitasking. For example, it could be that adolescents become more efficient media multitaskers over time and learn to adapt to the various cognitive demands of media multitasking situations.

Overall, these findings suggest that media multitasking rather leads to a maintenance of attention problems than to a reinforcement of these problems (after an initial effect). The findings of the present studies are in line with Slater (2007), who argues that "The pattern of mutual reinforcement between selection of media content and the effects of such content, then, will rarely lead to extremes of attitude or behavior. Instead, this pattern may result in the maintenance of various attitudes or behaviors for users of specific media content despite competing influences" (Slater, 2007, p. 289). The present studies provide some preliminary empirical evidence for this constant character of media multitasking on attention problems. However, the present findings are based on two different cohorts of younger and older adolescents. To fully understand whether initial effects of media multitasking in early adolescents do not continue during later development, the same cohort of adolescents needs to be followed for several years.

The finding that there were no reciprocal effects is in contrast to a previous study that has identified reciprocal relationships between media multitasking, gratifications, and needs (Wang & Tchernev, 2012). In this study, media multitasking and motivations were measured much more frequently and during shorter time periods using experience sampling methodology (i.e., thrice per day for 4 weeks). It is likely that needs and gratifications change much quicker than more stable personality traits, such as attention problems. Thus, the differences between the findings of their study and ours may be because of different variables that were assessed—attention problems versus motivations—and of the different time lags used in these studies. To fully understand reciprocal effects between media multitasking and attentional control processes, future studies may benefit from using shorter time lags and more frequent assessments. For these means, experience sampling methodology might be one of the most adequate methods.

In sum, the present findings have important implications for media multitasking theories. Most importantly, the findings suggest that causal claims that have been made in previous studies need to be nuanced. Attention problems and media multitasking are mainly related between individuals, indicating that attention problems determine media multitasking to a high degree. This effect appears to be partly moderated by biological gender, indicating that this relationship is stronger for females than for males. Interestingly, for the overall sample, no causal effects of media multitasking on attention problems or vice versa were found. This indicates that although adolescents with attention problems are more likely to engage in media multitasking, this behavior may not further deteriorate attentional processes. However, this relationship might be moderated by age, with early adolescents being more vulnerable to media multitasking effects. Finally, because we did not find a longitudinal reciprocal relationship between media multitasking and attention problems in the present studies, the present findings suggest that media multitasking can be perceived rather as a maintaining factor of attention problems than a reinforcing factor and that important moderating factors exist that dampen initial detrimental effects.

Methodological implications

The present study also has important methodological implications. First, the RI-CLPM appears to be a fruitful approach for media effects research. Its clear distinction between within- and between-subject variations allowed us to draw more specific conclusions about the relationship between media multitasking and attention problems. Regarding the findings of the RI-CLPM, it becomes clear that within-subject effects only occurred for early adolescents and that the relationship between media multitasking and attention problems is mainly because of stable between-person differences. As has been shown by Hamaker et al. (2015), common CLPM may lead to incorrect conclusions about long-term relationships between two variables. We therefore believe that the RI-CLPM is a better alternative to the common CLPM for studying the many media effects that are supposed to occur on the within-person level over time.

A second methodological implication concerns the choice of time lags. In the present two studies, we found an effect of media multitasking on attention problems for early adolescents only for the 3-month time lags. For the 6-month time lags, we still found a consistent between-subject correlation but no cross-lagged effects. These findings indicate that although adolescents with higher levels of attention problems are more likely to multitask at any given moment, there are no long-term effects of media multitasking on attention problems within a 6-month period. Based on the results of Study 1 with 3-month time lags, we may tentatively conclude that these effects occur within shorter time periods. That is, an individual's level of media multitasking may affect this person's attention problems within 3 months but not within 6 months. These 6-month time lags may be too long to detect such effects on the individual level, particularly during periods such as adolescence, when developmental changes occur quickly.

The choice of time lags is particularly important considering mutually reinforcing effects. In longitudinal media effects research, typically, the same time lags are employed for studying media selection and media effects. However, it may very well be that these effects have a very different duration (Slater, 2007). It is likely that the effects of attention problems on media multitasking (i.e., selection effects) have a much shorter duration than the effects of media multitasking on attention problems. Thus, although someone with attention problems may be likely to engage in media multitasking at any point in time, the effects of media multitasking on attention problems may take weeks or months to occur. That the time lags in the present studies were not adequate to capture these selection effects may be supported by the finding that—for the 3-month time lags—we found that increases in media multitasking were related to simultaneous increases in attention problems, irrespective of age and gender. This simultaneous increase might be because of the fact that the two variables are related on a more fine-grained level and that changes occur quicker than 3 months. For example, it could indicate that the simultaneous increase in both variables is because of reciprocal relationships that occur within shorter time periods.

Limitations and implications for future studies

Although the present study provided the first evidence for a long-term effect of media multitasking on attention problems among early adolescents, it is important to note that it is not fully possible to infer causality based on longitudinal data. Although CLPMs are typically used to establish causality (Selig & Little, 2012), the found cross-lagged effects could also be because of a third unobserved variable that influences both media multitasking and attention problems. Although the autoregressive paths in the model somewhat decrease the likelihood of other time-invariant variables having an effect on the long-term relationship between these variables (see, e.g., Berrington, Smith, & Sturgis, 2006), there might still be other unobserved time-varying third variables that caused the cross-lagged effects. This could, for example, be a biological factor that develops in early adolescence and that may account for both increases in media multitasking at Time 1 and increases in attention problems at Time 2. Nevertheless, the observed effects may be a first indication for a causal relationship between the two variables that needs to be further examined in future studies. Particularly, experimental studies are needed to provide further evidence on potential short-term effects and mediating mechanisms.

Moreover, the present study relied on self-reports, both for media multitasking as well as for attention problems. Self-reports of media multitasking have their limitations because it is difficult to estimate the amount of time that someone engages in several media simultaneously. This is particularly true for social media that may be used only briefly but frequently during other media activities. It is therefore not surprising that previous observational studies have shown that people tend to underestimate their multitasking behavior (see Brasel & Gips, 2011). Moreover, self-reports of attention problems among adolescents may also be biased because some adolescents may underestimate their attention problems. Nevertheless, self-reports of attention problems are commonly used among adolescent samples, also in clinical settings.

Despite the limitations of self-reported data, we believe that the present study provides a significant contribution to the field. The large majority of studies on the potential cognitive effects of media multitasking are based on self-reported measures of media multitasking (see Ophir et al., 2009; Pea et al., 2012; Ralph et al., 2013; Sanbonmatsu et al., 2013). However, all of these studies only investigated the relationship cross-sectionally. By employing a longitudinal design, our study extends this line of research. Moreover, using self-reports allowed us to test this relationship among large samples of adolescents and over longer time periods. Future studies may advance the field by systematically assessing both media multitasking and attention problems with both self-reports and more objective measures, such as observational methods or automatic tracking software (e.g., Rich, Bickham, & Shrier, 2015).

Another limitation of the present article is that there was a significant dropout of participants in Study 2. This dropout was mainly because of the switch between school years between Wave 2 and Wave 3 and an inability to track participants who have changed schools or classes during the school year. However, the sample was still sufficiently large and the findings of the cross-sectional correlations still highly similar to those of Study 1. We therefore may conclude that the dropout did not substantially affect the results. Nevertheless, it may still be that the nonfindings in the RI-CLPMs were based on systematic bias within these dropouts rather than to the specific time lags. Our conclusions about these time lags are therefore drawn with caution and need to be replicated in future longitudinal studies.

The strengths of the significant cross-lagged paths for early adolescents ranged from = .16 to .19 (b^*). Effects in this range are commonly interpreted as small effects. However, according to Adachi and Willoughby (2015), in longitudinal models that take into account autoregressive effects (i.e., previous levels of a variable), even very small effects may be meaningful. Attention problems are rather stable personality traits. That the effects of media multitasking on attention problems are present even after controlling for previous levels of attention problems indicates that these effects may indeed be meaningful. However, small effect sizes could also imply that important moderating factors are not investigated. Most importantly, Wang, Irwin, Cooper, and Srivastava (2015) have recently proposed that specific media multitasking combinations have different effects on varying cognitive functions. For example, Jeong and Hwang (2016) have shown that low levels of user control over the media multitasking situations led to more negative effects on cognitive outcomes than high levels of user control. Investigating the differential effects of multiple dimensions of media multitasking may thus be particularly useful for future research.

Conclusion

The present study provides a complex picture of the relationship between media multitasking and attention problems. Overall, adolescents with attention problems engage in media multitasking more frequently. Engagement in media multitasking, however, has detrimental effects on subsequent attention problems only among early adolescents. It might be that early adolescents are particularly sensitive to these effects. The findings are in line with asymmetric spiral models of media effects which indicate that attention problems are related to immediate engagement in media multitasking but that the effects of media multitasking exert their influence only after some time. Moreover, the present findings might indicate that media multitasking does not lead to extreme attention problems over time but, rather, that it maintains attention problems despite competing influences.

Notes

1 Confirmatory factor analyses of the attention problems scale in each wave showed that the nine items loaded (all factor loadings > .55) on one factor, Wave 1: $\chi^2(27, n = 1{,}223) = 225.093$, $p < .001$, CFI = .946, RMSEA = .077 (90% CI: .068–.087), SRMR = .033; Wave 2: Wave 2: $\chi^2(27, n = 1{,}198) = 215.296$, $p < .001$, CFI = .950, RMSEA = .076 (90% CI: .067–.086), SRMR = .033; Wave 3: $\chi^2(27, n = 1{,}089) = 268.318$, $p < .001$, CFI = .948, RMSEA = .091 (90% CI: .081–.101), SRMR = .033.

2 Originally, six schools participated. However, one school only participated in Wave 1 and was, therefore, not considered in the analysis.

3 We also conducted all analyses with a sample consisting only of those respondents who completed all three waves ($N = 430$). The analyses for the overall model and multigroup models revealed similar results.

Supporting Information

Additional supporting information may be found in the online version of this article: Table S1. Correlations Among Variables in Study 1 and Study 2

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