Juggling with media

The consequences of media multitasking for adolescent development

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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].

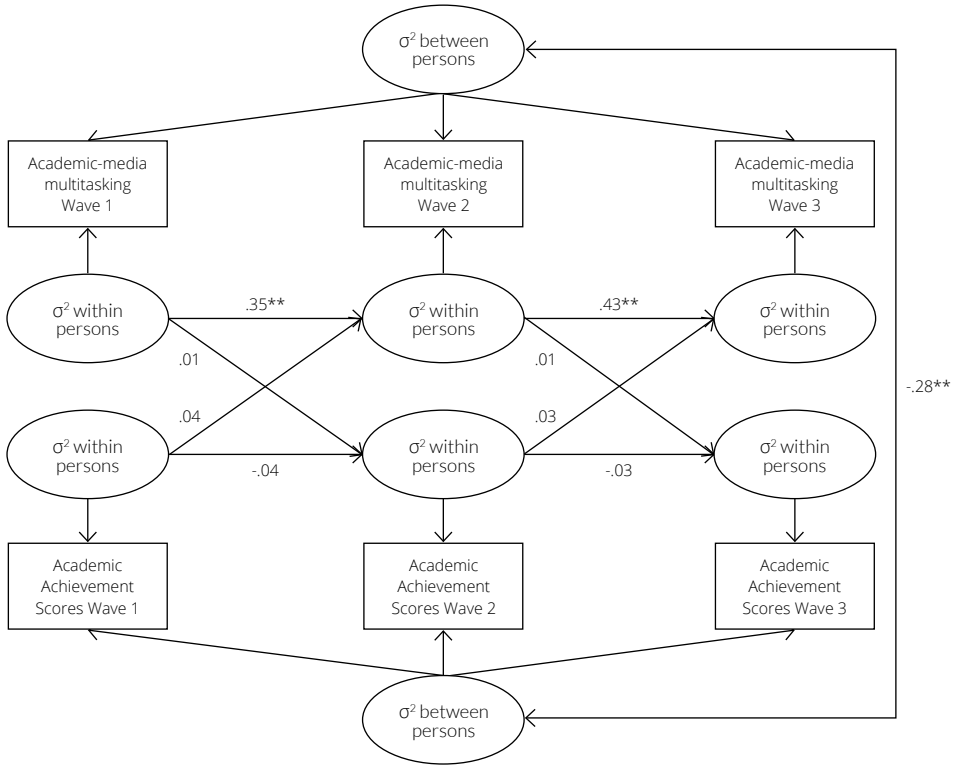

Figure 1. Simplified model with the standardized maximum likelihood parameter estimates for the between-person correlation and the within-person relationships between academic-media multitasking and academic achievement scores.

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.

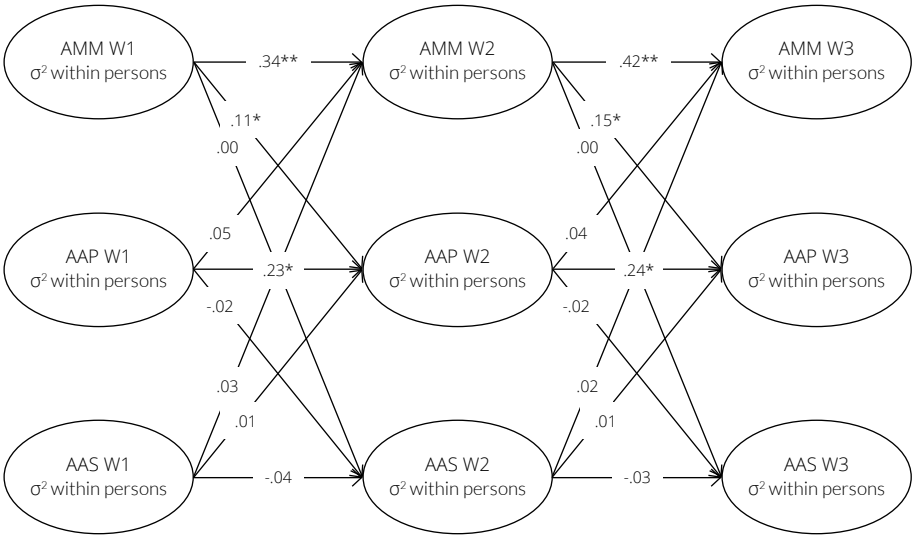

Figure 2. Simplified model with the standardized maximum likelihood parameter estimates for the within-person effeects between academic-media multitasking, academic attention problems, and academic achievement scores.

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.

REFERENCES

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders, 5th edition*. Washington, DC: American Psychiatric Pub.

Armstrong, G., Boiarsky, G. A., & Mares, M. (1991). Background television and reading performance. *Communication Monographs*, *58*, 235-253. doi:10.1177/009365000027003003

Armstrong, G. B., & Greenberg, B. S. (1990). Background television as an inhibitor of cognitive processing. *Human Communication Research*, *16*, 355-386. doi:10.1111/j.1468-2958.1990.tb00215.x

Birchwood, J., & Daley, D. (2012). Brief report: The impact of attention deficit hyperactivity disorder (ADHD) symptoms on academic performance in an adolescent community sample. *Journal of Adolescence*, *35*, 225-231. doi:10.1016/j.adolescence.2010.08.011

Blair, C., & Diamond, A. (2008). Biological processes in prevention and intervention: The promotion of self-regulation as a means of preventing school failure. *Development and Psychopathology*, *20*, 899-911. doi:10.1017/S0954579408000436

Bowman, L. L., Levine, L. E., Waite, B. M., & Gendron, M. (2010). Can students really multitask? An experimental study of instant messaging while reading. *Computers & Education*, *54*, 927-931. doi:10.1016/j.compedu.2009.09.024

Busch, V., Laninga-Wijnen, L., Schrijvers, A. J. P., & De Leeuw, J. R. J. (2015). Associations of health behaviors, school performance and psychosocial problems in adolescents in the Netherlands. *Health Promotion International*, 1-12. doi:10.1093/heapro/dav058

Carrier, L. M., Rosen, L. D., Cheever, N. A., & Lim, A. F. (2015). Causes, effects, and practicalities of everyday multitasking. *Developmental Review*, *35*, 64-78. doi:10.1016/j.dr.2014.12.005

Chen, Q., & Yan, Z. (2016). Does multitasking with mobile phones affect learning? A review. *Computers in Human Behavior*, *54*, 34-42. doi:10.1016/j.chb.2015.07.047

Clayson, D. E., & Haley, D. A. (2013). An introduction to multitasking and texting prevalence and impact on grades and GPA in marketing classes. *Journal of Marketing Education*, *35*, 26-40. doi:10.1177/0273475312467339

Common Sense Media (2015). *The common sense census: media use by tweens and teens*. Retrieved from https://www.commonsensemedia.org/research/the-common-sense-census-media-use-by-tweens-and-teens.

Curran, P. J., & Bauer, D. J. (2011). The disaggregation of within-person and between-person effects in longitudinal models of change. *Annual Review of Psychology, 62*, 583-619. doi:10.1146/annurev.psych.093008.100356

Duckworth, A. L., & Seligman, M. E. (2005). Self-discipline outdoes IQ in predicting academic performance of adolescents. *Psychological Science, 16*, 939-944. doi:10.1111/j.1467-9280.2005.01641.x

Fisch, S. M. (2000). A capacity model of children's comprehension of educational content on television. *Media Psychology, 2*, 63-91. doi:10.1207/S1532785XMEP0201_4

Fox, A. B., Rosen, J., & Crawford, M. (2009). Distractions, distractions: Does instant messaging affect college students' performance on a concurrent reading comprehension task? *CyberPsychology & Behavior, 12*, 51-53. doi:10.1089/cpb.2008.0107

Frey, N., Fisher, D., & Hattie, J. (2016). Surface, deep, and transfer? Considering the role of content literacy instructional strategies. *Journal of Adolescent & Adult Literacy, 60*, 567-575. doi:10.1002/jaal.576

Gottschling, J., Spengler, M., Spinath, B., & Spinath, F. M. (2012). The prediction of school achievement from a behavior genetic perspective: Results from the German twin study on cognitive ability, self-reported motivation, and school achievement (CoSMoS). *Personality and Individual Differences, 53*, 381-386. doi:10.1016/j.paid.2012.01.020

Hamaker, E. L., Kuiper, R. M., & Grasman, R. P. (2015). A critique of the cross-lagged panel model. *Psychological Methods, 20*, 102-116. doi:10.1037/a0038889

Jeong, S., & Hwang, Y. (2012). Does multitasking increase or decrease persuasion? Effects of multitasking on comprehension and counterarguing. *Journal of Communication, 62*, 571-587. doi:10.1111/j.1460-2466.2012.01659.x

Jeong, S., & Hwang, Y. (2016). Media multitasking effects on cognitive vs. attitudinal outcomes: A meta-analysis. *Human Communication Research, 42*, 599-618. doi:10.1111/hcre.12089

Junco, R. (2012). In-class multitasking and academic performance. *Computers in Human Behavior, 28*, 2236-2243. doi:10.1016/j.chb.2012.06.031

Junco, R., & Cotten, S. R. (2012). No A 4 U: The relationship between multitasking and academic performance. *Computers & Education, 59*, 505-514. doi:10.1016/j.compedu.2011.12.023

Karlen, Y. (2016). Differences in students' metacognitive strategy knowledge, motivation, and strategy use: A typology of self-regulated learners. *The Journal of Educational Research, 109*, 253-265. doi:10.1080/00220671.2014.942895

Lang, A. (2000). The limited capacity model of mediated message processing. *Journal of Communication, 50*, 46-70. doi:10.1111/j.1460-2466.2000.tb02833.x

Lang, A. (2006). Using the limited capacity model of motivated mediated message processing to design effective cancer communication messages. *Journal of Communication, 56*, S57-S80. doi:10.1111/j.1460-2466.2006.00283.x

Lee, S. J. (2009). Online communication and adolescent social ties: Who benefits more from Internet use? *Journal of Computer-Mediated Communication, 14*, 509-531. doi:10.1111/j.1083-6101.2009.01451.x

Lee, J., Lin, L., & Robertson, T. (2012). The impact of media multitasking on learning. *Learning, Media and Technology, 37*, 94-104. doi:10.1080/17439884.2010.537664

Lenhart, A., Ling, R., Campbell, S., & Purcell, K. (2010). *Teens and mobile phones: Text messaging explodes as teens embrace it as the centerpiece of their communication strategies with friends*. Pew Internet & American Life Project.

Levine, L. E., Waite, B. M., & Bowman, L. L. (2012). Mobile media use, multitasking and distractibility. *International Journal of Cyber Behavior, Psychology and Learning, 2*, 15-29. doi:10.4018/ijcbpl.2012070102

Mercer, N. (2008). The seeds of time: Why classroom dialogue needs a temporal analysis. *The Journal of the Learning Sciences, 17*, 33-59. doi:10.1080/10508400701793182

Muthén, L.K. & Muthén, B.O. (2012). *Mplus user's guide*. Seventh Edition. Los Angeles, CA: Muthén & Muthén.

Nie, N. H., & Hillygus, D. S. (2002). Where does internet time come from?: A reconnaissance. *IT & Society, 1*, 1-20.

Ophir, E., Nass, C., & Wagner, A. D. (2009). Cognitive control in media multitaskers. *Proceedings of the National Academy of Sciences*, *106*, 15583-15587. doi:10.1073/pnas.0903620106

Polderman, T. J., Boomsma, D., Bartels, M., Verhulst, F., & Huizink, A. (2010). A systematic review of prospective studies on attention problems and academic achievement. *Acta Psychiatrica Scandinavica*, *122*, 271-284. doi:10.1111/j.1600-0447.2010.01568.x

Pool, M. M., Koolstra, C. M., & van der Voort, T. H. A. (2003). The impact of background radio and television on high school students' homework performance. *Journal of Communication*, *53*, 74-87. doi:10.1111/j.1460-2466.2003.tb03006.x

Pool, M. M., van der Voort, T. H. A., Beentjes, J. W. J., & Koolstra, C. M. (2000). Background television as an inhibitor of performance on easy and difficult homework assignments. *Communication Research*, *27*, 293-326. doi:10.1177/009365000027003002

Ravizza, S. M., Hambrick, D. Z., & Fenn, K. M. (2014). Non-academic internet use in the classroom is negatively related to classroom learning regardless of intellectual ability. *Computers & Education*, *27*, 327-352. doi:10.1016/j.compedu.2014.05.007

Robbins, S. B., Lauver, K., Le, H., Davis, D., Langley, R., & Carlstrom, A. (2004). Do psychosocial and study skill factors predict college outcomes? A meta-analysis. *Psychological Bulletin*, *130*, 261-288. doi:10.1037/0033-2909.130.2.261

Rosen, L. D., Carrier, M. L., & Cheever, N. A. (2013). Facebook and texting made me do it: Media-induced task-switching while studying. *Computers in Human Behavior*, *29*, 948-958. doi:10.1016/j.chb.2012.12.001

Rosen, L. D., Lim, A. F., Carrier, L. M., & Cheever, N. A. (2011). An empirical examination of the educational impact of text message-induced task switching in the classroom: Educational implications and strategies to enhance learning. *Psicología Educativa*, *17*, 163-177. doi:10.5093/ed2011v17n2a4

Salvucci, D. D., & Taatgen, N. A. (2008). Threaded cognition: An integrated theory of concurrent multitasking. *Psychological Review*, *115*, 101-130. doi:10.1037/0033-295X.115.1.101

Salvucci, D. D., & Taatgen, N. A. (2010). *The multitasking mind*. New York: Oxford University Press.

Sanbonmatsu, D. M., Strayer, D. L., Medeiros-Ward, N., & Watson, J. M. (2013). Who multi-tasks and why? Multi-tasking ability, perceived multi-tasking ability, impulsivity, and sensation seeking. *PloS One*, *8*, e54402. doi:10.1371/journal.pone.0054402

Scholtens, S., Rydell, A. M., & Yang-Wallentin, F. (2013). ADHD symptoms, academic achievement, self-perception of academic competence and future orientation: A longitudinal study. *Scandinavian Journal of Psychology*, *54*, 205-212. doi:10.1111/sjop.12042

Shih, S. (2013). A null relationship between media multitasking and well-being. *PloS One*, *8*(5), e64508. doi:10.1371/journal.pone.0064508

Smits, J. A. E., & Vorst, H. C. M. (1990). *SchoolVragenLijst voor basisonderwijs en voortgezet onderwijs: SVL. Handleiding voor gebruikers* [School questionnaire for elementary and secondary school: User's manual]. Nijmegen, the Netherlands: Berkhout. Steiger.

Srivastava, J. (2013). Media multitasking performance: Role of message relevance and formatting cues in online environments. *Computers in Human Behavior*, *29*, 888-895. doi:10.1016/j.chb.2012.12.023

Subrahmanyam, K., Michikyan, M., Clemmons, C., Carrillo, R., Uhls, Y. T., & Greenfield, P. M. (2013). Learning from paper, learning from screens: Impact of screen reading and multitasking conditions on reading and writing among college students. *International Journal of Cyber Behavior, Psychology and Learning*, *3*, 1-27. doi:10.4018/ijcbpl.2013100101

van der Schuur, W. A., Baumgartner, S. E., Sumter, S. R., & Valkenburg, P. M. (2015). The consequences of media multitasking for youth: A review. *Computers in Human Behavior*, *53*, 204-215. doi:10.1016/j.chb.2015.06.035

Wallis, C. (2010). *The impacts of media multitasking on children's learning and development: Report from a research seminar*. New York, NY: The Joan Conney Center at Sesame Workshop.

Wei, F. F., Wang, Y. K., & Klausner, M. (2012). Rethinking college students' self-regulation and sustained attention: Does text messaging during class influence cognitive learning? *Communication Education*, *61*, 185-204. doi:10.1080/03634523.2012.672755

Wei, F. F., Wang, Y. K., & Fass, W. (2014). An experimental study of online chatting and notetaking techniques on college students' cognitive learning from a lecture.

Computers in Human Behavior, 34, 148-156. doi:10.1016/j.chb.2014.01.019

Wood, E., Zivcakova, L., Gentile, P., Archer, K., De Pasquale, D., & Nosko, A. (2012). Examining the impact of off-task multi-tasking with technology on real-time classroom learning. *Computers & Education, 58*, 365-374. doi:10.1016/j.compedu.2011.08.029

Zhang, W. (2015). Learning variables, in-class laptop multitasking and academic performance: A path analysis. *Computers & Education, 81*, 82-88. doi:10.1016/j.compedu.2014.09.012

Zimmerman, B. J. (2000). Attaining self-regulation: A social cognitive perspective. In M. Boekaerts, P. R., Pintrich, & M. Zeidner (Eds.). *Handbook of self-regulation* (pp. 13-39). San Diego, CA: Academic Press.