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Multitasking and Dual Motivational Systems: A Dynamic Longitudinal Study

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This study further explores the myth of media multitasking: that is, why people increasingly media multitask despite its known harmful effects on performance. Building on previous research on the emotional gratifications of media multitasking and guided by the dynamic motivational activation (DMA) approach, this study specifies emotional gratifications in terms of positive and negative emotions, as well as their underlying appetitive and aversive motivational changes. Using a dynamic panel analysis of longitudinal experience sampling data collected from 71 adolescents (ages 11–17; 61% girls) over 2 weeks, this study identifies several dynamic reciprocal impacts of media multitasking and the dual motivational systems. As predicted by DMA, media multitasking coactivates both the appetitive and aversive motivational systems, and increases both positive and negative emotions; interestingly, only the appetitive system goes on to determine subsequent media multitasking.

Keywords: Multitasking, Appetitive, Aversive, Dynamic Motivational Activation, Reinforcing Spirals, Experience Sampling

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Previous research has shown how multitasking is associated with performance deterioration (Wang, David, et al., 2012a), decreased cognitive functioning (Baumgartner, Weeda, van der Heijden, & Huizinga, 2014), and even safety threats in certain circumstances (Strayer, Drews, & Johnston, 2003). So why do people increasingly multitask, especially media multitask, despite these negative consequences? This trend has been dubbed the myth of multitasking (Rosen, 2008a, p. 105; Wang & Tchernev, 2012). In an initial investigation, Wang and Tchernev (2012) suggested emotional gratification through dynamic self-reinforcement as this myth's underlying mechanism in everyday life. The current study further tests and clarifies this mechanism. Specifically, it identifies the roles of positive and negative emotions—and their underlying appetitive and aversive motivational systems—in multitasking.

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Guided by the dynamic motivational activation (DMA) theoretical framework, Wang and Tchernev (2012) found evidence for emotional gratification as the outcome of increasing media multitasking over time, using four weeks of longitudinal experience sampling data. Their study reveals that although emotional needs were not explicitly sought, multitasking behavior resulted in emotional gratification. The authors suggested that "it is likely that this emotional gratification associated with multitasking serves as an implicit yet powerful drive" for multitasking in daily life (Wang & Tchernev, 2012, p. 509). More importantly, as argued by DMA and shown in the dynamic modeling results of their longitudinal data, the reciprocal effect works in a continuous self-reinforcing manner, like a locomotive picking up steam, that might lead to significant long-term effects on individuals (Wang & Tchernev, 2012).

To complicate these findings, a growing body of research based on surveys suggests that both positive and negative emotions may drive multitasking. For example, enjoyment was found to positively predict multitasking behaviors (Hwang, Kim, & Jeong, 2014). It is likely that the pursuit of pleasure, an award, or positive emotion—from any category of needs in the uses and gratifications terminology (Wang & Tchernev, 2012)—motivates people to multitask. Other studies have shown that boredom, fatigue, and/or anxiety induced by arduous activities trigger the simultaneous performance of other activities (e.g., Lin, 2013). For example, when completing schoolwork, especially when the work is boring or tiring, students often use media to balance out negative feelings about the work. This indicates that avoiding negative emotion can motivate multitasking as well. Therefore, the current study builds on a more fundamental view on motivations and emotions.

Seeking positive emotions and avoiding negative emotions correspond to the appetitive and aversive motivational systems: the fundamental dual motivational systems that organize and determine our emotions, cognition, and behaviors, including our media experience (e.g., Lang, 2006; Wang, Lang, & Busemeyer, 2011). Here, emotions are broadly defined as feelings for or against an attitude object, where an attitude object can be an event, a person, or an idea (Larsen, McGraw, & Cacioppo, 2001). According to the dual motivational systems theories, positive emotion and negative emotion indicate the activation of the appetitive and aversive motivational systems, respectively (Cacioppo & Berntson, 1994; Lang, 2006). To explore this mechanism in more detail, the present study addresses several questions. How exactly do the two motivational systems work to drive multitasking behavior over time? Specifically, does multitasking engage both motivational systems and lead to both types of motivational activation? In turn, do both types of motivational activation affect subsequent multitasking behaviors? Or is one motivational system more influential than the other during multitasking behaviors?

This study follows up on the earlier exploration of the myth of media multitasking (Wang & Tchernev, 2012) to specify the reciprocal dynamic influences between multitasking behaviors and underlying motivations—and the corresponding emotions—in daily life. It further clarifies the myth by specifying the emotional gratification observed in earlier research, in terms of the more fundamental appetitive and aversive

motivational systems. Hypotheses are derived and tested regarding how the two motivational systems can be activated simultaneously (coactivation) by multitasking behaviors and, in turn, how they may or may not reduce or drive subsequent media multitasking behaviors. That is, this study directly tests how the two motivational systems, indicated by the experiences of positive and negative emotions, influence subsequent multitasking. In addition, it characterizes multitasking behaviors by their resource-demanding nature (i.e., the number of additional tasks) and the main task duration. Recent research has highlighted the need to differentiate the resource demands of different multitasking behaviors in examining multitasking choices and effects (Wang, Irwin, Cooper, & Srivastava, 2015; Xu, Wang, & David, 2016). Doing so can determine how likely people are to engage, consciously or not, in media multitasking in daily life (Wang et al., 2015). These specifications of both emotional gratification and media multitasking behaviors help illuminate our understanding of the myth of multitasking.

Multitasking and media multitasking

The accessibility of media allows the seamless integration of study, work, play, and social interaction, facilitating media multitasking as a way of life for the younger generation (e.g., David et al., 2015; Rosen, Mark Carrier, & Cheever, 2013; Srivastava, 2013). Multitasking is defined as simultaneously performing multiple tasks to accomplish distinct goals (Jeong & Fishbein, 2007; Sanbonmatsu, Strayer, Medeiros-Ward, & Watson, 2013). In specifying that the simultaneous tasks serve distinct or unrelated goals, this definition differentiates multitasking from behaviors that also involve the coordination of multiple modalities or tasks serving related goals. For example, listening to a lecture and texting with friends about plans for the weekend is considered to be multitasking, as the two activities serve unrelated goals, but listening to the lecture and taking notes or reading a handout on the lectured content are not considered multitasking in the current study, as they are centered around a (closely) related goal. When media use is involved in multitasking, it is usually referred to as media multitasking, and in today's modern society, most multitasking behaviors among adolescents involve media (Pea et al., 2012; Rideout, Foehr, & Roberts, 2010).

Research has shown that young people not only regularly perform two tasks at the same time, but even three or four. For example, college students frequently combine music, texting, and social media with homework (David et al., 2015). David and colleagues (2015) found that, among college students, bundle multitasking (i.e., multitasking or task switching with more than three activities at the same time) is almost as frequent as pairwise multitasking (i.e., performing two activities at the same time). Similarly, American adults often engage in two additional media activities when reading, watching, or listening to news (Ran, Yamamoto, & Xu, 2016).

As the number of tasks added to the main task increases, the demand for cognitive resources often increases. For example, when doing homework, both listening to music and using social media at the same time is more demanding than only listening to music. As one's overall amount of attention is limited (Lang, 2006), spreading attention among more activities would cause a decrease in the cognitive resources devoted to the main task. This intuition is confirmed by research findings. David and colleagues (2015) found that, as the number of multitasking activities increased, the self-reported amount of attention allocated to the main study task decreased. Ran et al. (2016) tested the actual information recall from multitaskers who read news information and engaged in other activities, and found that engaging in three activities at the same time led to worse information retention than performing two activities.

In daily life, however, multitasking that is more cognitively demanding should be less likely to be selected, based on the principle of resource conservation or the law of less work (Wang et al., 2015). As mental resources are limited, it is a human tendency and an adaptive function to avoid over-demanding tasks so as to conserve mental resources in general (Hobfoll, 1989; Muraven & Baumeister, 2000; Wang et al., 2015). Using daily media multitasking behavior data, Wang et al. (2015) demonstrated that people indeed tend to select multitasking activities that are less cognitively demanding in daily life: "people seemingly have an intuitive grasp of their own cognitive limits and adjust their behaviors accordingly when interacting with this changing media landscape" (Wang et al., 2015, p. 122). This intuition may come from the negative feelings brought on by overloaded processing (Wang et al., 2015), which we will elaborate on in the following sections.

Dual motivational systems

To understand the nature of the emotional gratification of multitasking behaviors in daily life (Wang & Tchernev, 2012), we drew on the theories of dual motivational systems. Dual motivational systems theories propose that emotions are fundamentally organized by two motivational systems: the activation of positivity (the appetitive system) and the activation of negativity (the aversive system; e.g., Bradley, 2009; Cacioppo & Berntson, 1994; Cacioppo, Gardner, & Berntson, 1997). The theories do not draw sharp divisions between classes of emotions, such as emotional states and emotional evaluation. Instead, emotions are broadly defined as feelings for or against an attitude object, where an attitude object can be an event, a person, or an idea (Larsen, McGraw, & Cacioppo, 2001). Following this perspective, the current study examined adolescents' emotional responses to the main task in multitasking, including their feelings towards and evaluation of the task (e.g., stimulating, pleasant, boring, difficult).

Theories of dual motivational systems assume that the experience of positive or negative emotions indicates the activation of the appetitive or aversive motivational systems, respectively (Cacioppo & Berntson, 1994; Larsen et al., 2001).

The dual motivational system perspective separates the positive affective processes from negative ones and proposes that the underlying appetitive and aversive systems have distinct adaptive functions and activation characteristics (Bradley, 2009; Lang, 2006; Wang, Solloway, Tcherney, & Barker, 2012b). Following the dual motivational view, the appetitive system is activated by positive stimuli, elicits positive emotions, and fosters approach behavior, whereas the aversive system is activated by negative stimuli, elicits negative emotions, and fosters avoidance behaviors. Such activations can be automatic in a more bottom-up manner, controlled in a more top-down manner, or both (Lang, 2006). Neuroimaging investigations have identified different neural substrates and response patterns for evaluating negative and positive stimuli (Berntson & Cacioppo, 2008), lending support to the perspective that both positive and negative emotions and their underlying motivations are better conceptualized as bivariate instead of bipolar. That is, the two motivational systems are functionally independent, although they may be correlated in many contexts (Cacioppo, Gardner, & Berntson, 1999; Larsen et al., 2001).

The theoretical proposition of separating positive and negative affective and evaluative processes allows for several modes of activating the appetitive and aversive systems (Cacioppo & Berntson, 1994; Cacioppo et al., 1997, 1999; Larsen et al., 2001), such as uncoupled activation, coinhibition, or coactivation (e.g., Cacioppo et al., 1999). Uncoupled activation occurs when changes in one system are not accompanied by changes in the other. Coinhibition occurs when changes in one system are associated with opposite changes in the other, whereas coactivation occurs when changes in one system are parallel with changes in the same direction in the other system. Coactivation is of special interest in this study. People can experience both positive and negative feelings at the same time ("mixed feelings") in various life occasions, including during media use, as demonstrated by both field and lab studies (Wang, Solloway et al., 2012). In everyday multitasking, routinized, uninteresting, and sometimes tedious or frustrating tasks are often coupled with emotionally rewarding activities, especially those involving media (e.g., playing television or music in the background, browsing friends' social media pages).

On one hand, the positive feelings induced by multitasking have been documented across many studies. Such feelings may come from the enjoyment brought by the additional tasks or, alternatively, an (illusive) perception of efficiency can come from completing tasks simultaneously (e.g., Wang, David et al., 2012a). For example, an experimental study found that combining a tedious reading task with watching TV made the whole experience more enjoyable than reading alone (Xu & David, 2018). Another experiment compared actual versus perceived task performance between two types of media multitasking situations. It demonstrated that people felt that they did a better job in a more demanding media multitasking situation, even though the eye-tracking data and behavioral data evidenced significantly worse performance in the situation, compared to a less demanding situation (Wang, David et al., 2012a). The authors suggested the "busier" multitasking situation may "allow for the illusion of efficiency more readily" (Wang, David et al., p. 974). The extant research findings

suggest that multitasking, especially in the self-selective situations of everyday life, should activate the appetitive motivational system and, hence, increase positive emotions regarding the whole experience. Thus, the overall more enjoyable experience may color the appraisal of the main task, and lead to a more positive emotional evaluation of the main task. We proposed that:

> H1: Multitasking will lead to a more positive emotional evaluation of the main task.

On the other hand, the aversive motivational system may also be activated by multitasking, leading to an increased negative evaluation of the main task. There are two possible mechanisms for this. First, during multitasking, cognitive resources are distracted and allocated to the secondary task(s), and the reduced cognitive capacity available for the main task typically hinders performance on the main task (Ophir, Nass, & Wagner, 2009; Strayer et al., 2003; Wang, David, et al., 2012a). According to research on goals, negative feelings are a signal of the current progress falling behind what is expected (Carver & Scheier, 1981, 1998). Thus, when multitasking to the extent that they can sense the dampened performance of the main task, multitaskers may feel frustration, stress, anxiety, regret, or a mix of these emotions. Second, in most multitasking scenarios in everyday life, people seem to combine tedious tasks with fun, secondary activities. Since a secondary activity in most cases constitutes an emotionally positive comparison point, the main task may seem even more tedious or stressful since it is being compared with the often fun or stimulating secondary activity during multitasking. This is termed the contrast effect of emotional evaluation (Brickman, Coates, & Janoff-Bulman, 1978; Helson, 1948). Thus, we proposed that:

> H2: Multitasking will lead to a more negative emotional evaluation of the main task.

In addition, the duration of the task may interact with multitasking to influence motivational activation and emotions. It is likely that as a task's duration increases with multitasking, the amount of attentional resources that are devoted to emotional processing decreases; therefore, the higher cognitive load attenuates the emotional impact of multitasking. Recent neuroimaging studies, drawing on resource theories, found that as a cognitive load increases, more activities over a longer period of time may dampen both positive and negative feelings (e.g., Van Dillen, Heslenfeld, & Koole, 2009). Recent research on the multi-dimensional framework of media multitasking illustrated that those multitasking activities demanding more cognitive resources are less likely to be selected in daily life, which reflects an adaptive function of human attention and decision selectivity (Wang et al., 2015). One possible source of such human adaptiveness may be the "numbing" effect of a cognitive load on motivational systems. The hypothesized effects of multitasking on positive and negative evaluations of the main task (H1 and H2) should depend on the task's duration. We thus proposed that:

H3: A longer task duration will reduce the effect of multitasking on increasing the positive emotional evaluation of the main task. That is, task duration will moderate the effect of multitasking on positive emotions.

H4: A longer task duration will reduce the effect of multitasking on increasing the negative emotional evaluation of the main task. That is, task duration will moderate the effect of multitasking on negative emotions.

Dynamic motivational activation

The DMA framework has been proposed as a way to understand the dynamic, reciprocal nature of media choices and media effects (e.g., Wang, 2014; Wang et al., 2011; Wang & Tchernev, 2012). The DMA includes two key components in understanding media processing, effects, and choices: the feedback effects within a system and the reciprocal causality between systems.

The feedback effect refers to the self-sustaining or self-causing property that accumulates the system's earlier responses and integrates them into the current state of the system, moderating how the system responds to external stimuli at the moment (Buzsàki, 2006; Wang et al., 2011; Wang & Tchernev, 2012). Feedback is a fundamental property of any dynamic system, which diverges from the traditional stimulus-response view of causality favored by behaviorism (e.g., Wang, Tchernev et al., 2012). From the dynamic system perspective, a human mind is an open, complex system, as it not only constantly processes and exchanges information from external inputs, but also produces self-generated mental representations and information. The latter feeds back into the processing of external stimuli and, thus, moderates the effects of the external stimuli on the system (Buzsàki, 2006; Wang et al., 2011).

In addition to feedback effects, the DMA emphasizes another key component in media research: reciprocal causality. Reciprocal causality refers to the mutual influence between systems of media choices and media effects. That is, media choices produce media effects, but media effects, in turn, will impact subsequent media choices. Dual motivational theories also propose that, after experiencing a positive emotion from an event, individuals may exhibit expectations of positive emotions for future unknown events (Cacioppo, Gardner, & Berntson, 1999). In other words, when the appetitive motivational system is gratified by an event, it is likely that the appetitive motivation to approach for a reward will be triggered for the event subsequently. For example, multitasking may result in different levels of activation of the appetitive and the aversive systems, indicated by positive and negative emotions, respectively. The positive and negative emotions gained from multitasking at this time point, in turn, will influence subsequent multitasking. Taken together, DMA teases apart the self-causing feedback effects from previous time points to more accurately estimate how a current media choice produces media effects and how media effects influence subsequent media multitasking. Figure 1 shows a conceptual schematic diagram demonstrating the theoretical propositions of DMA.

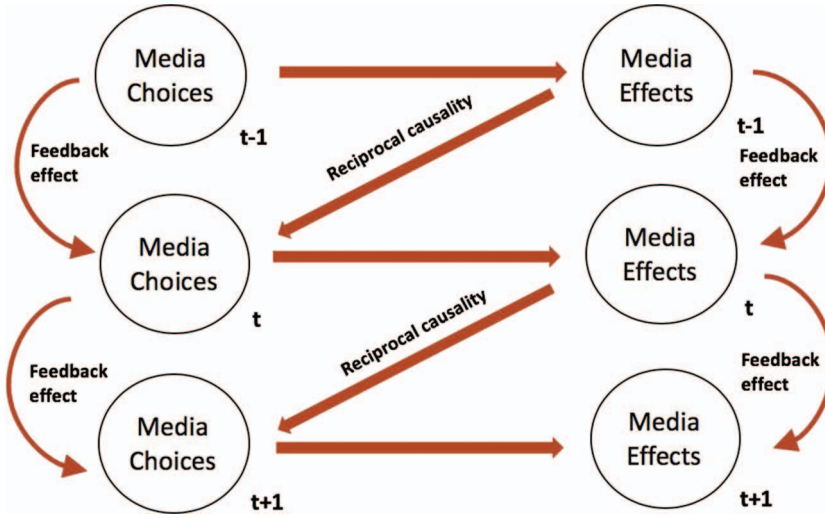

Figure 1 Conceptual schematic diagram of the theoretical propositions of dynamic motivational activation (DMA).

There are two possible directions of reciprocal causality effects: reinforcing and reducing (Slater, 2007). Reinforcing occurs when a behavior makes a person reach a state that may drive the person to continue engaging in the behavior to maintain that state. For example, enjoyment from multitasking may prompt one to continue to multitask in order to sustain the enjoyment. Reducing, also termed satiation, occurs when a system reaches a certain state that exceeds certain, implicit criterion; at this point the system may change its patterns, such as by stopping the behavior (Carver & Scheier, 1981). For example, one may experience enough gratification from multitasking and will thus reduce multitasking in a subsequent time point.

Based on the reciprocal causality mechanism proposed by DMA, positive and negative emotions resulting from the main task may affect subsequent multitasking behaviors, and the effects can either positively reinforce or negatively reduce the behavioral tendency. Both positive and negative emotions can have a reinforcing effect on subsequent behaviors. For example, positive emotions—that is, perceiving the main task as rewarding, pleasant, and stimulating—can lead to a reinforcing effect in which the multitasking behavior is continued to gain more positive feelings (Milyavskaya & Inzlicht, 2017; Slater, 2007). Negative emotions from the main task (e.g., perceiving it as difficult, boring, tiring, and unpleasant) may also increase the decision to engage in multitasking later, as adding more stimuli to the task may increase positive feelings (Calderwood, Ackerman, & Conklin, 2014). In contrast, the reducing effect is a self-regulating adjustment in response to external stimulation and tends to reach homeostasis (Slater, 2007). Negative or positive emotions may reduce subsequent multitasking. Previous research examining daily media use has

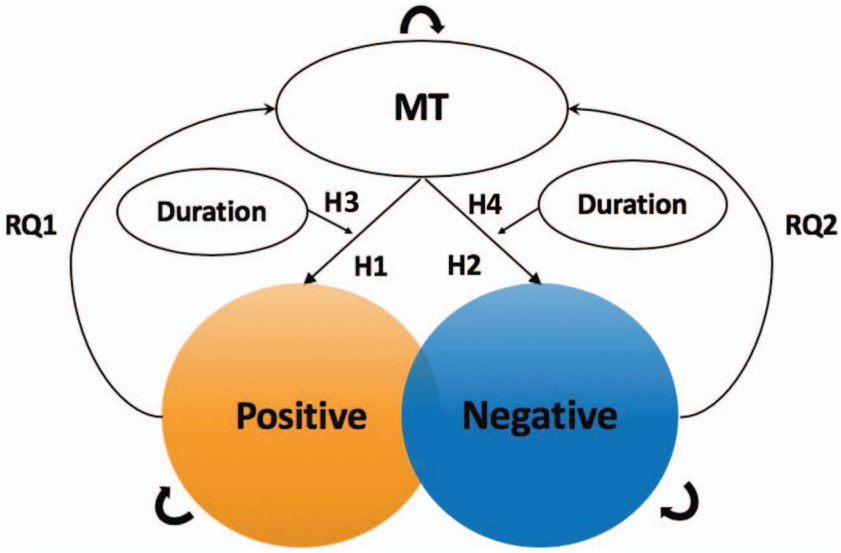

Figure 2 The conceptual model of reciprocal dynamic influences of positive emotion, negative emotion, and multitasking.

found a reduction effect between the gratification of needs and subsequent needs (Wang & Tchernev, 2012). When a certain need is satisfied, the level of the need will be reduced. In addition, negative feelings, such as the anxiety and stress increased by multitasking, may reduce engagement in subsequent multitasking.

In sum, both directions of reciprocal causality—reinforcing or reducing—are possible. In this study, we examined positive and negative emotions separately as indicators of dual motivational systems' activation. We explored how the positive emotion toward the main task will influence subsequent decisions to multitask. Is it a reinforcing effect or a reduction effect? We asked the same question with regard to those negative emotions that indicate actions of the aversive motivational system. We asked the following research questions, which are summarized in Figure 2 along with the hypotheses.

> RQ1: Will positive emotional evaluations of the main task increase or reduce subsequent multitasking?
>
> RQ2: Will negative emotional evaluations of the main task increase or reduce subsequent multitasking?

The hypothesized dynamic panel models

To test the hypotheses and explore the research questions, multilevel dynamic panel models were proposed. Following previous studies with similar data collection

methods (Wang & Tchernev, 2012; Wang, Tchernev, & Solloway, 2012c), this study included in the models autoregressive "lag 1" and "lag 3" feedback effects. The lag 1 term refers to the multitasking behavior at a previous time point, and the lag 3 term is of interest because it represents a possible relationship between the current state and the state at the same time on a previous day, which might help us control for any daily patterns of emotions and multitasking in the models.

Equation 1 below specifies the model for predicting positive emotions for the main task for individual i at time point t ($\text{Pos}_{i,t}$). It includes the feedback effects of positive emotions from the previous time point and from a day ago (the coefficients are α_1 and α_2, respectively). Then, it is determined by task duration, multitasking, and their interactions, as proposed by H1 and H3. In addition, age and gender are controlled for in all models, as previous studies have found that they can make a difference (Xu et al., 2016). The last two terms in the model are the error terms. Specifically, $\varepsilon_{i,t}$ is the error that is not predicted by the model for individual i at time point t, while u_i estimates idiosyncratic errors, which are individual-level effects that we do not or cannot measure. For all the models, N is the number of individuals in the study and T is the number of observations for each individual. A similar model is proposed to predict negative emotion for individual i at time point t ($\text{Neg}_{i,t}$), to test H2 and H4 in Equation 2.

$$\begin{aligned}\text{Pos}_{i,t} = {} & \alpha_1 \cdot \text{Pos}_{i,t-1} + \alpha_2 \cdot \text{Pos}_{i,t-3} + \beta_1 \cdot \mathit{Duration}_{i,t} + \beta_2 \cdot \mathit{MT}_{i,t} \\ & + \beta_3 \cdot \mathit{MT} \times \mathit{Duration}_{i,t} + \mathit{Age}_i + \mathit{Gender}_i + u_i \\ & + \varepsilon_{i,t} \ \text{ for } i = \{1, \ldots, N\} \text{ and } t = \{1, \ldots, T\} \end{aligned} \tag{1}$$

$$\begin{aligned}\text{Neg}_{i,t} = {} & \alpha_1 \cdot \text{Neg}_{i,t-1} + \alpha_2 \cdot \text{Neg}_{i,t-3} + \beta_1 \cdot \mathit{Duration}_{i,t} + \beta_2 \cdot \mathit{MT}_{i,t} \\ & + \beta_3 \cdot \mathit{MT} \times \mathit{Duration}_{i,t} + \mathit{Age}_i + \mathit{Gender}_i + u_i \\ & + \varepsilon_{i,t} \ \text{ for } i = \{1, \ldots, N\} \text{ and } t = \{1, \ldots, T\} \end{aligned} \tag{2}$$

Finally, Equation 3 estimates whether positive and negative emotions toward the main task can predict subsequent multitasking (RQ1 and RQ2). In addition to the lag 1 and lag 3 autoregressive feedback terms and the controlled variables of age and gender, the model includes positive and negative emotions at preceding times ($\text{Pos}_{i,t\text{-}1}$ and $\text{Neg}_{i,t\text{-}1}$, respectively). Because task duration should affect the likelihood to add multitasking activities, it was also controlled for.

$$\begin{aligned}\mathit{MT}_{i,t} = {} & \alpha_1 \cdot \mathit{MT}_{i,t-1} + \alpha_2 \cdot \mathit{MT}_{i,t-3} + \beta_1 \cdot \mathit{Duration}_{i,t} + \beta_2 \cdot \mathit{Pos}_{i,t-1} \\ & + \beta_3 \cdot \mathit{Neg}_{i,t-1} + \mathit{Age}_i + \mathit{Gender}_i + u_i \\ & + \varepsilon_{i,t} \ \text{ for } i = \{1, \ldots, N\} \text{ and } t = \{1, \ldots, T\} \end{aligned} \tag{3}$$

Method

Participants

In total, 73 adolescents living in the midwestern region of the United States were recruited through online ads, digital posters on middle schools' and high schools' websites, and ResearchMatch.org (Harris et al., 2012). They completed the study for monetary compensation during 2016–2017. Two participants' data were excluded from the analysis for noncompliance with the data reporting procedures (e.g., late reports). The remaining 71 participants were 11–17 years old (M = 14.01, SD =1.68), and 43 (60.56%) were female. The majority were Caucasian (42.25%) or African American (32.39%), and the rest self-identified as Asian, Hispanic, or multiple ethnicities.

The experience sampling method

We adopted the experience sampling method used in previous longitudinal media use research (e.g., Wang & Tchernev, 2012; Wang, Tchernev, & Solloway, 2012c). Participants reported their activities, both media-related and non–media related, three times a day for 14 days. Each participant was provided with a pre-configured tablet to report his or her activities. To minimize the influence of activity reporting on participants' media use behaviors, the device was configured to only allow reporting through an app and communication with the researchers was through a participant account (associated with a numeric identity to ensure data confidentiality). Participants were given time windows of 2–5 hours to submit their reports at midday (11 a.m.–1 p.m.) for morning activities, in the late afternoon (4–6 p.m.) for noon to afternoon activities, and before they went to bed (8 p.m.–1 a.m.) for evening activities. A clock alarm on the tablets was triggered at the beginning of each time window to remind participants of the reporting task.

Before the experience sampling began, all participants were trained for 2 hours and achieved 100% accuracy on a reporting test. During the training, we made sure participants understood the definition of multitasking in the current study as multiple activities serving distinct or unrelated goals. We showed the participants a variety of examples based on this definition. For instance, if they were listening to a lecture and using a computer to find online information about the lecture topic, that would not count as multitasking, as these two activities would serve a related goal. If they were listening to a lecture and texting a friend about plans for the weekend, however, that would be considered as multitasking, as the two activities serve unrelated goals. Ultimately, however, participants would decide whether the multiple activities they performed served related or unrelated goals from their perspectives. Participants also completed demographic survey questions.

The data collection avoided school breaks and major holidays in the community, as adolescents' media use patterns during holidays and vacations may differ from those during regular school days (Vandewater & Lee, 2009). This restriction helped mitigate variations in daily multitasking due to the timing of the data collection.

Measures

At the beginning of the survey, participants were asked to "please select all of the following activities you have done since you last reported. (Select all that apply.)" Activities were defined by a general-purpose category (education, responsibilities/obligations, social/recreation, exercise, eat/drink, personal, and others). During the training, the researcher defined and gave examples for each category of activity. Then participants reported more specific sub-categories within each category (e.g., for educational activities, sub-categories included learning, taking a class, and doing homework/assignments).

Then, participants were asked "if you were doing anything else during this activity, please check the box next to that other activity below. If you were doing more than one other thing, check each box." Participants could select their multitasking choices by checking from 8 categories of media activities (radio, phone/portable device, phone/portable device for social media, print, computer–desktop/laptop, computer for social media, video game console, and other media use) and 7 categories of non-media activities (education, responsibilities/obligations, social/recreation, exercise, eat/drink, personal, and others). A sum of the number of simultaneous activities was used as a measure of multitasking, where 0 represented no multitasking, 1 represented performing one activity simultaneously, 2 represented performing two activities simultaneously, 3 represented performing three activities simultaneously, and so forth.

For each activity, participants then reported the duration of each activity in minutes. The question was "how much time did you spend on [this activity]?" "This activity" was auto-filled with the name of the activity participants selected for the first question at the beginning of the survey, not the multitasking activity. Answers to this question were used as a measure of task duration. Lastly, for each activity, such as doing homework, participants rated 7 emotional responses to the activity, using 11-point scales (1 = not at all, 11 = completely). The questions were: "to what extent was this activity rewarding/tiring/pleasant/unpleasant/stimulating/boring/difficult?" The average of three positive evaluation ratings (rewarding, pleasant, and stimulating) was used as a measure of positive emotion in response to the activity (α = .70), and the average of the other four (unpleasant, tiring, boring, and difficult) was used as a measure of negative emotion to the activity (α = .74).

For each participant, time series data were created for the two multitasking variables and the two emotional variables described above: (a) task duration in minutes (M = 83.49, SD = 98.69), (b) multitasking (M = 0.37, SD = 0.63), (c) negative emotion (M = 2.87, SD = 2.28), and (d) positive emotion (M = 5.02, SD = 2.98). For each time window, data were averaged from all the tasks reported for each report window (morning, afternoon, evening) to generate one data point. Thus, for each participant, there are three data points per day for 14 days, resulting in 42 data points for each of the four variables.

It is interesting to note that the average multitasking was 0.37 in the current sample. A distribution analysis of multitasking showed that about 60% of all the activities

Table 1 Model Evaluation and Estimated Coefficients for Emotion Models

	Positive Emotion $_{i,t}$	Negative Emotion $_{i,t}$
	M (SE)	*M (SE)*
Intercept	-4.80 (3.16)	1.42 (2.71)
Emotion $_{i,t-1}$	0.01 (0.02)	0.07 (0.01)**
Emotion $_{i,t-3}$	0.07 (0.02)**	0.16 (0.02)**
Task duration $_{i,t}$	0.01 (0.001)**	0.01 (0.000)**
Multitasking $_{i,t}$	1.55 (0.14)**	1.11 (0.11)**
Multitasking $_{i,t}$ x Task duration $_{i,t}$	-0.005 (0.001)**	-0.004 (0.001)**
Age	0.55 (0.23)*	-0.02 (0.19)
Gender	0.99 (0.73)	0.24 (0.57)
Wald χ^2	423.80[a]	557.89[a]

Note: i,t = for individual *i* at time point *t*. [a]The model is significantly improved compared to the null model. $^{*}p < .05$; $^{**}p < .001$.

reported were single tasks (multitasking = 0). Considering the data collection was during school days for middle and high school students, these results were consistent with expectations. For this sample of participants, an average of 76.13% ($M = 0.76$, $SD = 0.38$) of their multitasking activities involved media use.

Dynamic panel modeling analysis

By considering both within-individual dynamics across time and variations across individuals in the multilevel time series data, dynamic panel models provided simultaneous examinations of both levels of variation, while accounting for unobserved individual heterogeneity (Baltagi, 2008). We fit the models using the Generalized Method of Moments estimator, implemented by the xtdpdsys command of Stata/IC 14.0 (Arellano & Bover, 1995; Blundell & Bond, 1998). Compared with the Maximum Likelihood Estimation, the Generalized Method of Moments estimator does not put any assumptions on the distribution of the data, which is essential when data is not normally distributed and allows greater flexibility in model estimations (Baum, Schaffer, & Stillman, 2003). Models were compared using Wald $\chi 2$ (Engle, 1984) and the final selected models passed the Sargan test of overidentifying restrictions (Arellano & Bond, 1991).

Results

Effects of multitasking behaviors on emotions

Model coefficients and model fit statistics regarding H1 and H3 that predicted positive emotions and regarding H2 and H4 that predicted negative negative emotions to the main activity are summarized in Table 1 and Figure 3.

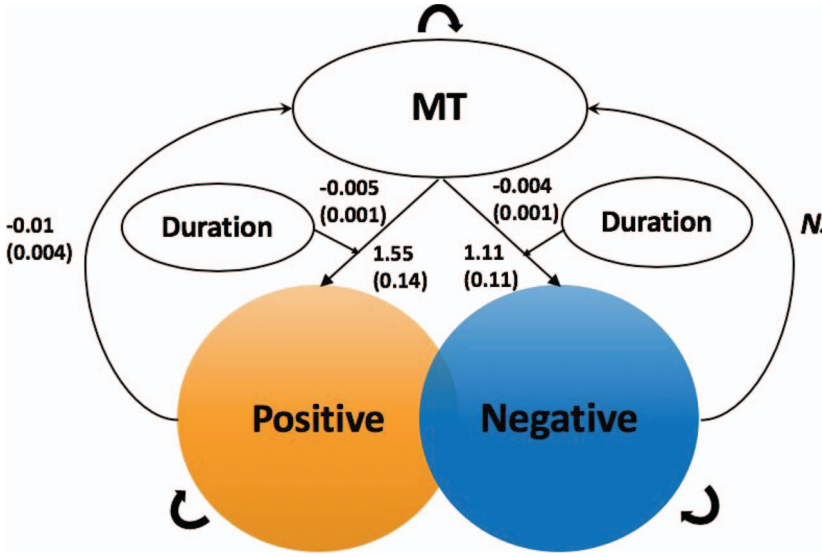

Figure 3 The results of the proposed model.

Supporting H1, multitasking significantly increased positive emotional evaluations of the main task. As estimated by model coefficients, on average, when multitasking increased by one unit—that is, by adding one additional activity to the main task—positive emotion increased 1.55 units on the 11-point scale. This effect depended on the task duration, as predicted by H3. There was a significant interaction effect between multitasking and task duration. As estimated by the coefficient of the interaction term (see Table 1), holding the multitasking constant, when the task duration increased by one minute, the positive emotion decreased by 0.005 units, meaning that for an additional hour of multitasking, positive emotion decreased by 0.3 units. In addition, there was a significant daily pattern of positive emotion: it was determined by positive emotion at the same time point on the previous day (lag 3 autoregressive term), but not by positive emotion from the previous time point (lag 1 autoregressive term).

As predicted by H2, multitasking significantly increased negative emotional evaluations of the main task as well. As shown in Table 1, on average, when multitasking increased by one unit (adding one additional activity to the main task), negative emotion increased 1.11 units on the 11-point scale. This effect again was moderated by the task duration, which supports H4. Holding multitasking constant, when the time duration increased by one unit (minute), the negative emotion decreased by 0.004, meaning that for an additional hour of multitasking, negative emotion decreased by 0.24 units. In addition, both lag 1 and lag 3 feedback effects significantly predicted negative emotions, indicating that negative emotions

Table 2 Model Evaluation and Estimated Coefficients for Competing Multitasking Models

	Multitasking $_{i,t}$	
	Model 1	Model 2
	M (SE)	*M (SE)*
Intercept	0.21 (0.52)	0.22 (0.52)
Multitasking $_{i,t-1}$	0.05 (0.02)*	0.05 (0.02)*
Multitasking $_{i,t-3}$	0.11 (0.02)**	0.11 (0.02)**
Task duration $_{i,t}$	0.0004 (0.0001)**	0.0004 (0.0001)**
Negative emotion $_{i,t-1}$	0.001 (0.01)	-0.007 (0.01)
Positive emotion $_{i,t-1}$	-0.01 (0.004)*	-0.02 (0.01)*
Positive emotion $_{i,t-1}$ x Negative emotion $_{i,t-1}$	. . .	-0.002 (0.002)
Age	-0.01 (0.03)	-0.02 (0.03)
Gender	0.34 (0.18)	0.34 (0.18)
Wald χ^2	78.84[a]	79.10

Note: i,t = for individual *i* at time point *t*. [a]The model is preferred. Selection is based upon the *p*-value associated with the Wald $\chi 2$ value difference between the two competing models (*df* = the difference of the number of coefficients of the two competing models). The difference is not significant for the two models and, thus, the simpler model is preferred. $^{*}p < .01$; $^{**}p < .001$.

from both the previous time point and at the same time point on the previous day determined the current negative emotion.

Effects of emotions on subsequent multitasking behaviors

To examine how positive and negative emotions (RQ1 and RQ2) affected subsequent multitasking behaviors, two competing models were tested: (a) the proposed model with main effects of emotions on multitasking, as presented in Equation 3 (Model 1 in Table 2); and (b) a competing model adding an interaction term of positive and negative emotions, as the two emotions may moderate each other's effects on subsequent multitasking (Model 2 in Table 2). As tested by the Wald χ^2 for both models, the simpler model without the interaction term (Model 1) was preferred.

Specifically, to answer RQ1, positive emotion reduced subsequent multitasking. As positive emotion increased by one unit (on an 11-point scale), subsequent multitasking decreased by 0.01 (the number of other tasks). In addition, both lag 1 and lag 3 feedback effects predicted multitasking. To answer RQ2, negative emotion did not have a significant effect on subsequent multitasking.

Discussion

This study continued to explore the myth of multitasking in daily life among young people (Wang & Tchernev, 2012) by identifying reciprocal effects over

time between multitasking behaviors and the dual motivational systems. Previous research suggested that emotional gratification, although not explicitly or consciously sought after, might actually drive multitasking behaviors in daily life (Wang & Tchernev, 2012). Based on the dual motivational theories (Cacioppo & Berntson, 1994; Lang, 2006) and the dynamic extension of those theories (DMA; Wang et al., 2011; Wang & Tchernev, 2012), the current study further clarifies the myth of multitasking by specifying the roles of emotions in daily multitasking, as well as their underlying appetitive and aversive motivational systems. These two motivational systems are fundamental to a human's ability to survive and thrive, as they organize and determine a human's affective, cognitive, and behavioral responses, including media experiences (Cacioppo & Berntson, 1994; Cacioppo et al., 1997; Lang, 2006). Results of this study provide the first evidence that the two motivational systems are activated simultaneously (coactivation) by multitasking behaviors, as predicted by the dual motivational theories. Interestingly, the appetitive motivational gratification (indicated by positive emotion) gained from multitasking—but not its counterpart, aversive motivational gratification (indicated by negative emotion)—reduces tendencies to engage in subsequent multitasking.

Another main theoretical contribution of the current study was to characterize multitasking behaviors by their resource-demanding nature (i.e., the number of additional tasks added to the main task) and task duration. This was based on a recent theoretical development in multitasking research that highlights the importance of differentiating multitasking behaviors, taking into consideration the different content and structure features of tasks, as well as the relationship between the tasks (Wang et al., 2015; Xu et al., 2016). Indeed, our findings suggest that the effects of multitasking on both appetitive and aversive motivational systems depend on the resource-demanding natures of the multitasking behaviors, and that the effects are further moderated by the task duration. This highlights the need to better conceptualize and specify different types of multitasking in investigating the myth and effects of multitasking.

Coactivation of appetitive and aversive motivations from multitasking

From the dual motivational systems perspective (Lang, 2006; Wang et al., 2011), multitasking in daily life—typically involving media—should engage the two fundamental motivational systems. Our findings show that multitasking coactivates both the appetitive and aversive systems, as predicted by the coactivation hypothesis. The coactivation hypothesis is a critical theoretical argument of the dual motivational systems theories, but has seldom been empirically tested. A few empirical studies have found evidence supporting the hypothesis in lab experiments on media content processing (David, Horton, & German, 2008; Keene, Lang, & Loof, 2019; Wang, Solloway et al., 2012). The current study is among the first to test the hypothesis in everyday multitasking settings. Our results show that, as predicted by the coactivation hypothesis, when the participants engaged in more multitasking activities, they indeed experienced stronger positive *and* negative emotions. This finding of media

use behavior patterns is consistent with previous findings on media content processing. For example, while viewing sports broadcasts, viewers experienced both positive and negative emotions at the same time (David et al., 2008). Psychophysiological evidence has likewise shown that the two motivational systems were coactivated while viewing short, persuasive messages and has determined the allocation of attentional resources to the messages (Wang, Solloway et al., 2012).

Furthermore, the interaction of multitasking and the task time reduces both negative emotion and positive emotion. This can be explained by resource theories that predict that, as multitasking increases, the amount of attentional resources devoted to processing emotional information decreases; therefore, higher cognitive load attenuates the emotional impact of both the aversive and appetitive systems (e.g., Van Dillen et al., 2009).

Appetitive motivation and multitasking

How then do the appetitive and aversive motivational systems influence subsequent multitasking in turn? From the perspective of dual motivational theories, after experiencing emotional outcomes from an event, individuals may exhibit expectations of similar emotions for future corresponding events (Cacioppo, Gardner, & Berntson, 1999). Emotional outcomes of multitasking, whether positive or negative, may influence subsequent multitasking. Our findings suggest that appetitive motivation and gratification, as indicated by positive emotions gained from the activity or activities, are more powerful in determining subsequent multitasking in daily life than their aversive counterparts. The partial negative association between positive emotions and subsequent multitasking found in our study implies that adolescents multitask, such as by listening to music or checking social media sites, to help maintain or increase their positive emotions toward the main task.

It is worth noting that the participants in this study were 11- to 17-year-olds. Adolescence is sometimes thought of as a unique phase of human development, characterized by the dominance of the appetitive motivational system (e.g., Doremus-Fitzwater, Varlinskaya, & Spear, 2010), including in media choice and use behaviors (e.g., Wang, 2014). A great number of studies have suggested that during our youth, as we are rapidly growing, evolutionary pressures have led to alterations in the evolutionarily old brains and reward-related neurocircuitry that provide the impetus to seek primary rewards, such as new territories, sexual partners, and food (Doremus-Fitzwater et al., 2010; Spear, 2000). The preeminence of the appetitive motivational system results in the expression of adolescent-typical behaviors, such as seeking rewards, positive feelings, and novelty (Arnett, 1994; Doremus-Fitzwater et al., 2010). Thus, it is not surprising that among our sample of adolescents, the appetitive system was powerful in influencing multitasking behaviors.

In an added twist, the aversive system, as indicated by negative emotions, did not predict subsequent media multitasking. This implies that adolescents are not trying to use multitasking to manage their negative feelings towards the main task—the

boring, tiring, difficult, and unpleasant everyday obligations—through multitasking. Instead, what really drives them to add additional activities, mostly media activities, to the main task is to make themselves feel better about the main task: to make it a little more rewarding, pleasant, and stimulating. The effect of positive emotions on subsequent multitasking does not depend on negative emotions either. Earlier explorations of the myth of multitasking (Wang & Tchernev, 2012) suggested that emotional gratification drives media multitasking despite the cost of cognitive needs (e.g., homework, learning, information seeking). The current study extends our understanding by specifying that the emotional gratification gained from multitasking is more associated with the appetitive motivational system.

Reciprocal, dynamic impacts of dual motivations on media multitasking

Now we put the two sides of the story together. Multitasking increases both positive and negative emotions towards the main task, but only positive emotions towards the main task influence subsequent multitasking. Note that the main task here was operationalized as everyday non-media activities, such as doing homework, cleaning the house, and resting. The results suggest that adding media or non-media activities to a main non-media task increases positive and negative emotions. However, when adolescents felt more positively (i.e., more rewarded, pleasant, or stimulated) about the main activity, they were less likely to multitask subsequently.

The model coefficient of positive emotions on succeeding multitasking is negative, demonstrating a reducing reciprocal effect of the main task on subsequent multitasking. The reducing reciprocal effect indicates that if adolescents gain positive emotions from a main task, their multitasking level will decrease subsequently. Our findings provide implications for parents and educational practitioners on how to mitigate adolescents' excessive multitasking in their daily life. This study offers evidence for an intuitive solution: engage adolescents in activities that can gratify the appetitive system, making them rewarding, pleasant, and stimulating. For instance, by designing more interactive lecture materials, educators can provide stronger gratification to adolescents' appetitive system and, thus, help reduce adolescents' task-irrelevant multitasking during learning. Parental efforts toward engaging children in sports, outdoor activities, or visiting places of interest likewise open up possibilities for children to play, learn, and explore so as to gratify their appetitive system, which can reduce multitasking in everyday life (e.g., Zaman, Nouwen, Vanattenhoven, de Ferrerre, & Looy, 2016). Overall, the results of our study suggest that high-quality non-media activities satisfying the appetitive motivational system could reduce (media) multitasking.

What is alarming is the lack of a significant reducing effect of negative emotions on subsequent multitasking. According to the self-regulation theories (Carver & Scheier, 1981, 1998), negative emotions signal a lack of progress and, thus, increased effort should be devoted into the main task and, subsequently, less multitasking should be performed during the main task. However, results from this study did not show a significant reducing effect of negative emotions on subsequent

multitasking. Future research can replicate this study with a larger and more diverse sample to test whether negative emotions towards the main task influence subsequent multitasking. In addition, it is worth noting that some personality traits may moderate the relationship between negative emotions and multitasking: for example, the ability to monitor and detect the discrepancy between goals and current behaviors (Carver & Scheier, 1981; Scheier & Carver, 1983).

Conclusion and future studies

This study is among the first to examine the dynamic relationship between the fundamental dual motivation systems and multitasking (primarily media multitasking) in a naturalistic setting. As predicted, multitasking leads to the coactivation of both appetitive and aversive systems, but only the appetitive motivation influences subsequent multitasking. The method and analysis used in the study help to reveal important motivational mechanisms underlying the myth of multitasking in everyday life. First of all, compared to cross-sectional survey studies, our approach takes advantage of the temporal order of the designated cause and effect variables (Menard, 2002), and affords the testing and estimation of reciprocal causality between multitasking behaviors and emotions (Granger 1980, 2001; Wang & Tchernev, 2012). Similarly, compared to lab experiments that usually force participants to engage in specifically designed multitasking activities, our study allowed participants to report their self-selected multitasking choices and psychological experiences in naturalistic contexts of everyday life, lending greater ecological validity (McCarney et al., 2007).

Several limitations of the study should be noted and addressed in future studies. First, in specifying a general model of multitasking in the everyday life of adolescents, we necessarily omitted distinctions between specific activities and between diverse combinations of activities, including the nature of the media content and activity. For example, a wide range of content and production characteristics, such as emotional content and pacing (e.g., Lang, 2000; Wang, Solloway et al., 2012), can impact the emotional systems. Future research should examine the features of tasks and media to see how they produce different motivational and behavioral impacts in media choices, switches, and multitasking (Wang, 2014). Second, this study only investigated how multitasking influenced the emotional evaluation of the main task. It would be interesting to examine evaluations of the secondary task(s). For example, does the primary task mostly lead to negative emotions while the secondary task typically adds positivity?

Third, in terms of the design of this longitudinal study, the question on multitasking during the main task was asked before the question on emotional evaluations of the main task, and the participants were asked to report emotional evaluations as outcomes of the tasks and activities; still, these two questions were measured at the same time point (daily in the morning, in the afternoon, or in the evening). Therefore, the causality between multitasking and emotional evaluations of the main task should be interpreted with caution. In fact, even within a certain time window (morning,

afternoon, or evening), multitasking and the emotional evaluations of the main task may dynamically influence each other. For example, multitasking changes how people feel about the main task, which in turn influences the intensity of multitasking during the main task.

Lastly, it would be valuable to investigate the long-term effects of multitasking using a representative sample of participants. Like a locomotive engine picking up steam, these self-reinforcing processes, together with moderating individual traits, might lead to significant long-term effects on individuals (Wang & Tchernev, 2012). For example, research has suggested that media multitasking is negatively associated with self-control (Xu et al., 2016) and cognitive functions (Ophir et al., 2009). Considering the expansion of our information and technology environment, it is critical to examine the long-term mutual influences of multitasking (especially media multitasking), affective and cognitive functions, and personal traits from a dynamic, developmental perspective (Wang & Tchernev, 2012). Individuals and groups with different appetitive and aversive motivational traits (e.g., Lang, 2006), self-regulation (Carver & Scheier, 1998), and media use patterns (e.g., Jeong & Fishbein, 2007) likely paint distinctive pictures of learning and development through their life journeys.

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