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Multidimensions of Media Multitasking and Adaptive Media Selection

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This study identifies 11 basic cognitive dimensions of media multitasking behaviors based upon resource theories. These dimensions provide a conceptual framework to help compare and synthesize media multitasking studies. In addition, using 2 empirical data sets, we examine how these cognitive dimensions interact with each other to predict choices of media multitasking behaviors in daily life in an adaptive manner to conserve limited mental resources. A systematic understanding of the multiple cognitive dimensions of media multitasking behaviors has the potential to foster theory-guided designs and more mindful selection of media tasks, technologies, and environments to curb negative consequences of media multitasking and utilize its benefits.

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Media effects research consistently shows negative consequences of media multitasking, yet media choice research depicts its increasing prevalence. Media multitasking is widely known to be detrimental to cognitive performance (e.g., Armstrong & Chung, 2000), cognitive functions (e.g., Ophir, Nass, & Wagner, 2009), and can even be life-threatening (e.g., McCartt, Hellinga, & Bratiman, 2006). However, media saturation and convergent technologies have made media multitasking a way of life (Rideout, Foehr, & Roberts, 2010). For example, a majority of teenagers multitask "most" or "some" of the time while listening to music (73% of respondents), using a computer (66%), watching TV (68%), and reading (53%; Rideout et al., 2010). In fact, media multitasking is increasingly perceived as a required skill for employees and students (Adler & Benbunan-Fich, 2012).

An interesting question surfaces: Are we indeed becoming "dumb" and doomed to "fall," as mainstream press articles and books with titles like *The Dumbest Generation* (Bauerlein, 2008) and "The Autumn of the Multitaskers" (Kirn, 2007) suggest? In other words, are we maladapted to the accelerating development of media technologies and an increasingly saturated media environment because we — unconsciously or consciously — select behaviors that deteriorate our performance and cognitive functions? This remains unclear from existing research.

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Current work on media multitasking focuses on either laboratory experiments that show its negative effects, or surveys that describe its popularity and trends in daily life. The present study starts to bridge these two research programs and explore the (mal)adaptive nature of media multitasking in our daily life through two steps. First, it conceptualizes and differentiates media multitasking behaviors along multiple basic cognitive dimensions based upon well-established psychological research on mental resources (e.g., Salvucci & Taatgen, 2008; Wickens, 2002). This conceptualization helps put large varieties of media multitasking behaviors under the same cognitive framework. This can help compare and synthesize diverging empirical studies in literature.

Second, in conjunction with research on "the law of less work" and resource conservation, this study explores how the proposed cognitive dimensions can help predict people's media multitasking behavioral choices in daily life. Specifically, it starts to test the proposed cognitive dimensional framework of media multitasking using daily media multitasking choice data. This analysis illustrates how people may select certain media multitasking behaviors over others in an adaptive manner to conserve mental resources (Hobfoll, 1989; Kool, McGuire, Rosen, & Botvinick, 2010).

These two goals are related. The cognitive dimensions of media multitasking behaviors, which identify and differentiate cognitive demands between behaviors, should predict both multitasking effects and choices. In addition, reconciling and synthesizing studies on media multitasking effects helps predict choices of media multitasking behaviors, because in daily life, positive and rewarding media experiences reinforce the media choice behavior while negative and unrewarding experiences discourage the behavior (Wang & Tchernev, 2012).

But just what is media multitasking? Media multitasking is a concept in great need of explication and specification. Research on media multitasking often limits the definition to correspond to the specific purposes and context of the study. For example, the concept has been commonly and parsimoniously defined as doing two activities simultaneously, including at least one media activity. Although such working definitions enjoy a practical appeal, it makes comparing findings across studies a challenge as a higher-order concept like "media multitasking" encompasses a diverse array of behaviors. For example, the commonalities between a study on multitasking with background television (e.g., Armstrong & Chung, 2000) and a study on multitasking with six computer puzzles (e.g., Adler & Benbunan-Fich, 2012) are not immediately clear.

Although conceptual abstraction is necessary for building theory, it may cause researchers and readers to overlook key differences across contexts. This is problematic for this area of research as media multitasking behaviors differ in a number of important ways, which ultimately affects their demand on cognitive resources. We find it important to closely examine differences in the cognitive demands associated with specific media multitasking behaviors, as well as to more closely consider how these demands might guide real-world media choice behaviors. To achieve this goal, we propose a multidimensional framework that explicitly describes any given media multitasking behaviors using 11 theory-driven dimensions.

Our approach to media multitasking emphasizes the need to understand how human cognitive systems can handle multiple media tasks simultaneously, and how these capabilities may guide human interactions with the mediated environment. Experimental research has consistently demonstrated that juggling two or more tasks impairs performance on specific cognitive tasks under explicit or implicit time pressure, although the severity of the impairment varies across different task combinations (e.g., Consiglio, Driscoll, Witte, & Berg, 2003; Wang, David, et al., 2012).

Two theoretical perspectives on cognitive system performance are used to account for varying multitasking performance: central bottleneck theories and limited capacity (or resource) theories. Furthermore, along with "the law of less work," which summarizes findings on the human tendency to minimize and avoid effort from psychology, neuroscience, and decision science literature, the levels of cognitive demands associated with media multitasking behaviors can be used to predict media multitasking choices in daily life.

Central bottleneck, limited resources, and the law of less work

Central bottleneck theories posit structural limitations in underlying cognitive systems as the primary reason for detriments to performance (Marois & Ivanoff, 2005). These theories argue that human cognition is directed by a mechanism that sequentially processes stimuli that require attention (Levy & Pashler, 2008). This suggests that the limitations of information processing during multitasking are primarily attributable to structural limitations. Because only one task can be processed at a given moment, simultaneous requests for mental resources result in deleterious effects on cognitive processes. This view has provided a parsimonious account of many empirical findings, including the Psychological Refractory Paradigm (PRP) and attentional blinks studies (e.g., Marois & Ivanoff, 2005).

Theories of limited capacity or resource provide an alternative view of limitations in human information processing and cognitive functions (Kahneman, 1973). Capacity is conceptualized as energy required for the completion of any given task, such as encoding, storing, and retrieving information (Lang, 2000, 2006). Decreases in performance are expected when the mental capacity required for two tasks exceeds the total amount of capacity available. From this view, multitasking performance is primarily limited by available capacity, rather than a cognitive structure that excludes the possibility of parallel processing. In other words, it is possible for the cognitive system to perform multiple tasks in parallel if capacity is sufficient. In addition, individuals with higher capacities may handle the same multitasking behaviors more easily and successfully, and thus be more likely to multitask.

Multiple resources theories are a variant of the limited capacity theories. They argue that the cognitive system has multiple pools of mental resources that may be used in completing a given task or multiple tasks (Basil, 1994; Wickens, 2002). These different pools are typically associated with specific modalities of information (Basil, 1994; Salvucci & Taatgen, 2008). For example, there is a resource pool dedicated to the processing of visual information and a separate resource pool dedicated to the processing of auditory information. Each of these pools has limitations affecting the amount of information that can be processed at a given moment. Resources can be allocated both intentionally and automatically (and sometimes unconsciously) depending on features of the stimuli and the goals or motivations of individuals (Lang, 2006; Shiffrin & Schneider, 1977). For example, media psychological research has established that characteristics of media production and content can elicit allocation of mental resources to processing the media automatically (e.g., Lang, Park, Sanders-Jackson, Wilson, & Wang, 2007; Wang, Solloway, Tchernev, & Barker, 2012).

The same principle applies to media multitasking contexts (Wang, David, et al., 2012). Competition for access to these resource pools will result in a bottlenecking in the processing, leading to performance decreases in the cognitive tasks (Salvucci & Taatgen, 2008; Wang, David, et al., 2012). Thus, again, media multitasking behaviors that are less likely to cause bottlenecking and failure of tasks are more likely to be selected by users. This could either be an intentional, mindful choice based on user experience and self-regulation (e.g., managing workflows; cultivating good study habits), or an unconscious choice reflecting an automatic tendency to avoid aversive experiences associated with poor performance (e.g., stopping a distractive conversation with passengers to focus on finding directions while driving).

These reviewed theoretical perspectives are consistent with our current understanding of human working memory, such as explicated by the multicomponent theory (Baddeley, 2012). The theory proposes four primary components and mechanisms in explaining working memory performance: The phonological loop, which temporarily stores and maintains (by rehearsals) heard or spoken linguistic information; the visuospatial sketchpad, which stores visual information; the episodic buffer, which integrates and temporarily stores information from multiple resources, and interacts with episodic long-term memory; and finally, the central executive system, which is in charge of attentional focus and task switches. The phonological store, the visuospatial sketchpad, and the episodic buffer have limited capacities. The central executive system needs to serially process tasks, which creates the central bottleneck phenomena.

Probably because mental resources are limited, scholars have observed that humans tend to avoid cognitively demanding tasks, which has been coined "the law of less work" (Allport, 1954; Hull, 1943; Kool et al., 2010), and to conserve resources (Hobfoll, 1989; Muraven & Baumeister, 2000). In fact, as Allport argued more than half a century ago, effort, except when we are highly motivated, is "disagreeable" (p. 21). Indeed, neuroscientific evidence suggests that cognitive effort elicits aversive responses in humans. Research has found that human nucleus accumbens' (NAcc) responses increase when the reward value of a task increases, but decrease when the associated cognitive demand of the task increases, suggesting that cognitive effort has a reward discounting effect (Botvinick, Huffstetler, & McGuire, 2009).

The avoidance of effortful actions can be automatic, as suggested by the quick aversive response in the brain described above, but it can also be an intentionally controlled process. For example, behavioral economists and decision scientists have recognized the effects of effort avoidance on human choice behaviors. They assign an effort cost value to different options, which is theorized as part of a decision-maker's tradeoff evaluations against other relevant dimensions of the options, such as accuracy (e.g., Payne, Bettman, & Johnson, 1993; Smith & Walker, 1993). In some contexts, decision-makers select less accurate options, which are still viewed as subjectively optimal choices because they reduce effort costs (Anderson, 1990; Payne et al., 1993).

Multiple cognitive dimensions of media multitasking

Based upon resource theories and empirical research on media multitasking, we have identified 11 basic dimensions of media multitasking behaviors that affect resource demand and resource allocation. Consequently, these dimensions can help predict behavioral performance. Additionally, they can help predict media multitasking choices because of our tendency to conserve resources and follow "the law of less work." In general, highly demanding multitasking behaviors are less likely to be selected in daily life.

For simplicity of discussion, we only consider media multitasking involving two tasks in which one or both tasks utilize media technology. We organize the 11 dimensions into four categories, reflecting what aspect of the media multitasking behavior the dimension helps inform: How are the two tasks related to each other? (*Task Relations*) How is task information presented to the user? (*Task Inputs*) Is any behavioral response required by the tasks? (*Task Outputs*) Do differences in users affect the processing of and responses to the tasks? (*User Differences*) In addition, to illustrate the 11 dimensions, nine experimental studies that clearly specify each task are analytically reviewed and summarized in Table 1.

Task relations

Unlike media choice and processing research that focuses on scenarios involving a single media task at a time, what is critical to the understanding of media multitasking is the need to consider the relationship between multiple tasks. Theoretical and empirical research has suggested five dimensions of task relations that can affect resource demand and allocation.

Task hierarchy

Task hierarchy reflects the relative importance given to each task in a media multitasking situation. Two tasks can range along a continuum from a primary task with a background/secondary task to two equally important tasks. To better manage limited resources, cognitive systems operate in such a way that more important tasks are allocated more resources, leading to better cognitive performance (Dijksterhuis & Aarts, 2010; Lang, 2006). For example, Lin, Robertson, and Lee (2009) compared

Table 1 A Summary and Representative Examples of 11 Cognitive Dimensions of Media Multitasking

Empirical Examples	Task Relations					Task Inputs			Task Outputs		User Differences	Performance Evaluations
	Task Hierarchy	Task Switch	Task Relevance	Shared Modality	Task Contiguity	Info Modality	Info Flow	Emotional Content	Behavioral Responses	Time Pressure		
Burke et al. (2005)	+1	+1	−1	−1	0	banner: +1 text: +1	banner: 0 text: +1	banner: 0 text: −1	banner: −1 text: +1	+1		banner task recall; perceived task load; text task completion time
Armstrong and Chung (2000)	+1	+1	−1	−1	−1	TV: −1 text: +1	TV: −1 text: +1	TV: +1 text: −1	TV: −1 text: −1	+1		accuracy of recall and recognition for the reading task
Pool et al. (2003)	+1	+1	−1	TV: −1 radio: +1	−1	TV: −1 radio: +1 text: +1	TV: −1 radio: −1 text: +1	TV: +1 radio: +1 text: −1	TV: −1 radio: −1 text: +1	−1		accuracy and completion time of the paper-and-pencil task
Hawkins et al. (2005)	−1	+1	+1	0	0	TV: −1 text: +1	TV: −1 text: +1	TV: +1 text: 0	TV: −1 other: −1	−1	attentional style	duration of TV looks (no performance evaluation)
Moreno and Mayer (1999)	−1	+1	+1	audio: +1 no audio: −1	+1	audio: −1 no audio: +1	audio: −1 no audio: −1	audio: 0 no audio: 0	audio: −1 no audio: −1	0		retention, matching, and transfer tests
Lin et al. (2009)	video test: −1 no test: +1	+1	−1	−1	−1	TV: −1 text: +1	TV: −1 text: +1	TV: +1 text: −1	TV: −1 text: −1	+1	content expertise	reading test performance (knowledge, comprehension, and analysis questions)

Table 1 Continued

Empirical Examples	Task Relations					Task Inputs			Task Outputs		User Differences	Performance Evaluations
	Task Hierarchy	Task Switch	Task Relevance	Shared Modality	Task Contiguity	Info Modality	Info Flow	Emotional Content	Behavioral Responses	Time Pressure		
Wang, David, et al., 2012	−1	IM: +1 phone: −1	−1	IM: −1 phone: +1	0	IM: +1 phone: −1	IM: +1 phone: −1	IM: +1 phone: +1	IM: +1 phone: +1	+1		IM/phone task performance; visual search task performance
Adler and Benbunan-Fich (2012)	−1	+1	−1	−1	+1	all: +1	all: +1	all: −1	all: +1	+1	multi-vs. sequential taskers	productivity and accuracy on all tasks
Foerde et al. (2006)	−1	−1	−1	+1	0	computer screen: +1 sound: +1	computer screen: −1 sound: −1	computer screen: −1 sound: −1	computer screen: +1 sound: +1	+1		types of learning and memory between conditions

Note: See the Appendix (available on the Journal website and also from the first author) for more details on how each dimension was coded. In general, scores of +1 refer to the presence of relatively high levels of the dimension (or a relatively certain "yes"/"presence"); −1 generally refers to relatively lower levels of the dimension (or a relatively certain "no"/"absence"); and 0 refers to something in between (or ambiguity or a mix of possible presence and absence).

task performance between multitasking conditions in which watching television and reading educational material were either given equal importance or the reading task was assigned more importance. Participants better remembered what was read in the latter multitasking conditions.

Extending the research on performance outcomes to behavioral choices, we expect that more efficient behaviors (e.g., placing more importance on the task that is evaluated for its outcomes) are more likely to be selected. Unless both tasks are fairly trivial, we also expect that strategically prioritizing the more demanding task (e.g., focusing on homework with music in the background) should be more efficient and thus selected more frequently than treating both tasks as equals (e.g., doing homework while memorizing music).

Task switch

This dimension captures the extent of control people have over switching between tasks — that is, whether the media allows the user to change where mental resources are allocated. Existing empirical tests on media multitasking typically grant the user control over what task they attend to at a given time point, but there are exceptions. For example, Wang, David, et al. (2012) compared attentional and behavioral differences between instant messaging (IM) and phone conversations while performing a computer visual search task. IM afforded participants more control over when to look at the message sent by the conversation partner and when to respond, and hence more control over task switches between the conversation task and the visual search task. In comparison, task switching in the phone multitasking condition tends to be dictated by the social expectation to be responsive to the partner on the phone.

In general, multitasking involves both intentional decisions to switch between tasks and interruptions caused by the nature of the tasks (Benbunan-Fich, Adler, & Mavlanova, 2011). Whether more control over task switches improves task performance depends on a number of additional factors such as task relevance (Salvucci & Taatgen, 2008), but in general, media multitasking with greater task switch control should be selected more often.

Task relevance

This dimension addresses whether the tasks involved in media multitasking serve closely related goals (or a single overarching goal). Salvucci and Taatgen (2008) proposed that people organize information and tasks into cognitive "threads" specifically around their goals. These threads keep information and tasks coordinated, allowing for relatively smooth integration of multiple simultaneous processes. However, having multiple goals may increase cognitive demands as multiple threads compete for resources. Most existing media multitasking experiments examine tasks with distinct and unrelated goals (e.g., six separate puzzle tasks in Adler & Benbunan-Fich, 2012). However, Moreno and Mayer (1999) demonstrated that when two tasks are centered on a common goal, task performance can be improved. Levy and Pashler (2008) found that participant's vehicle braking performance improved with the addition of a secondary task redundantly indicating the vehicle in front of them was braking. In general, more relevant tasks should be combined more often in multitasking. Indeed, people in naturalistic settings have been shown to engage in media multitasking toward the same general goal or related subgoals (e.g., Hawkins et al., 2005).

Shared modality

This refers to the degree of shared sensory modalities (e.g., visual, auditory, kinesthetic) between the tasks. Typically only one task can have primary access to a sensory resource at any given time. If multiple tasks are competing for the same modality resource, they must proceed in a sequential manner. This sequential processing creates a cognitive bottleneck, which is experienced as slowed reaction times and interference in cognitive, perceptual, and/or motor processes (Salvucci & Taatgen, 2008).

For example, Moreno and Mayer (1999) compared learning during an animated presentation with either text or audio supporting materials. Both animation and text information are processed visually, but audio narration splits the information between auditory and visual processes. They found that learning was facilitated with the combination of auditory and visual materials. This suggests that sharing tasks over multiple sensory modalities may be a key to improve multitasking performance. Multitasking behaviors that allocate resource demands across modalities should be selected more often than those that create heavy competition for the same modality resource.

Task contiguity

This dimension refers to the physical proximity between the tasks. Spatial contiguity, or presenting information close to one another, should reduce task switch time and cognitive resource costs (Mayer & Moreno, 2002). Naturally, contiguous tasks are more likely than those far apart. However, we would note that the cognitive benefit of physical proximity generally is limited to relevant tasks.

In other words, physical closeness of multiple information inputs generally leads to positive outcomes, but only when information is also cognitively close. For example, when irrelevant online banner ads were placed close to the visual search task, the processing of ads significantly impaired the visual search task performance (Burke, Hornof, Nilsen, & Gorman, 2005). Hence, contiguity should generally increase multitasking tendencies, although resulting performance can differ because of other factors like task relevance.

Task inputs

The effects of media format and content on processing, resource allocation, and resource demand have been a focus of media psychologists (e.g., Lang, 2006). Based upon this literature, each task in media multitasking can be considered separately along three key dimensions.

Information modality

This refers to sensory modalities involved in a task. Most relevant to current media multitasking paradigms are the visual, auditory, and motor modalities (Salvucci & Taatgen, 2008; Wickens, 2002). Tasks engaging multiple sensory modalities will utilize multiple cognitive resource pools. This creates more opportunities for conflicts and interferences between tasks, and also competes for the limited executive resource that helps manage the use of the multiple resource pools (Salvucci & Taatgen, 2008; Wang, David, et al., 2012). Thus, generally they should be less frequently selected; however, as discussed earlier, other dimensions, especially whether the tasks compete for the same resources should also matter.

Information flow

How the information is transmitted to the user during a task can determine how cognitively demanding the task is. Static, written content typically can be returned to at any time, which gives the user more control over the pacing of the incoming information flow. In comparison, video and audio content is transitory and must be attended to at the moment of presentation. In addition, media processing research has shown that faster-paced content can elicit greater attention and emotional arousal until the moment when the pacing is too fast, cognitive overload occurs, and the processing of the incoming information suffers (e.g., Lang, 2000; Lang et al., 2007). During multitasking, since mental resources have to be split between tasks, transitory and fast-paced media are expected to more easily cause cognitive overload, and thus in general, be less selected than stable, slow-paced media.

Emotional content

The emotional valence (i.e., positive, negative, mixed) and intensity (i.e., arousing or calm) of media content can determine the allocation of mental resources to the processing of the media (Lang, 2006; Wang, Solloway, et al., 2012). From the perspective of motivated information processing theories, there can be top-down and bottom-up influences on mental resource allocation to the processing of information. While the aforementioned dimension of task hierarchy emphasizes the top-down, goal-directed, consciously controlled mechanism of resource allocation, the dimension of emotional content considers the bottom-up, less- or subconscious, stimulus-driven resource allocation mechanism (Cacioppo & Berntson, 1999; Shiffrin & Schneider, 1977).

Media research has robustly shown that emotional valence and intensity interact with each other to attract or repel cognitive resources to the media stimuli (e.g., Lang et al., 2007; Wang, Lang, & Busemeyer, 2011; Wang, Solloway, et al., 2012). Typically more intense or arousing media content attracts more resources to encode the media information until the point where action tendencies (e.g., fight, flight, approaching) are triggered (e.g., Lang, 2006; Wang, Solloway, et al., 2012).

Media multitasking often includes emotional content. For example, in the background television research paradigm, television often offers stimulating and emotional content while the reading or homework task often is informative, neutral content, such as on history and science (e.g., Lin et al., 2009). Thus, television likely distracts mental resources from the reading or homework task although the latter is often explicitly instructed as the primary task in the experiments. In other words, the bottom-up mechanism interferes with the top-down mechanism to determine resource allocation. In daily media multitasking, emotional tasks, especially positive, pleasant ones (e.g., entertainment media), are typically more likely to be selected (Wang & Tchernev, 2012).

Task outputs

The nature of media task outputs also affects the resource allocation and demand. Two dimensions are highly relevant to media multitasking.

Behavioral responses

This dimension refers to whether a task requires a user's behavioral responses beyond cognitive processing. Decisions about how to respond and the execution of the response consume resources. For example, in the background television paradigm, the television task typically does not require any explicit behavioral response. In contrast, media multitasking that involves active behavioral tasks, such as computer puzzles (Adler & Benbunan-Fich, 2012; Foerde, Knowlton, & Poldrack, 2006) and mediated conversations (Wang, David, et al., 2012) add more complex dynamics to media multitasking. Because media tasks requiring behavioral responses generally demand more resources, they are less likely to be combined with other tasks than those requiring no behavioral responses. However, they may become more common in daily life as interactive technologies become more prevalent.

Time pressure

People may employ different decision strategies and have different performance outcomes as time pressure on the task varies (Busemeyer & Townsend, 1993). The speed versus accuracy tradeoff effect is a good example (Pachella & Fisher, 1972). In addition, as time pressure increases, levels of stress and arousal may increase, which can affect task performance as well. Media multitasking experiments generally impose time restrictions on participants (e.g., 3 seconds, in Foerde et al., 2006; 2 minutes, in Wang, David, et al., 2012) so that multitasking effects on task performance can be more accurately assessed within certain time frames.

Some media multitasking behaviors in daily life do not have clearly defined time constraints, and thus their experience and perceived performance may differ from those in laboratory settings. Experience sampling methods have become important for exploring the conditions under which media multitasking actually occurs in daily life (e.g., Wang & Tchernev, 2012). In general, tasks with higher time pressure are less likely to be combined with other tasks.

User differences

Many psychological and demographic individual differences affect cognitive functions and task performances, including media multitasking. As suggested by Adler and Benbunan-Fich (2012), people have different tendencies to perform multiple tasks in a sequential versus parallel manner. Users' traits, such as mindfulness (Ie, Haller, Langer, & Courvoisier, 2012), content expertise (Lin et al., 2009), attentional styles (Hawkins et al., 2005), extraversion and neuroticism (Oswald, Hambrick, & Jones, 2007; Wang & Tchernev, 2012), and sensation seeking (Jeong & Fishbein, 2007), have been examined to determine their effects on media multitasking performance. In particular, survey research of media multitasking often focuses on identifying users' differences that predict selection of media multitasking behaviors. For example, neuroticism has been found to increase media multitasking behavior in daily life (Wang & Tchernev, 2012).

Comparing different multitasking behaviors

Table 1 summaries nine empirical studies to illustrate how media multitasking behaviors can be analytically interpreted through the 11 dimensions and thus help predict cognitive resource demand and allocation. Conceptualizing media multitasking as multidimensional allows for an explicit comparison between different multitasking behaviors. Some instances may be more cognitively demanding than others, generally leading to worse performance outcomes and being less frequently selected in daily life.

For example, compare the Moreno and Mayer (1999) study with the Pool, Koolstra, and van der Voort (2003) study in Table 1. They vary on several dimensions. In the Pool et al. study, the background media tasks are distractors. They are less important than and irrelevant to the homework task (i.e., differing task hierarchy and low task relevance). In the Moreno and Mayer study, the tasks of attending to different media information inputs are equally important and facilitate one another (i.e., equal task hierarchy and high task relevance).

As a result, Moreno and Mayer (1999) found learning performance enhancements (when information inputs used different modalities), whereas Pool et al. (2003) only find learning performance detriments. Despite these differences, both studies suggest multitasking performance is optimized when the modality of tasks is varied (e.g., audio input for one task, visual input for another) than when the tasks share the same modality. These examples also highlight the importance of considering the interacting nature of the identified cognitive dimensions of multitasking.

In addition to helping compare and synthesize existing empirical studies that mostly focus on its effects, conceptualizing media multitasking using multiple cognitive dimensions can also help predict media multitasking behavior choices. Next, we present two studies to test how cognitive dimensions can predict people's self-selected media multitasking behaviors in daily life. In particular, these studies test the interacting nature of the cognitive dimensions.

As reviewed, people generally conserve cognitive resources by avoiding situations involving high cognitive demands (Hobfoll, 1989; Kool et al., 2010). From this perspective, decisions and choices serve adaptive functions to help us appropriately interact with our environment, including the mediated environment. Such adaptations help us conserve mental resources to better survive and thrive (Wang, 2014; Wang

Table 2 Examples of Media Multitasking Behaviors Illustrating Cognition Dimensions of Multitasking (Study 1)

		Shared modalities between media tasks	
		High	Low
Control over media information flows	High	TV + print	Web browsing + recorded music
	Low	TV + radio	Web browsing + radio
		Behavioral response requirements	
		High	Low
Control over media information flows	High	Web browsing + chatting	Web browsing + e-mail
	Low	Online video + chatting	Online video + e-mail

& Tchernev, 2012). Hence, we are generally more likely to select media multitasking behaviors that are less cognitively demanding in a naturalistic environment.

Study 1

Eight common media multitasking behaviors were selected from 24 media multitasking behaviors proposed in the Collins (2008) media multitasking measures to gather self-report data from media users (see Table 2). Four of the behaviors involve a combination of two distinct media platforms (e.g., TV, radio, print media, and Internet), and were selected according to a 2 (Shared Modalities: high, low) × 2 (Control over Information Flows: high, low) factorial design. For example, as shown in Table 2, simultaneous use of TV and print media is a media multitasking behavior exemplifying high levels in both shared modality and control over information flows, while TV and radio exemplify a high level of shared modality and a low level of control over information flows. As reviewed earlier, higher levels of shared modalities between tasks make a multitasking behavior more demanding, while higher levels of control over information flows make it less demanding. Thus, we predict the following:

H1: Media multitasking behaviors with higher levels of shared modalities between tasks are less likely to be selected in daily life than those with lower levels of shared modalities.

H2: Media multitasking behaviors with higher levels of control over information flows are more likely to be selected in daily life than those with lower levels of control.

H3: The two cognitive dimensions will interact with each other to affect people's media multitasking choices such that those with lower levels of shared modality and higher levels of control over information flows are the most likely to be selected, but those with higher levels of shared modality and lower levels of control are the least likely to be selected.

The other four media multitasking behaviors involve two online media activities (e.g., web browsing, chatting, e-mail, and online video viewing) and were selected using a 2 (Control over Information Flows: high, low) × 2 (Behavioral Response Requirements: high, low) factorial design. In addition to testing the effects of the information flow dimension on media multitasking choices (i.e., H2), we will test the effects of the dimension of behavioral responses. As reviewed earlier, if the requirement of behavioral responses is high, then the behavior will be more cognitively demanding. Thus, we propose the following:

H4: Media multitasking behaviors with higher levels of behavioral response requirements are less likely to be selected in daily life than those with lower levels of requirements.

H5: Behavioral response requirements will interact with information flow to affect people's media multitasking choices such that those with lower response requirements and higher levels of control over information flows are the most likely to be selected, but those with higher response requirements and lower levels of control are the least likely to be selected.

Participants and procedures

In total, 295 undergraduate students at a large university in the Midwestern United States volunteered for the study for course credit. They were 21.20 years old on average ($SD = 3.20$), and 65% were female. The participants completed the questions on computers in groups of 3–6 in a laboratory. Media multitasking behaviors were assessed using a format adopted from the Collins (2008) study. Participants were asked to rate how often they perform each of the eight combinations of media activities, as summarized in Table 2, using a 7-point Likert scale (1 = *never* and 7 = *always*). The order of the questions was randomized.

Results

Repeated-measures analysis of covariance (ANCOVA) tests were conducted on the reported frequency of the two sets of media multitasking behaviors, controlling for gender. Gender was statistically controlled because it has been shown to affect media choices (e.g., Passig & Levin, 1999).

Frequencies of multitasking behaviors involving two media platforms

Supporting H1, the dimension of shared modalities significantly predicted media multitasking choices, $F(1, 293) = 388.05$, $p < .001$, partial $\epsilon^2 = .57$. As predicted, media multitasking with higher levels of shared modalities between tasks ($M = 3.23$, $SE = .08$) were less likely to be selected than those with lower levels of shared modalities ($M = 5.16$, $SE = .08$).

Supporting H2, the dimension of control over information flows significantly predicted media multitasking choices, $F(1, 293) = 130.12$, $p < .001$, partial $\epsilon^2 = .31$. Media multitasking behaviors with higher levels of control ($M = 4.76$, $SE = .08$) were more likely to be selected in daily life than those with lower levels of control ($M = 3.64$, $SE = .09$).

As predicted by H3, the two dimensions, shared modalities and information flows, interacted with each other to affect media multitasking choices, $F(1, 293) = 14.66$, $p < .001$, partial $\epsilon^2 = .35$. As shown in Figure 1a, media multitasking behaviors with low levels of shared modalities and high levels of control over information flows were the most likely to be selected, and those with high levels of shared modalities and low levels of control were the least likely to be selected. All planned pairwise comparisons between the four types of media multitasking behaviors were significant (ps $< .01$).

Frequencies of multitasking behaviors involving two online media activities
Behavioral frequencies of two simultaneous online activities further supported H2's prediction regarding the control over information flows, $F(1, 293) = 118.28$, $p < .001$, partial $\epsilon^2 = .29$. Consistent with findings on multitasking with two media, media multitasking with two online activities showed the same pattern: Online multitasking with higher levels of control ($M = 5.02$, $SE = .10$) were more frequently selected than those with lower levels ($M = 3.95$, $SE = .11$).

Supporting *H4*'s prediction on the effect of behavioral response requirements on multitasking choice, online multitasking with higher behavioral response requirements ($M = 4.$ 21, $SE = .11$) were less likely to be selected than those with lower requirements ($M = 4.77$, $SE = .09$), $F(1, 293) = 35.61$, $p < .001$, partial $\epsilon^2 = .11$.

Finally, as predicted by *H5*, there was a significant interaction effect between behavioral response requirements and control over information flows on online multitasking choices, $F(1, 293) = 11.58$, $p < .005$, partial $\epsilon^2 = .01$. As shown in Figure 1b, online multitasking behaviors with low response requirements and high levels of control over information flows were the most likely to be selected, and those with high response requirements and low levels of control were the least likely to be selected. Again, all planned pairwise comparisons between the four types of online multitasking behaviors were significant (ps $< .05$).

Study 2

Using experience sampling methods (Kubey, Larson, & Csikszentmihalyi, 1996), Study 2 further tested interaction effects of multiple cognitive dimensions of media multitasking on behavioral choices. Compared to Study 1, which used a summative self-report measure, Study 2 recorded participants' experience over a relatively long time—4 weeks. This procedure helps reduce influences on reporting accuracy from memory errors, self-perception bias, and perceived norms. In addition, Study 1 used close-ended media task combinations defined by researchers, but Study 2 utilized open-ended, self-identified, and self-initiated reporting. The latter may help construct everyday multitasking data that more accurately reflect the participants' experience.

According to a 2 (Task Contiguity: high, low) × 2 (Task Relevance: high, low) factorial design, four media multitasking combinations were selected for coding from the experience sampling data (see Table 3). These behaviors involved activities that were most commonly reported in combination with another activity (or activities) according to the experience sampling data. As shown in Table 3, for example, e-mailing and

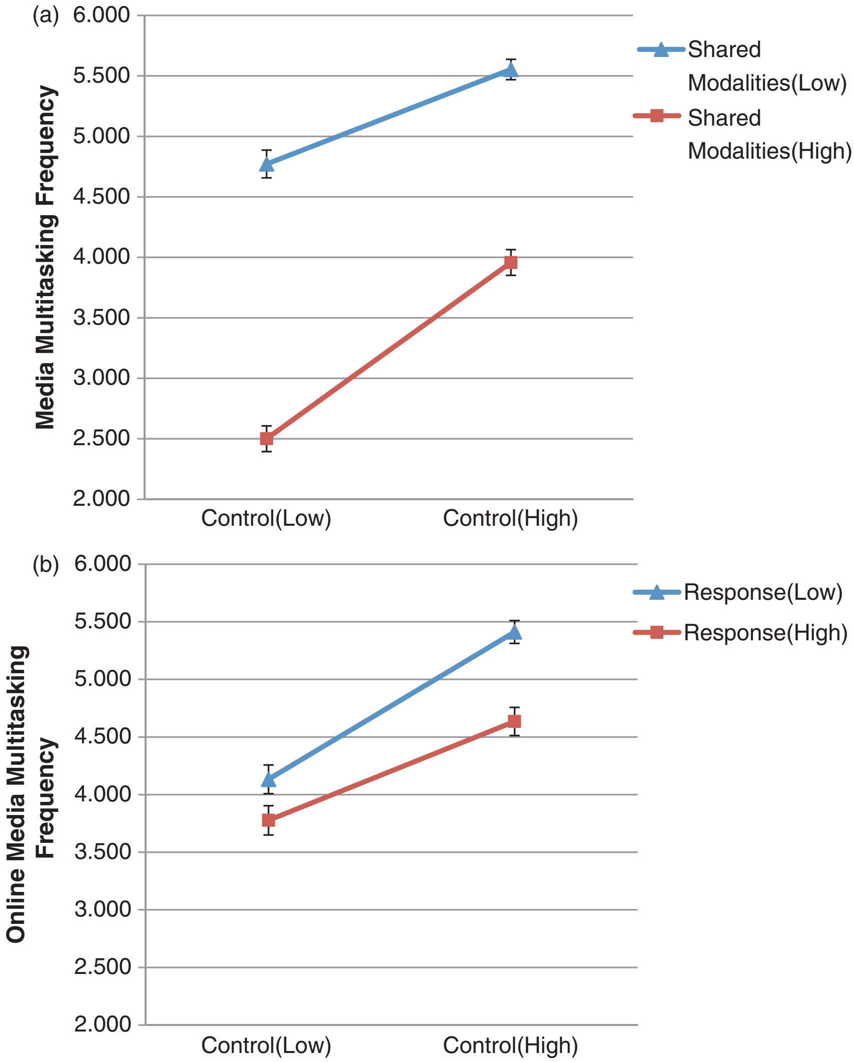

Figure 1 (a) Media multitasking frequencies are determined by high vs. low control over information flows of the media and high vs. low levels of shared modalities between the media (Study 1). (b) Online media multitasking frequencies are determined by high vs. low control over information flows of the online media and high vs. low requirements for behavioral responses (Study 1).

using Facebook exemplifies high levels in task contiguity (both on computer) and task relevance (both for social, interpersonal communication purposes); and e-mailing and web browsing exemplifies a high-level task contiguity (again, both on computer) but a low level in task relevance (assuming web browsing is not primarily for social purposes). As reviewed earlier, higher levels of task contiguity make multitasking

Table 3 Examples of Media Multitasking Behaviors Illustrating Cognition Dimensions of Multitasking (Study 2)

		Task Contiguity	
		High	Low
Task relevance	High	E-mail + Facebook	Computer offline + learning
	Low	E-mail + web browsing	Computer offline + TV

behavior less demanding. However, the benefit of task contiguity generally is limited to relevant tasks, but not irrelevant tasks (Burke et al., 2005). Thus, we propose the following hypotheses:

H6: Media multitasking behaviors with higher levels of task contiguity are more likely to be selected in daily life than those with lower levels of contiguity.

H7: Media multitasking behaviors with higher levels of task relevance are more likely to be selected in daily life than those with lower levels of relevance.

H8: Task contiguity and relevance will interact with each other to affect people's media multitasking choices in the way that those with higher levels of contiguity are more likely to be selected when the tasks are more relevant.

Participants and procedures

In total, 20 undergraduate students at the same university volunteered for Study 2 for course credit and monetary compensation. They were 21.10 years old on average ($SD = 1.17$), and 70% were female. Using the experience sampling method detailed by Wang and Tchernev (2012), participants reported their activities three times per day for 4 weeks using a cellphone-like device provided by the researchers. The device could only be used to report to a research account (associated with a numeric identity assigned to the participant to ensure confidentiality) and when necessary, communicate with the researchers. Participants were given 1.5-hour windows to submit their reports at midday, in the evening, and before going to bed. A flashing light on the device reminded the participants to enter reports at the beginning of each window. All participants were trained for 3 hours and achieved 100% accuracy in the reporting tests. Specifically, they were trained to follow a codebook to report their activities. The codebook was developed and described in the study by Wang and Tchernev (2012). After data collection, the researchers coded all four multitasking behaviors examined in this study (with a 100% agreement in the coding reliability test), and summed the frequency of the behaviors per reporting time window for each participant.

Results

A repeated-measures ANCOVA test, 2 (Task Contiguity) × 2 (Task Relevance) × 3 (Time of the Day), was conducted on the media multitasking frequency, controlling for gender.

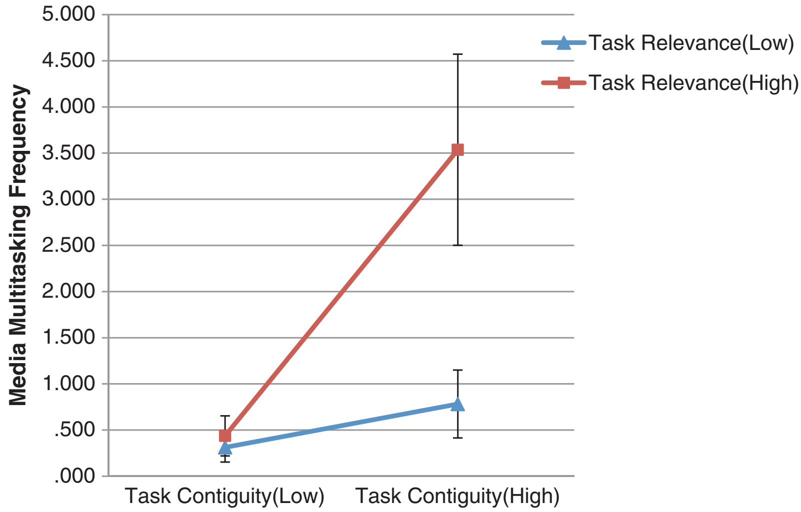

Figure 2 Media multitasking frequencies are determined by high vs. low task continuity and high vs. low task relevance (Study 2).

Supporting *H6* on the effect of task contiguity, media multitasking behaviors with higher contiguity ($M = 2.16$, $SE = .57$) were more likely to be selected than those with lower contiguity ($M = .38$, $SE = .17$), $F(1, 18) = 10.59$, $p < .005$, partial $\epsilon^2 = .37$. Also as predicted by *H7* on the effect of task relevance, media multitasking behaviors with higher relevance ($M = 1.99$, $SE = .54$) were more likely to be selected than those with lower relevance ($M = .55$, $SE = .19$), $F(1, 18) = 8.49$, $p < .01$, partial $\epsilon^2 = .32$.

The two dimensions were predicted to interact with each other (H8), and this is supported, $F(1, 18) = 5.40$, $p < .05$, partial $\epsilon^2 = .23$. As shown in Figure 2, when task relevance was low, task contiguity did not predict behavior ($F < 1$); when task relevance was high, multitasking behaviors with high contiguity ($M = 3.54$, $SE = 1.04$) were selected more frequently than those with low contiguity ($M = .44$, $SE = .22$), $F(1, 18) = 9.10$, $p < .01$, partial $\epsilon^2 = .34$.

Discussion

The purpose of this article was twofold. First, it identified 11 cognitive dimensions of media multitasking behaviors based upon research on information processing and effects, especially limited capacity and multiple resources theories. This provided a coherent conceptual framework to help identify different cognitive demands across various media multitasking behaviors, and thus help compare and synthesize media multitasking studies in the literature. Second, using this dimensional framework and the conception of resource conservation and the law of less work in cognition and decision research, it started to test how the cognitive dimensions can predict choices of media multitasking behaviors in our daily life. In particular, the two studies examined how the cognitive dimensions interact with each other to determine media multitasking choices.

This research explores a general question on the adaptive—or maladaptive—nature of humans' interactions with a rapidly changing media environment from the theoretical perspectives of limited resources and resource conservation. If our interactions with media tend to be adaptive, we should select less demanding multitasking behaviors more often than those that are more demanding so as to conserve mental resources, and better survive and thrive (Hobfoll, 1989; Kool et al., 2010; Payne et al., 1993; Wang & Tchernev, 2012). Indeed, this is what our findings suggest.

Varying cognitive demands of media multitasking behaviors

In some sense, media multitasking exemplifies multiple challenges facing contemporary society. It is the product of too many goals and not enough time, too many options and not enough discretion, and a building pressure to be increasingly productive. In the literature, media multitasking is often practically defined as using a medium to accomplish a goal while simultaneously being engaged in another task with a different goal (Jeong & Fishbein, 2007; Meyer & Kieras, 1997; Ophir et al., 2009; Wang, David, et al., 2012).

However, media multitasking is multifaceted. The wide variations in tasks and contexts that fall under this general heading must be more carefully considered and organized based upon cognitive theories. The 11 cognitive dimensions identified in this study are among the first steps to conceptualize this ever more common behavior as a multidimensional phenomenon, particularly emphasizing the cognitive demands placed on the multitasking individual by the characteristics of the task combinations and the task contexts.

The proposed dimensional framework draws largely from limited capacity and multiple resources theories, which have been dominant theoretical perspectives in media information processing research. Much of this literature has focused on processing and effects of various media, including multimedia content (e.g., television ads) where information is streamed simultaneously via audio and visual channels. Although these theories have been prolific in understanding synchronous processing of multimedia content, media multitasking presents even more complex scenarios. Each of the 11 cognitive dimensions can make a media multitasking situation more or less cognitively demanding, and thus influence performance and choice behaviors.

Across the 11 dimensions, multitasking situations can vary significantly in their level of resource requirements, aggravated by some dimensions and alleviated by some others. Hence, on the one hand, the extension of the resource theories from a single-task context to the context of multitasking should help further develop and test these theories. On the other hand, the multidimensional conceptualization has at least three implications for understanding media multitasking behaviors.

First, trying to draw a general conclusion on the effects of "media multitasking" may be oversimplistic because this concept is underspecified and can refer to considerably different cognitive phenomena. For example, we cannot simply conclude that engaging in other media activities while learning is always harmful (or beneficial) for the learning. Rather, learning outcomes depend on the specific task situations as conceptualized by the different cognitive dimensions. For instance, irrelevant media activities impair learning (Pool et al., 2003), while highly relevant ones can facilitate learning, especially if they are executed through a different modality channel from the learning task modality (Moreno & Mayer, 1999).

Second, the multidimensional cognitive attributes of media multitasking are at least one of the reasons why some media multitasking studies with very similar experimental designs still generated inconsistent results. When we compare empirical studies, we must carefully consider that not only the manipulated dimensions affect the outcome variables, but also that there may be other dimensions differing between experiments that may be overlooked. Hence, the proposed dimensional framework can help better compare and synthesize media multitasking literature in a more systematic way.

Third, from the proposed framework of multiple cognitive dimensions, media multitasking generally presents more complex scenarios and demands than typical single media use, but it also leads to more opportunities for strategic allocation of users' cognitive resources. This will be discussed in more detail shortly.

Adaptive media choice behavior

Based upon the cognitive dimensional framework and research on mental resource conservation and the law of less work, we have empirically demonstrated that in their daily lives, people are more likely to select media multitasking behaviors that are less cognitively demanding so as to conserve limited resources. The media multitasking choices were predicted by the multiple interacting dimensions.

Specifically, Study 1 showed how the cognitive demands associated with the dimensions of shared modalities, information flows, and behavioral responses predicted media multitasking behavior choices. As predicted, the fewer modalities held in common between tasks (e.g., one task is primarily visual while the other primarily auditory), the more control individuals had over task information flows (e.g., user controlled play speed and playback, or slow-paced information streams), and the fewer behavioral response requirements (e.g., background media), the more likely individuals were to engage in the multitasking behaviors. This is consistent with many large national survey studies on media multitasking behavioral patterns (e.g., Carrier, Cheever, Rosen, Benitez, & Chang, 2009).

Using experience sampling data, Study 2 showed how the dimensions of task contiguity and task relevance affected media multitasking choice behaviors. As predicted, more contiguous task combinations were more frequent; as were more relevant task combinations. An interesting interaction effect emerged, such that more contiguous tasks were selected more frequently than less contiguous tasks, but only if the two tasks were highly relevant. This finding resonated with what was found in a recent study in learning. Kaminski and Sloutsky (2012) manipulated the bar graphs used to teach children how to read graphical information. Children were presented with graphs containing either monochromatic bars or bars filled with irrelevant, decorative objects. Although the objects were physically contiguous with the task at hand, the irrelevant information interfered with the children's learning process.

Our findings suggest that although not necessarily intentional, in general people adopt adaptive decision and media use behaviors in response to an increasingly saturated media environment. People seemingly have an intuitive grasp of their own cognitive limits and adjust their behaviors accordingly when interacting with this changing media landscape. This observation may provide some comfort to those who worry that the ubiquity of multitasking behavior could spell disaster (e.g., Kirn, 2007). However, it is worth noting three points here.

First, we only used college student samples in the current studies. Due to the characteristics of this population sample, the examined behaviors may appear rather homogenous, as suggested by small variance around the estimated means in both data sets. Also, there is seemingly little likelihood for certain media multitasking behaviors to be selected in daily life (e.g., multitasking behaviors with low task contiguity in Study 2). Future research can further examine these questions using more diverse and ideally representative samples.

In addition, it will be interesting to examine how the multitasking choice behaviors differ by demographic groups, personality traits, and healthy versus patient groups with attention or decision deficits. We may discover maladaptive media multitasking behavior among certain groups of people, which can shed light on our further understanding of dynamic, mutually causal relationships between media processing and effects, media use, and individual differences (Slater, 2007; Wang & Tchernev, 2012; Wang, 2014).

Second, the current findings focused on general media multitasking behavioral patterns in daily life. There may exist a misperception or misuse of specific media multitasking behaviors. For example, Wang, David, et al. (2012) demonstrated in an experiment that people tend to overestimate their capabilities to simultaneously conduct multiple visual tasks compared to when they split the tasks over visual and auditory channels. The researchers speculated that because visual tasks in daily life are often perceived as effortless, "processing multiple streams of information in the visual channel may allow for the *illusion* of efficiency more readily than in other modalities," although the performance outcomes indicated otherwise (p. 974).

This potential illusion may partially explain the concerning tendency to combine visual tasks, such as television and homework, and texting and driving. Likely because of this illusion, relying upon the automatic, unconscious behavioral tendency to avoid cognitive demanding tasks may be harmful. Therefore, expanding media literacy to include better media multitasking practice will be beneficial. People can be educated to recognize the demanding nature of many of these tasks and trained to more mindfully and strategically select certain media multitasking behaviors while avoiding others.

Third, empirical data presented here do not intend to test and challenge the well-established understanding of performance deterioration of multitasking (typically under high time pressure) when compared to single-task performance. Instead, from the dimensional framework, this study pointed out ways to more strategically select and design media technologies, tasks, and environments to promote better media multitasking. Interestingly, in both studies, the examined dimensions showed relatively large effect sizes on media multitasking selection. All but one of the effects' partial ϵ^2 values ranged from .11 (the dimension of behavioral response requirements) to .57 (the dimension of shared modality). Only the interaction effect between behavioral response requirements and control over information flows was small, with a partial ϵ^2 of .01. This suggests, some of the 11 dimensions of multitasking are likely much more influential on cognitive demands than others and, thus, have a larger impact on multitasking consequences and choices. Future studies—again, ideally with representative samples—should replicate these findings and further quantify the different impacts of these 11 dimensions. This knowledge will not only enrich our understanding of the resource theories and the law of less work, but also help guide better media multitasking research and practice.

Better media multitasking

In literature, media multitasking has generally been shown to cause performance detriments. However, using the dimensional framework developed in this study, recommendations can be made to mitigate the negative effects by mindfully alleviating the overall cognitive demands imposed by multitasking situations, and more strategically allocate media users' cognitive resources.

Evaluation on multitasking performance depends largely on the definition of success. Except for tasks that are under time pressure or highly demanding alone (e.g., driving, complicated problem solving), immediate loss in performance caused by multitasking may be gained somewhere down the line. For most multitasking situations, the overarching goal is likely to optimally distribute resources to achieve the best overall outcomes across tasks over time.

The 11 cognitive dimensions proposed here suggest many strategies to achieve this. For example, media multitasking with homework may decrease work efficiency, but can increase positive emotional feelings and enjoyment (Wang & Tchernev, 2012), and thus may motivate students to work longer and be more productive in the long run. In other words, the dimension of emotional content of multitasking behavior can be utilized for its motivational benefits.

Particularly, we may increase the benefits of media multitasking while doing homework if the media task is strategically designed to minimize its competition for the mental resources needed by the homework. For example, we can design the media task to be relevant and contiguous to the homework task and to require different modality resources from those needed by the homework. These strategies are based upon the dimensions of both task relations (e.g., task switch, task relevance, shared modalities, and task continuity) and task inputs (e.g., information modalities and flows). Indeed, the strategies have been suggested by empirical findings (e.g., Moreno & Mayer, 1999), but more empirical tests are still needed to test these recommendations.

Media multitasking research should contribute to the design of media technologies that improve the outcomes of resource allocation during complex tasks. Global positioning system (GPS) technology is a good example. It facilitates driving by alleviating resource demands by the directions task. Based upon the shared modalities dimension proposed in our framework, in most situations, using GPS voice guidance should be preferred over GPS image guidance because the former is less competitive for the visual resources required by other driving tasks, such as monitoring traffic (Wang, David, et al., 2012).

Relatedly, Levy and Pashler (2008) found that redundant situation information provided by a secondary task during driving improved driver's braking responses. Media researchers need to further assess precisely when additional information inputs help drivers and how, as well as explore when additional information overwhelms the cognitive processing system.

In a media-saturated society, such as the United States, where on average, a home has 3.8 televisions, 2.5 radios, 2.0 computers, and 2.3 video game consoles (Rideout et al., 2010), media multitasking quickly becomes a pressing issue. In all, the proposed dimensional framework allows us to better recognize media multitasking for the complex phenomenon that it is. It provides a theoretical structure upon which media multitasking research can be compared and synthesized. It intends to stimulate new research by identifying dimensions currently overlooked in the existing literature and help guide future research designs. Also, it offers a systematic, theory-guided framework to promote better, more mindful design and choices of media multitasking.

Media multitasking research should continue to develop and test this dimensional framework. New dimensions may be added, especially as new media technologies emerge. Guided by cognitive theories, media multitasking research should seek to inform practitioners and the public how media technologies and tasks can be better designed and selected to help people more safely, effectively, and efficiently interact with environmental demands, including those imposed by media.

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Supporting Information

Additional supporting information may be found in the online version of this article:

Appendix. The brief codebook for Table 1.

References

Adler, R. F., & Benbunan-Fich, R. (2012). Juggling on a high wire multitasking effects on performance. *Journal of Human Computer Studies*, **70**, 156–168.

Allport, G. W. (1954). *The nature of prejudice*. New York, NY: Addison Wesley.

Anderson, J. R. (1990). *The adaptive character of thought*. Hillsdale, NJ: Lawrence Erlbaum.

Armstrong, G. B., & Chung, L. (2000). Background television and reading memory in context. *Communication Research*, **27**, 327–352.

Baddeley, A. (2012). Working memory: Theories, models, and controversies. *Annual Review of Psychology*, **63**, 1–29.

Basil, M. D. (1994). Multiple resource theory I: Application to television viewing. *Communication Research*, **21**, 177–207.

Bauerlein, M. (2008). *The dumbest generation: How the digital age stupefies young Americans and jeopardizes our future*. New York, NY: Jeremy P. Tarcher/Penguin Group.

Benbunan-Fich, R., Adler, R. F., & Mavlanova, T. (2011). Measuring multitasking behavior with activity-based metrics. *ACM Transactions on Computer-Human Interaction*, **18**(2), 1–22.

Botvinick, M. M., Huffstetler, S., & McGuire, J. T. (2009). Effort discounting in human nucleus accumbens. *Cognitive, Affective, & Behavioral Neuroscience*, **9**, 16–27.

Burke, M., Hornof, A., Nilsen, E., & Gorman, N. (2005). High-cost banner blindness: Ads increase perceived workload, hinder visual search, and are forgotten. *ACM Transactions on Computer-Human Interaction*, **12**, 423–459.

Busemeyer, J. R., & Townsend, J. T. (1993). Decision field theory: A dynamic cognition approach to decision making. *Psychological Review*, **100**, 432–459.

Cacioppo, J. T., & Berntson, G. G. (1999). The affect system: Architecture and operating characteristics. *Current Directions in Psychological Science*, **8**, 133–136.

Carrier, L. M., Cheever, N. A., Rosen, L. D., Benitez, S., & Chang, J. (2009). Multitasking across generations: Multitasking choices and difficulty ratings in three generations of Americans. *Computers in Human Behavior*, **25**, 483–489.

Collins, R. L. (2008). Media multitasking: Issues posed in measuring the effects of television sexual content exposure. *Communication Method and Measures*, **2**, 65–79.

Consiglio, W., Driscoll, P., Witte, M., & Berg, W. P. (2003). Effect of cellular telephone conversations and other potential interference on reaction time in a braking response. *Accident; Analysis and Prevention*, **35**, 495–500.

Dijksterhuis, A., & Aarts, H. (2010). Goals, attention, and (un)consciousness. *Annual Review of Psychology*, **61**, 467–490.

Foerde, K., Knowlton, B. J., & Poldrack, R. A. (2006). Modulation of competing memory systems by distraction. *Proceedings of the National Academy of Sciences of the United States of America*, **103**, 11778–11783.

Hawkins, R. P., Pingree, S., Hitchon, J., Radler, B., Gorham, B. W., Kahlor, L., ... Kolbeins, G. H. (2005). What produces television attention and attention style? *Human Communication Research*, **31**, 162–187.

Hobfoll, S. E. (1989). Conservation of resources: A new attempt at conceptualizing stress. *American Psychologist*, **44**, 513–524.

Hull, C. L. (1943). *Principles of behavior*. New York, NY: Appleton-Century.

Ie, A., Haller, C. S., Langer, E. J., & Courvoisier, D. S. (2012). Mindful multitasking: The relationship between mindful flexibility and media multitasking. *Computers in Human Behavior*, **28**, 1526–1532.

Jeong, S. H., & Fishbein, M. (2007). Predictors of multitasking with media: Media factors and audience factors. *Media Psychology*, **10**, 364–384.

Kahneman, D. (1973). *Attention and effort*. Englewood Cliffs, NJ: Prentice-Hall.

Kirn, W. (2007, November 1). The autumn of the multitaskers. *The Atlantic.* Retrieved from http://www.theatlantic.com/magazine/toc/2007/11.

Kool, W., McGuire, J. T., Rosen, Z. B., & Botvinick, M. M. (2010). Decision making and the avoidance of cognitive demand. *Journal of Experimental Psychology: General*, **139**, 665–682.

Kubey, R., Larson, R., & Csikszentmihalyi, M. (1996). Experience sampling method applications to communication research questions. *Journal of Communication*, **46**(2), 99–120.

Lang, A. (2000). The limited capacity model of mediated message processing. *Journal of Communication*, **50**, 46–70.

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.

Lang, A., Park, B., Sanders-Jackson, A. N., Wilson, B. D., & Wang, Z. (2007). Cognition and emotion in TV message processing: How valence, arousing content, structural complexity, and information density affect the availability of cognitive resources. *Media Psychology*, **10**, 317–338.

Levy, J., & Pashler, H. (2008). Task prioritization in multitasking during driving: Opportunity to abort a concurrent task does not insulate braking responses from dual-task slowing. *Applied Cognitive Psychology*, **22**, 507–525.

Lin, L., Robertson, T., & Lee, J. (2009). Reading performances between novices and experts in different media multitasking environments. *Computers in the Schools*, **26**, 169–186.

Marois, R., & Ivanoff, J. (2005). Capacity limits of information processing in the brain. *Trends in Cognitive Sciences*, **9**, 296–305.

Mayer, R. E., & Moreno, R. (2002). Animation as an aid to multimedia learning. *Educational Psychology Review*, **14**, 87–99.

McCartt, A. T., Hellinga, L. A., & Bratiman, K. A. (2006). Cell phones and driving: Review of research. *Traffic Injury Prevention*, **7**, 89–106.

Meyer, D. E., & Kieras, D. E. (1997). A computational theory of executive cognitive processes and multiple-task performance: Part I. Basic mechanisms. *Psychological Review*, **104**, 3–65.

Moreno, R., & Mayer, R. (1999). Cognitive principles of multimedia learning: The role of modality and contiguity. *Journal of Educational Psychology*, **91**, 358–368.

Muraven, M., & Baumeister, R. F. (2000). Self-regulation and depletion of limited resources: Does self-control resemble a muscle? *Psychological Bulletin*, **126**, 247–259.

Ophir, E., Nass, C., & Wagner, A. (2009). Cognitive control in media multitaskers. *Proceedings of the National Academy of Sciences of the United States of America*, **106**, 15583–15587.

Oswald, F. L., Hambrick, D. Z., & Jones, L. A. (2007). Keeping all the plates spinning: Understanding and predicting multitasking performance. In D. H. Jonassen (Ed.), *Learning to solve complex scientific problems* (pp. 77–97). Mahwah, NJ: Erlbaum.

Pachella, R. G., & Fisher, D. (1972). Hick's law and the speed-accuracy trade-off in absolute judgment. *Journal of Experimental Psychology*, **92**, 378–384.
Passig, D., & Levin, H. (1999). Gender preferences for multimedia interfaces. *Journal of Computer Assisted Learning*, **16**, 64–71.
Payne, J. W., Bettman, J. R., & Johnson, E. J. (1993). *The adaptive decision maker*. Cambridge, England: Cambridge University Press.
Pool, M. M., Koolstra, C. M., & van der Voort, T. (2003). The impact of background radio and television on high school students' homework performance. *Journal of Communication*, **53**, 74–87.
Rideout, V. J., Foehr, U. G., & Roberts, D. F. (2010). *Generation M^2: Media in the lives of 8- to 18-year-olds*. Menlo Park, CA: Henry J. Kaiser Family Foundation.
Salvucci, D. D., & Taatgen, N. A. (2008). Threaded cognition: An integrated theory of concurrent multitasking. *Psychological Review*, **115**, 101–130.
Slater, M. (2007). Reinforcing spirals: The mutual influence of media selectivity and media effects and their behavior on individual behavior and social identity. *Communication Theory*, **17**, 281–303.
Shiffrin, R. M., & Schneider, W. (1977). Controlled and automatic human information processing: II. Perceptual learning, automatic attending and a general theory. *Psychological Review*, **84**, 127.
Smith, V., & Walker, J. M. (1993). Monetary rewards and decision cost in experimental economics. *Economic Inquiry*, **31**, 245–261.
Kaminski, J. A., & Sloutsky, V. M. (2012). Extraneous perceptual information interferes with children's acquisition of mathematical knowledge. *Journal of Educational Psychology* Advance online publication.
Wang, Z. (2014). Bridging media processing and selective exposure: A dynamic motivational model of media channel choices and choice response time. *Communication Research*. [Published online first] doi: 10.1177/0093650214534963
Wang, Z., David, P., Srivastava, J., Powers, S., Brady, C., D'Angelo, J., & Moreland, J. (2012). Behavioral performance and visual attention in communication multitasking: A comparison between instant messaging and online voice chat. *Computers in Human Behavior*, **28**, 968–975.
Wang, Z., Lang, A., & Busemeyer, J. R. (2011). Motivational processing and choice behavior during television viewing: An integrative dynamic approach. *Journal of Communication*, **61**, 71–93.
Wang, Z., Solloway, T., Tchernev, J. M., & Barker, B. (2012). Dynamic motivational processing of anti-marijuana messages: Coactivation begets attention. *Human Communication Research*, **38**, 485–509.
Wang, Z., & Tchernev, J. M. (2012). The "myth" of media multitasking: Reciprocal dynamics of media multitasking, personal needs, and gratifications. *Journal of Communication*, **62**, 493–513.
Wickens, C. D. (2002). Multiple resources and performance prediction. *Theoretical Issues in Ergonomics Science*, **3**, 159–177.