Background Paper

Media-Multitasking:
Implications for Learning and Cognitive Development in Youth

Prepared for the NSF-Sponsored Seminar on Implications of Media-Multitasking for Learning and Cognitive Development in Youth

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June 2009

Executive Summary

Children are growing up in a rapidly changing, information-rich age in which communication technology has become more affordable, accessible, and available than ever before. Today, American children ages 8 to 18 spend approximately the same amount of time with media per day as they did before the recent explosion of digital tools (around 6.5 hours), but they have increased the *amount* of media content they consume by approximately two hours per day (Roberts, Foehr, & Rideout, 2005). According to the Kaiser Family Foundation, approximately one-third of children say they usually absorb some other medium while watching TV, listening to music, using the computer, or reading (Roberts, Foehr, & Rideout, 2005). The phenomenon of "media-multitasking" and its inherent mental habits of dividing attention, switching attention, and keeping multiple trains of thought in working memory have significant implications for the way young people think, learn, socialize, and understand the world.

Scholars know a great deal about the mechanisms of human development that support children's acquisition of new knowledge and skills. As the media environment that surrounds children grows more ubiquitous, and children's media activity continues to grow in terms of exposure and complexity, it is important to reexamine and reframe existing theories and practices in the realms of education and human development. Our intention is to spur research on media-multitasking in youth and adults by defining key questions for interdisciplinary research and stimulating the formation of a community where more coordinated research efforts and future collaborations can take place.

The purpose of the first NSF-sponsored seminar on media-multitasking in youth, to be held on July 15th, 2009 at Stanford University, in collaboration with the Joan Ganz Cooney Center, is to:

- Create a forum for interdisciplinary exploration of available research and agenda setting for future inquiry;
- Understand the theoretical and experimental base from which to launch cutting-edge basic and applied research on media-multitasking; and
- Increase public awareness and drive policymaker interest in the implications of media-multitasking for children's learning and development.

The purpose of this background paper is to: (1) Briefly describe the current state of knowledge on media-multitasking, as it relates to cognitive development and learning in children; (2) Define questions and topics for interdisciplinary discussion and research coordination, focusing on the development of new methods, models, and theories for studying media-multitasking effects on learning and development; and (3) Catalyze discussion at the July 15 seminar.

Part I of this paper provides a brief overview of the existing literature on media-multitasking, as it relates to learning and cognition. We suggest three major categories of research that will benefit greatly from interdisciplinary knowledge sharing and coordination of future research efforts: *Media-multitasking and Cognition*, *Media-multitasking and Learning in Informal and Formal Environments*, and *Designs that Leverage Media-Multitaskers*. **Part II** discusses the goals of the seminar.

I. Overview of existing literature on media-multitasking, learning, and cognition.

Media-Multitasking is defined as engaging in multiple media activities simultaneously, including multiple windows on a single media platform and/or multiple media (e.g., web surfing on a computer while watching TV). Media-multitasking behaviors can be measured using an index that quantifies time spent using various media simultaneously relative to total media use (Ophir, Nass, & Wagner, in submission), although the advantages and disadvantages of different measures of multitasking is not understood. Media-multitasking can also be classified along a continuum, ranging from concurrent tasks with rapid switching to sequential tasks with longer time between switching (Salvucci, Taatgen & Borst, 2009). In considering the effects of media-multitasking on learning and cognition, it is important to consider the educational content of media (Schmidt & Vandewater, 2008), and the extent to which media is semantically related, or requires conflicting information processing resources. Previous research has shown that children with media in their bedrooms, girls, and high sensation seekers are more likely to engage in media-multitasking (Foehr, 2006; Jeong & Fishbein, 2007). Thus, media-multitasking may be influenced by contextual factors, such as bedroom media and parental mediation, as well as individual differences, such as age, gender, SES, sensation seeking, attention problems, selective exposure, and Internet addiction (Block, 2008). In sum, accurate measurement of media-multitasking, and consideration of the content, context, and individual differences involved will aid in understanding the impact of media-multitasking on learning and cognitive development in youth.

Media-multitasking and Cognitive Development: A significant topic for future study is how media-multitasking affects the development of neural structures in children's brains and cognitive abilities, as well as identifying neural structures involved in children's media-multitasking performance. Research in the adult population has indicated that multitasking is supported by cognitive and neuroanatomical systems in the pre-frontal cortex region of the brain (Burgess, 2000; Koechlin, Basso, Pietrini, et al., 1999). Depending on the task, additional systems, such as the striatum, likely also support multitasking (Foerde, Knowlton, & Poldrack, 2006). The pre-frontal cortex is broadly associated with "executive control," which refers to "the ability to coordinate thought and action and direct it toward obtaining goals" (Miller & Wallis, 2009). Research has shown that the ability to multitask is limited in adults by numerous cognitive "bottlenecks" that can appear in various stages of perceptual, cognition, and motor processing, depending on particulars of the task domain (Meyer & Kieras, 1997). Multiple-resource theories (e.g. Navon & Gopher, 1979; Wickens, 2002) specify how tasks using separate resources may proceed simultaneously without interference, but when there is a resource conflict, the needed resource can allocate part of its processing time to each task. A key limitation on multitasking is that the ability to perform more than one decision-making process at any given moment is limited by a "response selection bottleneck." When performing concurrent tasks, regions in the pre-frontal cortex involved in response selection seem to queue responses, resulting in task delays (Dux, Ivanoff, Asplund & Marois, 2006). However, there is evidence to suggest that individuals can perform two tasks efficiently if tasks are well-rehearsed or familiar, suggesting a potential for "adaptive executive control," which transforms condition-action production rules into procedural knowledge (Schumacher, Seymour, Glass, et al, 2001). Since people can only handle one decision making process at a time, the way to handle two

simultaneous processes is to make one of them automatic (so it requires no decision making). Reducing task interference may require extensive practice with the task, and can also be modulated by instructions about differential task priorities and the (daring) personal preference for scheduling tasks concurrently versus sequentially (cautious) (Schumacher, Seymour, Glass, et al., 2001). When and how such skills in dual task performance are acquired is a significant topic for future inquiry.

Few studies have examined the cognitive mechanisms and neural structures involved in children's media-multitasking, or the extent to which cognitive "bottlenecks" exist in children. Recent fMRI studies suggest that children are better at multitasking than adults, presumably due to their enhanced ability to allocate attention and filter out irrelevant information, as compared to middle-aged and older adults (Grady, Springer, Hongwanishkul, et al., 2006; Hamilton, 2008). Limitations in the ability to multitask have been documented among children diagnosed with attention deficit hyperactivity disorder (ADHD)[1] ages 7 - 13, indicating deficits in monitoring ongoing behaviors, goal-directed planning, and generating useful strategies for task completion (Siklos & Kerns 2004; Chan, Guo, Zou, et al., 2006).

Researchers have found evidence for small positive links between heavy electronic media use and mild attention problems among youth, particularly for entertainment content; however, the link between ADHD and electronic media use is complex and requires further research (Schmidt & Vandewater, 2008; Schnabel, 2009). Playing video games has been shown to improve visual attention in youth ages 7 - 22, in terms of allocating attention and filtering out irrelevant information (Dye & Bevalier, in press). In addition, playing video games has been shown to enhance the ability to divide visual attention in college students (Greenfield, Dewinstanley, & Kaye, 1994; Green & Bavelier, 2003). While the use of electronic visual media may enhance skills of visual attention and visual-spatial processing, it may not adequately cultivate higher order cognitive processing skills (Greenfield, 2009).

A key set of open questions are the causes and effects of long-term and chronic media multitasking with respect to cognitive processing. The results of one study (Ophir, Nass, & Wagner, in submission) showed that heavy media-multitaskers are more susceptible to interference from irrelevant environmental stimuli and from irrelevant representations in memory. This led to the surprising result that heavy media multitaskers performed worse on a test of task-switching ability, likely due to reduced ability to filter out interference from the irrelevant task set.

Media-Multitasking in Informal and Formal Learning Environments: Studies that examine the relationship between electronic media use and learning generally indicate that "the content delivered by electronic media is far more influential than the media themselves" (Schmidt & Vandewater, 2008). However, few studies to date have examined media-multitasking and learning in youth. Research on multitasking in the adult population generally indicates that multitasking impairs the speed and quality of task performance when compared to performing tasks serially (Rubinstein, Meyer, & Evans, 2001; Iqbal & Horvitz, 2007; Posner & Boies, 1971).

[1] Signs of ADHD in children are described as "inattention, hyperactivity, or impulsivity that significantly impairs social or academic functioning for at least 6 months" (Schmidt & Vandewater, 2008, p. 67).

In one study that examined the effects of media-multitasking in the classroom, college students in one group were allowed to use their laptops during lectures while those in the other group were not. Students with laptops were obviously distracted by having access to the Web, e-mail, IM, and other digital tools, and suffered decrements on traditional measures of memory for lecture content (Hembrooke & Gay, 2003).

In general, dividing attention has been shown to disrupt memory encoding and reduce subsequent recall (Naveh-Benjamin, Craik, Guez, & Krueger 2000). Especially when two channels of information convey semantically different information, viewers can recall less information, and often only focus on one channel (Bergen, Grimes, & Potter, 2005; Drew & Grimes, 1987; Grimes, 1991; Lang, 1995; Reese, 1984; cited in Foehr, 2006). Cable news shows frequently feature divided screens with tickers and running headlines of semantically unrelated information, and the presence of news tickers has been shown to reduce memory for news content among college students (Bergen, Grimes, & Potter, 2005). However, when different information channels require non-conflicting processing resources, multitasking may not necessarily impair task performance. Youths' performance on a homework task was reduced when multitasking with soap operas on television, but their performance was not affected when multitasking with music or music videos (Pool, Koolstra, & van der Voort, 2003). Finally, learning under multitasking versus focused attention conditions may result in different types of memory, with different implications for knowledge transfer. In a recent study of adults, learning while maintaining focused attention resulted in declarative memory, which is associated with hippocampal activity and considered to produce richer, more flexibly applied memories. Learning while multitasking resulted in procedural memory, a form of memory associated with activation of the striatum and used to support habitual task performance, which tends to generalize poorly to new situations (Foerde, Knowlton, & Poldrack, 2006). Thus, if information is learned under multitasking conditions, the flexible application of knowledge associated with creativity and adaptive problem solving may be less likely to occur.

Media-multitasking during lectures and homework may indicate that these tasks are failing to engage children's interests. Several children in the Kaiser Family Foundation's time-diary studies (Roberts, Foehr, & Rideout, 2005) expressed that media-multitasking warranted the "slight" reduction in productivity because it helped them avoid boredom. Dewey (1915) theorized that "the divided mind" represents a division between interest and effort, "External mechanical attention to a task as a task is inevitably accompanied by random mind-wandering along the lines of the pleasurable," (p. 9). Meanwhile, children learn "the exact amount of attention that has to be given to the external material to satisfy the requirements of the teacher, while saving up the rest of his powers for following lines of suggestion that appeal to him," (p. 10). In *Outliers*, Gladwell (2008) notes frequently that extraordinarily successful people have dedicated at least 10,000 hours worth of practice in their area of expertise. The relationship between media-multitasking and the ability and desire to focus, or to unify interest and effort, is an important topic for future inquiry in the domain of learning.

Barron's (2006) work on learning ecologies for youth development of technological fluency, as well as Hidi and Renniger's (2006) model of interest development, provide theoretical frameworks for understanding conditions that promote interest and learning across informal and

formal settings. In particular, intimate social relationships play an important role in developing interests that lead to learning across informal and formal boundaries (Barron, 2006). There is evidence to suggest that media use is displacing family interactions in the home (Wallis, 2006) and cultivating impersonal social relationships (Turkle, 2007). However, the content of media and the context of use are important considerations. When media displace educational activities, they have been shown to adversely impact scholastic achievement, but when media provide educational opportunities, they have been shown to promote scholastic achievement (Schmidt & Vandewater, 2008).

Finally, the non-linear and decentralized structure of information on the web, which is potentially contributing to media-multitasking behaviors, has potential to promote learning and creativity. In *Everything is Miscellaneous: the Power of the New Digital Disorder* (2007), Weinberger argues that by breaking down established orders of ordering information, individuals exposed to a concept in multiple decentralized contexts may gain deeper and more complex understandings of that concept (also see "cognitive flexibility theory" from Spiro & Jengh, 1990 for related prior work). Perhaps through revealing multiple and simultaneously true meanings of a concept, media-multitasking might cultivate "dialectical" reasoning (e.g. Nisbett, Peng, Choi, & Norenzayan, 2001). In sum, preliminary research in informal and formal learning environments suggests media-multitasking may well detract from learning, but it also has potential for enhancing learning. In considering the effects of media-multitasking on learning, it will be important to define the context of learning, how learning is measured, and the outcomes of learning that are valued.

Media-multitasking Designs to Enhance Learning: Many of today's digital tools were inspired by the highly influential 1945 *Atlantic Monthly* essay "As We May Think" by President Roosevelt's Science Advisor, Vannevar Bush. In this vision of the future of computing, Bush proposed that using technology to automate the routine aspects of thought would help to free up more time for scholars to devote to the creative aspects of thought (Bush, 1991; cited in Levy, 2007), solving what was referred to then as the "library problem," but which has more recently been reincarnated as "information overload" and the "data deluge" (NSF, 2008). Bush distinguished between the "routine" processes of thought, which he believed could be automated, and the creative work of deep and original thinking, which could not be automated. While modern society has better technology than ever before to automate and reduce the burden of routine processes of thought, it is failing to exploit its newfound time for creative thought and acts of leisure that nurture creative thought (Levy, 2007). When considering the role of media-multitasking in our lives, considering the ratio of creative to automated thought processes may serves as a useful heuristic or design principle.

A recent longitudinal study revealed that, although young people demonstrate an apparent ease and familiarity with computers, they rely heavily on search engines, view rather than read, and do not uniformly possess the critical and analytical skills to assess the information they find on the web (CIBER, 2008). The youth of today need effective strategies, tools, and techniques with which to navigate the sea of information surrounding them. Teaching young people how to organize and manage information could help them improve their productivity and develop more intentional media use. Parents, teachers, and youth need to know how to leverage media-

multitasking habits to enhance learning. Guidelines for effective media-multitasking could be derived from multiple resource theories, which specify when multitasking might result in information processing-resource conflicts, thus reducing learning and productivity. Furthermore, tasks involving routine thought processes might be completed effectively while multitasking, but tasks involving higher level cognitive skills, creative, or original thought require total focus. Salvucci & Taatgen (2008) propose a model for effective multitasking, which entails planning out an entire multitasking situation, suggesting individuals can move between tasks relatively automatically, and specifies principles for interruptions and keeping goals in working memory. Educational curriculum will need to incorporate different media activities to address the development of a variety of cognitive skills (Greenfield, 2009). Reading has been shown to develop imagination, induction, reflection, critical thinking, and vocabulary, while visual media affords the development of visual-processing skills. Jenkins, Clinton, & Purushotma, et al. (2006) argue that the participatory media culture, enabled by the web and wikis, blogs, and media-sharing sites such as Flickr and YouTube, cultivates skills which are critical to participation in a global society permeated by Information and Communication Technology (ICT). Among the cultural competencies he describes are "*transmedia navigation*: the ability to follow the flow of stories and information across multiple modalities" and "*multitasking*: the ability to scan one's environment and shift focus as needed to salient details."

Finally, a media-multitasking literacy curriculum should address how media distractions can strain social relations, particularly in the home (Wallis, 2006). Parents and teachers need to model effective multitasking and communicate the value of face-to-face interactions. Developing media-multitasking literacy has the potential to improve family interactions in the home as well as the quality of learning in informal and formal environments. As researchers elucidate how learning and cognitive development are supported in media-multitasking contexts, designers of educational tools and strategies can incorporate this knowledge to promote effective uses of media-multitasking. Media-multitasking can be like walking without looking where you're going, but if used consciously, it can perhaps help us get to where we're going and realize our creative visions more efficiently.

II. Goals for the Multitasking Seminar

By focusing on the increasingly prevalent and evolving behavior of media-multitasking, the seminar intends to create a forum for interdisciplinary dialogue about the frontiers of research. Leaders from fields related to media-multitasking, child development, and learning will convene at the conference, encouraging a new academic community that will engage in interdisciplinary knowledge sharing, agenda-setting, and collaborative research. The seminar will provide a venue as well as online tools to share preliminary findings on media-multitasking from our research labs. Furthermore, the seminar will catalyze research on this topic, promoting it among key decision-makers who may be able to advance investment in a new frontier of inter-disciplinary research.

One of the key outcomes for the seminar is to develop a coherent agenda for future research on the effects of media-multitasking on learning and cognitive development in informal and formal learning environments, as well as the effects on social interaction and social relations. Through

transparency and knowledge sharing facilitated by the conference sessions, and extensive public dissemination activities, the seminar aims to create a more informed community that will ultimately shape the future conduct of research on media-multitasking and children's learning and development. These conversations will have the potential to introduce new ways to invest government and philanthropic funds, influence state and national policy, and change practices in K-12 classrooms. The LIFE Center, MediaX, and the Joan Ganz Cooney Center, with generous support from the National Science Foundation and Spencer Foundation will ensure that the results of the workshop will reach a wide community of researchers, as well as policy and education stakeholders.

Overall, we hope to create a solid theoretical and experimental base from which to launch both basic and cutting-edge applied research on media-multitasking.

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