Media Multitasking and Cognitive, Psychological, Neural, and Learning Differences

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abstract

American youth spend more time with media than any other waking activity: an average of 7.5 hours per day, every day. On average, 29% of that time is spent juggling multiple media streams simultaneously (ie, media multitasking). This phenomenon is not limited to American youth but is paralleled across the globe. Given that a large number of media multitaskers (MMTs) are children and young adults whose brains are still developing, there is great urgency to understand the neurocognitive profiles of MMTs. It is critical to understand the relation between the relevant cognitive domains and underlying neural structure and function. Of equal importance is understanding the types of information processing that are necessary in 21st century learning environments. The present review surveys the growing body of evidence demonstrating that heavy MMTs show differences in cognition (eg, poorer memory), psychosocial behavior (eg, increased impulsivity), and neural structure (eg, reduced volume in anterior cingulate cortex). Furthermore, research indicates that multitasking with media during learning (in class or at home) can negatively affect academic outcomes. Until the direction of causality is understood (whether media multitasking causes such behavioral and neural differences or whether individuals with such differences tend to multitask with media more often), the data suggest that engagement with concurrent media streams should be thoughtfully considered. Findings from such research promise to inform policy and practice on an increasingly urgent societal issue while significantly advancing our understanding of the intersections between cognitive, psychosocial, neural, and academic factors.

One of the first influential reports on the phenomenon of media multitasking (MMT) revealed that American youth spend more time with media than any other activity: an average of 7.5 hours per day every day of the week, and 29% of that time is spent juggling multiple media streams simultaneously[1] (note that "media" refers to all forms of mediated communication of information or data). Even younger children spend ~2 hours per day with screen media,[2] and half of 5- to 8-year-olds engage in MMT at least occasionally.[2] MMT, however, is not just an

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American phenomenon. Kononova[3] investigated MMT behaviors across 3 countries (the United States, Russia, and Kuwait) and reported many parallels to the foregoing findings.[1,2] The ubiquity of media use and concomitant MMT have generated much scientific and societal interest in determining if and how MMT impacts affect behavior, cognition, and brain structure and function.

It is currently unknown whether differences in underlying neural and cognitive traits lead to differing levels of MMT or vice versa. Given that a large number of media multitaskers (MMTs) are children and young adults, whose brains are still developing, there is great urgency to understand the neurocognitive profiles of MMTs. It is critical to build a systematic understanding of the relation between the relevant cognitive domains and underlying neural structure and function. Of equal importance is understanding the types of information processing that are necessary in 21st century learning environments.

CURRENT STATE: RISING PREVALENCE OF MMT AND ASSOCIATED COGNITIVE, PSYCHOLOGICAL, NEURAL, AND LEARNING DIFFERENCES

A growing body of research investigating MMT has generally, but not always, revealed reduced performance on cognitive tasks and well-being surveys. Such research has raised concerns among parents and educators regarding the impact of MMT behavior during certain types of activities, such as doing homework and learning in technology-rich classrooms. Indeed, many teenagers report at least sometimes doing homework while using another medium, including television (51% of teenagers), social networking (50%), text messaging (60%), and listening to music (76%).[4] Importantly, extant evidence suggests that multitasking disrupts concurrent learning, and heavy MMT is associated with cognitive differences even when people are performing single tasks. These findings raise the possibility that the growing prevalence of MMT may impact everyday cognition beyond the classroom.

Here, we distinguish between investigations of (1) the cognitive, psychological, and neural profiles of individuals who engage in various levels of MMT, and (2) the consequences of multitasking with media while learning (whether in classroom or informal learning environments; for review of media–non-MMT, see ref 5).

Cognitive, Psychological, and Neural Profiles of MMTs

Cognitive Profiles of MMTs

Cognitive performance in MMTs has been assessed in the domains of working memory, interference management, attention, task-goal management, inhibitory control, relational reasoning, and long-term memory. Working memory studies reveal that heavier MMTs (HMMs) often underperform relative to lighter MMTs (LMMs),[6–10] although some studies show no difference as a function of MMT.[9,11–13] Likewise, studies investigating interference management (tasks requiring filtering out distracting information, either from the external environment [ie, from perception] or the internal environment [ie, from memory]) reveal that HMMs underperform relative to LMMs in some contexts,[8,11,14] but not in others.[7,9–12] In the domain of attention, HMMs appear to have difficulty on tasks that require sustained, goal-directed attention[15] (for null finding, see ref 12). Further support for this possibility is the finding that an attention-training intervention can partially remediate some of the underperformance by HMMs.[9] Finally, HMMs underperform on tests of relational reasoning,[13] inhibitory control[9,15] (for null effects, see ref 11,15), and long-term memory.[10]

High degrees of MMT might be viewed as a form of cognitive training that could confer benefits on other tests of multitasking and/or task-switching abilities. However, there is currently mixed evidence in support of this idea, with some reports of HMMs outperforming LMMs during task-switching and/or dual-tasking,[16] whereas others show the opposite effect,[11] and the majority show null effects.[8–10,12,14,16]

It is important to note that the heterogeneity in demographics, tasks, administration methods, power, and analytic approach, combined with the small number of studies contributing to the literature on each cognitive domain have contributed to a complex pattern of findings. However, the weight of the evidence overall points to HMMs demonstrating reduced performance in a number of cognitive domains relative to LMMs.

Psychological Profiles of MMTs

In addition to cognitive differences, heavier MMT is associated with differences in psychosocial variables. For instance, several independent groups have reported that MMT behavior positively correlates with trait impulsivity, with HMMs exhibiting higher impulsivity ratings[6,7,10,12] (for null finding, see ref 17). In one study, ratings on the attentional subscale in particular related to the foregoing memory differences, with higher attentional impulsivity predicting worse working memory performance and higher MMT scores.[11] Beyond impulsivity, MMT has been associated with increased sensation-seeking[6] (for a null finding, see ref 17), social anxiety and depression,[18] lower perceived social success,[19] and neuroticism,[18] as well as a lower belief that intelligence is malleable (growth mindset).[7] Given the limited number of observations bearing on each of these psychosocial variables, there is a critical need for further research on their associations with MMT.

Neural Profiles of MMTs

To date, only 2 studies have investigated neural profiles in MMTs.[14,17] Loh and Kanai[20] investigated structural profiles in MMT adults and showed that, relative to LMMs, HMMs exhibited less gray matter volume in the anterior cingulate cortex, a region broadly implicated in cognitive and/or social-emotional control. By using functional neuroimaging of adolescents and young adults performing a sentence comprehension task in the presence versus absence of distraction, 1 study found that heavier MMT was associated with greater distraction-related activity in several prefrontal regions implicated in attention processing.[17] The researchers posited that greater attentional effort is required by HMMs when performing under conditions of distraction. Although these studies suggest possible anatomical and functional differences in people who frequently media multitask versus those who do not, a fuller investigation of how structural and functional networks manifest differently in HMMs versus LMMs is needed, as are further investigations of task-based regional differences in function.

Interim Summary

The foregoing findings suggest that there are differences in the cognitive, psychological, and neural profiles associated with heavier versus lighter MMTs, and that this is the case even when performing single tasks. Given that many academic and career success outcomes depend on optimizing performance during single tasks (eg, test-taking or giving a presentation), a full understanding of the multidimensional profiles of HMMs during single-tasking is imperative.

Multitasking With Media While Learning

Research from multiple parts of the world demonstrates that students, while attempting to learn academic information, frequently engage with media not relevant to the task at hand. A majority of college students in the United States and Israel report using electronic media while in class, studying, or doing homework.[21,22] Parents of young children report that multitasking during homework begins by 5 to 8 years of age.[2] Even when children are not deliberately multitasking with 2 different mediums, they are often required to ignore background media to focus on a primary task, such as when infants play with toys while a parent watches television. However, research indicates that multitasking with media during learning can negatively affect academic outcomes,[23] and background media can reduce the quality of concurrent activities, such as homework[24] and toy play.[25] The research outlined below supports the American Academy of Pediatrics policy statements that discourage media use while older children do homework or while infants and young children play.

Concurrent Multitasking and Background Media

College students learn less when dividing attention between listening to lectures and interacting with handheld devices, whether sending or receiving text messages[26] or social networking and instant messaging (IM'ing) (ie, exchanging text messagesin real time).[27]

Just as MMT disrupts learning in a classroom setting, MMT and background media disrupt learning while doing homework. In several studies of eighth graders in the Netherlands, Pool et al[24] demonstrated that watching a Dutch-language soap opera while working on a task reduced accuracy and speed on both a paper-and-pencil task and a memorization task. With respect to reading as a primary task, background television interferes with students' ability to comprehend narratives, especially when actively watching the television program.[28] Similarly, reading while answering instant messages dramatically reduces reading efficiency. In one study, the time taken to read a passage increased from 29 minutes when not IM'ing to 49 minutes when IM'ing.[29] Doing homework while sending instant messages may not only slow down and degrade performance but also has been reported to negatively impact the learner's perceived ability to perform homework.[22] Other data suggest that accuracy on problem-solving homework tasks suffers as students switch more frequently to other computer-based tasks.[28]

Background television affects even the youngest children during play, which is integral to cognitive, social, and emotional development during infancy and early childhood (see ref 30). Just as older children do not perform as well on homework in the presence of background television, infants have shorter episodes of play and focused attention when background television is present.[25]

Long-Term Development and Achievement

Fewer studies have examined potential long-term impacts of MMT and background media. Results are correlational and mixed. One dominant method of assessing students' learning is grade point average (GPA). Studies investigating multitasking with media while learning (eg, receiving in-class texts[22]) have demonstrated a negative association with GPA. Although Lin et al[31] reported a limited association between MMT and GPA, they did find that Facebook and text message use negatively predicted GPA (see ref 22).

FUTURE RESEARCH

An overarching goal of any current national research agenda should be to address existing knowledge gaps by building a body of research on the relations between MMT and cognitive, psychosocial, neural, and academic factors. A rich body of well-established research on these relations is needed to guide evidence-based policymaking. Questions should include:

- Does MMT change brain and behavior, or do preexisting state or trait variable differences increase the probability of MMT behavior?
- Are younger populations particularly vulnerable? Is there a sensitive period wherein MMT should be limited or avoided?
- What makes media multitasking different from non-media multitasking? Do specific types of MMT affect cognitive, psychosocial, neural, or academic achievement factors differently? Do effects vary depending on activity and context (eg, listening to lecture, engaging with social media, studying)?
- What interventions are effective in remediating the effects of MMT, when, and for whom? Are different interventions needed for different populations (eg, age of onset, dose, type, neurocognitive profile)? What are the critical pedagogical issues regarding MMT in K-12 education?
- Can we leverage technology to develop more direct measures of MMT behavior, reducing measurement error?
- How can scholars from different disciplines conduct interdisciplinary research and use multiple research methods to better understand MMT and learning?

Findings from such research programs promise to inform policy and practice on an increasingly urgent social issue while significantly advancing our understanding of the intersections between cognitive, psychosocial, neural, and academic factors.

RECOMMENDATIONS

Until the causal directionality is known, it is premature to offer strong recommendations and guidelines. However, the following may be considered as preliminary recommendations:

Clinicians and Educators

Until we are able to understand the direction of causality, suggest to people of all ages and abilities that they give careful consideration to how they engage with media. Note that there is an immediate impact of MMT on concurrent learning. Regarding long-term outcomes, raise awareness of differences associated with MMT but also emphasize that we currently do not know if such behavior creates these differences (ie, debunk myth of established causality).

Policy Makers

Advocate for increased funding to examine the relation between MMT, cognition, and brain structure and function, and to determine causality.

ABBREVIATIONS

GPA: grade point average
HMMs: heavier media multitaskers
IM'ing: instant messaging
LMMs: lighter media multitaskers
MMT: media multitasking
MMTs: media multitaskers

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