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Facebook and texting made me do it: Media-induced task-switching while studying



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ABSTRACT

Electronic communication is emotionally gratifying, but how do such technological distractions impact academic learning? The current study observed 263 middle school, high school and university students studying for 15 min in their homes. Observers noted technologies present and computer windows open in the learning environment prior to studying plus a minute-by-minute assessment of on-task behavior, off-task technology use and open computer windows during studying. A questionnaire assessed study strategies, task-switching preference, technology attitudes, media usage, monthly texting and phone calling, social networking use and grade point average (GPA). Participants averaged less than six minutes on task prior to switching most often due to technological distractions including social media, texting and preference for task-switching. Having a positive attitude toward technology did not affect being on-task during studying. However, those who preferred to task-switch had more distracting technologies available and were more likely to be off-task than others. Also, those who accessed Facebook had lower GPAs than those who avoided it. Finally, students with relatively high use of study strategies were more likely to stay on-task than other students. The educational implications include allowing students short “technology breaks” to reduce distractions and teaching students metacognitive strategies regarding when interruptions negatively impact learning.

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1. Introduction

In our technologically rich world, multitasking is the norm; but is more prominent among youth and college students (Carrier, Cheever, Rosen, Benitez, & Chang, 2009). Monk, Trafton, and Boehm-Davis (2008) stated that for most people, “dealing with interruptions is not a problem to be overcome as much as it is an inevitable part of life. In fact, the ability to multitask is considered a desirable job skill by many employers, which is not surprising given that, on average, workers shift between tasks every 3 min” (p. 299).

A recent study by CourseSmart and Wakefield Research (Kessler, 2011) queried 500 college students and found that 73% were not able to study without some form of technology and 38% reported that they were not able to go more than 10 min without checking with their laptop, smartphone, tablet or e-reader. A study by Marci (2012) tracked 15 young adults in their 20s and 15 adults who grew up with older technologies and later adapted to newer ones with biometric belts and embedded eye glass cameras for more than 300 h of nonworking time. The authors discovered that while the later adopting adults switched from one task to another

17 times per hour the young adults task switched 27 times per hour, or once every 2 min. Although this is a small sample study, it is suggestive of a difference in task switching as a function of age and technological experience. Former Microsoft executive Linda Stone dubbed this problem, “continuous partial attention” (Rose, 2010) and a Stanford University study (Ophir, Nass, & Wagner, 2009) concurred that heavy media multitaskers performed worse than light media multitaskers in a laboratory test of task switching indicating that they were worse at ignoring irrelevant but distracting information in their environment.

In a field study, Gonzalez and Mark (2004) observed 14 information workers for 3 days, noting every action they took as they sat unobtrusively in the back of their cubicles. The average worker spent just over 3 min on a task before switching to another task, equally as often due to either an external disruption (e.g., e-mail, phone call) or an internal interruption (e.g., checking their computer, using e-mail).

In a subsequent study, Dabbish, Mark, and Gonzalez (2011) used data from 36 information workers and found that internal and external interruptions occurred equally as often, accounted for 40% of disrupted work (the other 60% were due to task completion), resulted in a return to the task only 70% of the time, and resulted in a resumption lag—the time to return to the work following the interruption—of more than 30 min when the tasks were resumed. These results matched studies showing that

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medical students (Judd & Kennedy, 2011) switched tasks 12 times an hour or every 5 min and that office workers changed tasks 12.5 times per hour with twice as many external as internal interruptions and a resumption lag of roughly 7 min depending on the type of interruption (Cades, Werner, Boehm-Davis, & Arshad, 2010).

Each of these studies used different populations and with younger people being more likely to use technology the question arises as to whether children, teens or young adults differ in task switching behavior. Reimers and Maylor (2005) used a laboratory study to confirm that switch costs—the additional amount of time to do two tasks, one at a time, versus switching back and forth between tasks—decreased from age 10 to 17 and then increased gradually from age 18 to 66. Additionally, using college students Bowman et al. (2010) had control group participants read a passage and take a test with two experimental groups, one that held an instant message (IM) conversation before reading and a second group who were interrupted with an IM conversation partway through reading. Although reading took 21% longer when the students were interrupted midway, the control and interrupted groups did not differ in comprehension, indicating that the cost of multitasking is time not performance. Another study (Wang et al., 2012) found that interruptions in the same modality (e.g., interrupting a visual task with a visual IM conversation versus an auditory phone conversation with the same content) reduced multitasking performance more than interrupting a task with another task in a different modality. Carr (2010) argued that not only does multitasking cause increased time to complete a task but it also results in more shallow thinking at the expense of deep, contemplative thought and analysis.

Although it is well-established in the experimental psychology literature that engaging in an extra (non-media) task during intentional learning results in significant memory disruptions in the laboratory (Baddeley, Lewis, Eldridge, & Thomson, 1984; Craik, Govoni, Naveh-Benjamin, & Anderson, 1996; Jacoby, 1991; Jacoby, Woloshyn, & Kelley, 1989), very little research has investigated how often students task switch during actual schoolwork. In one laboratory study (Brasel & Gips, 2011), college students and staff were presented with a television and computer screen and told to do whatever they wished for 30 min including changing channels or surfing the web. Using a video camera and eye fixations, the average student and staff member were observed making four switches per minute but only recalled making one or fewer per minute. Not surprisingly younger people made more switches than older people and, regardless of age, the computer was much more entrancing, with more gazes and longer gazes. Similarly, Oulasvirta, Rattenbury, Ma, and Raita (2012) investigated the conjecture that mobile devices are “habit forming” in that they produce a checking habit whereby someone makes brief visual inspections of the device’s content. Using a field study tracking and comparing smartphone users to laptop users over a period of nearly 2 months, Oulasvirta et al. found that the former produced substantially more quick uses of 30 s or less that were evenly spread throughout the day, which they interpreted as indicating checking behaviors. This suggests that the smartphone was serving as a trigger for constant, habitual usage.

In another real-world investigation, Moreno et al. (2012) sent six daily text messages at random times to 189 university students and determined that more than half the time they were using the Internet they were multitasking, with the most frequent Internet activity being social networking. Finally, another real-world study (Wang & Tchernev, 2012) found that media multitasking is driven by cognitive needs at the time rather than short-term emotional needs or long-term needs but that the driving force behind multitasking is emotional rewards gained—even at the cost of learning.

1.1. What impacts task switching?

Three key issues surround the impact of task switching: (1) primary task completion, (2) secondary (interruptive) task completion, and (3) resumption lag. As mentioned earlier, Wang et al. (2012) discovered that higher similarity between the primary and secondary tasks decreased performance on the primary task but not the secondary task. Cades, Kidd, King, McKnight, and Boehm-Davis (2010) found that in their relatively homogenous college population intelligence predicted all three components while neither impulsivity nor adaptability did the same. However, the investigators admitted that the participants did not show much variability on either impulsivity or adaptability, which may have obscured their results. In another study, Werner et al. (2011) found that those college students with better working memory capacity and better spatial abilities were better at resuming interrupted tasks while Cades, Trafton, Boehm-Davis, and Monk (2007) discovered that interruptions that prevented the participant from rehearsing the interrupted task—and required more cognitive effort—were more disruptive than those that were simpler and allowed the primary task goals and steps to be rehearsed during the interruption. This was confirmed and refined by Cades, Werner, Trafton, Boehm-Davis, and Monk (2008) who found that the number of mental operators required to complete an interruptive task leads to more disruption in the resumption of the primary task. Further, Cades, Trafton, and Boehm-Davis (2006) showed that over time people get better at dealing with interruptions although those benefits were limited to practice on the specific interrupting task and not practice with interruptions in general (Cades, Boehm-Davis, Trafton, & Monk, 2011).

1.2. Social media, multitasking and learning

Facebook has nearly one billion users worldwide (Smith, 2012) with more than 90% of teens (Common Sense Media, 2012) and college students (Junco, 2011) actively engaged. In an early study, Kirschner and Karpinski (2010) reported that college students who used Facebook spent less time studying and had lower grade point averages than those who did not use Facebook. More recently, Junco (2011) discovered that sharing links and checking up on friends on Facebook more often predicted higher college grades; making status updates more often predicted lower grades; and that overall GPA dropped .12 points for every 93 min above the average of 106 min per day spent on Facebook.

Multitasking has also been shown to be predictive of academic performance in survey research. For example, Junco and Cotton (2012) found that college students who spent more time using information and communication technologies while doing homework—specifically Facebook and texting—had lower college grade point averages. Junco and Cotton (2011) found that students who spent more time using instant messaging while studying or doing schoolwork had lower grades. Further Wood et al. (2012) reported that students who used Facebook or instant messaging during a college lecture did worse on an exam than those students who were not allowed to use a computer or access Facebook. In addition, Wood et al. (2012) found that students who did not multitask during the lecture did better than those who multitasked and the more multitasking they did the worse they performed. A study in Sweden (Rouis, Limayem, & Salehi-Sangari, 2011) confirmed and expanded these results finding that Facebook-using college students with extroverted personalities showed poorer academic performance than those with introverted personalities, which was moderated by their level of self-regulation. In contrast, a similar study done with Tunisian students (Rouis, 2012) showed no relationship between Facebook use and academic performance. In contrast, however, another study (Shah, Subramanian, Rouis, &

Limayem, 2012) found that “rich use of Facebook”—defined as being cognitively absorbed and deeply involved (e.g., “Time flies when I am using social media”)—actually predicted better academic performance among American university students. The current study will examine the impact of social media on learning using measures that are designed to capture different social media uses.

In a controlled study of the impact of technology on classroom performance, Rosen, Lim, Carrier, and Cheever (2011) randomly assigned students in multiple classrooms to one of three conditions based on how many text messages they were sent during a 30-min videotaped lecture after which they completed a test assessing retention of the material. Students received either no texts, four texts or eight texts and were asked to respond. Text messages were timed to be delivered at the same time as the to-be-tested information was displayed in the videotaped lecture. Rosen et al. found that while the four-text group did not perform significantly worse on the test than the no text group, the eight text group did perform significantly worse than the group who received no interruptive text messages. Further, students who opted to respond rapidly to text messages did significantly worse than those who chose to wait up to 5 min following the interruption to read and/or respond to the text. “This suggests that we should be teaching our students metacognitive strategies that focus on when it is appropriate to take a break and when it is important to focus without distractions” (Rosen et al., 2011, p. 174).

1.3. A model of the multitasking mind

Salvucci, Taatgen, and Borst (2009) presented the Unified Theory of the Multitasking Continuum (for a more detailed explanation see Salvucci & Taatgen, 2011) to explain task switching behaviors ranging from concurrent multitasking (e.g., listening and note-taking) requiring near simultaneous processing to sequential multitasking (e.g., writing a paper and reading an email) which allows more time (and control) between switches. The crux of the model is based on ACT-R architecture (Anderson, 2007), which posits information is processed by relatively independent but interacting modules including: (a) a declarative memory module that handles knowledge, instructions and memory for past events; (b) a goal module which tracks progress toward completion of the task; (c) a problem representation module which contains information generated during learning that may be needed later to complete the task; and (d) a procedural module that connects all of the modules together and monitors the flow of information between them. In ACT-R, all modules can work separately at the same time but each module can only work on a single task at a time. The second part of Salvucci et al.'s theory involves threaded cognition theory (Salvucci & Taatgen, 2008), which allows for multiple tasks to be performed concurrently. This theory explains how different tasks compete for resources—modules in the model—and interfere with each other when they share needed resources. If two tasks are similar, require complex problem representation, and/or need the same module at the same time, threaded cognition theory predicts that one thread must wait its turn to use necessary resources or modules. This waiting period delays processing and increases task completion time and resumption lag.

The final part of the Unified Theory of Multitasking, necessary for handling sequential multitasking, is Memory for Goal Theory (Altmann & Trafton, 2002), which explains how when we attempt to multitask, the new task goal must be activated more than the old task goal, which then begins to lose activation and fade away. This means that when the interruptive task is completed the original task will take additional time to reactivate and result in

longer time to complete than if it were attempted without interruption.

Other theories have been proposed to account for costs in multitasking but none are as complete as the Unified Theory of Multitasking. For example, Uses and Gratifications Theory (see Rubin, 2009 for a recent review of this theory) proposes that we possess needs including those that are emotional, cognitive, social, and habitual and are driven to gratify and reduce those needs through media usage. Wang and Tchernev (2012) examined the popularity of media multitasking within this framework and determined that this form of multitasking is not satisfying cognitive needs and, instead, emotional gratifications step to the forefront, which they argue explains why students might multitask while learning course materials.

Another theoretical approach to why students multitask revolves around Flow Theory (Csikszentmihalyi, 1990), which states that media use invokes a psychophysiological state that encompasses a strong, positive experience when confronted by a challenge balanced with the person's skill level, which compels someone's attention to the extent that other activities (e.g., the primary activities) become unimportant and neglected. Mauri, Cipresso, Balgera, Vilamira, and Riva (2011) examined flow state as a function of positive valence and high arousal during relaxation, Facebook navigation and stress and concluded that, “the psychophysiological state of people using social networking is characterized by high positive valence and high arousal, corresponding to a core flow state” (p. 730).

1.4. Hypotheses

The current study was designed to examine task switching by middle school, high school and college students studying classroom material in their typical study environment, rather than in a laboratory setting, and determine how often students switch from studying to another task, why they switch, and how this impacts their ability to learn. Based on prior research, the following hypotheses are proposed:

H1. Based on research with information workers, medical students and office workers, students will only maintain on-task behavior for short periods of time before switching to another task.

H2. Based on research showing the impact of task similarity and attitudes toward technology on task-switching behavior, students who demonstrate more off-task behavior will do so due to distractions posed by technology and media, preference for multitasking and negative attitudes toward technology.

H3. Students who maintain more on-task behavior will do so due to using technology to aid studying behaviors such as looking up information on the Internet or using a word processing program to compose their work in addition to preference for not multitasking and positive attitudes toward technology.

H4. Based on research on the impact of task similarity on multitasking difficulty, technology and media use plus technology distractors will predict task-switching behavior depending on the similarity between the distractor and primary tasks.

H5. Based on work examining the impact of technology on academic performance, on-task behavior, the use of social media, preference for multitasking and study strategies—will predict reduced academic performance.

2. Methods

2.1. Participants

Participants ($N = 279$) were recruited and observed by students in an upper-division general education course from the local Southern California area to participate in an observational study of studying behavior. Each student was asked to recruit up to three participants—limited to one each in middle school, high school and college—and to observe them studying in their typical study environment. Sixteen participants were eliminated for not performing the task (i.e., not studying during any of the observations). Overall, the participants ($N = 263$) included middle school students ($N = 31$; Mean age = 12.10), high school students ($N = 124$; Mean age = 16.27), lower-division university students ($N = 49$; Mean age = 22.39), and upper-division university students ($N = 59$; Mean age = 23.80). Participants included 117 males and 146 females who represented the local Southern California area's ethnic background: Asian/Asian-American/Pacific Islander ($N = 22$; 8.3%), Black/African-American ($N = 26$; 9.9%), Caucasian ($N = 62$; 23.6%), and Hispanic/Latino/Spanish Descent ($N = 115$; 43.7%). Participants supplied additional demographic information including residence zip code, which was transformed into estimated median income based on U.S. Census figures (U.S. Census Bureau, 2000). Overall median income averaged \$46,768 ($SD = 19,399$) and there were no differences in median income between school groups; $F(2,248) = 0.95$, $p > .05$.

2.2. Materials

2.2.1. Studying observation form

Trained observers used a Studying Observation Form developed for this study. The form included pre-observation data concerning the study location (bedroom desk, bedroom bed, kitchen table, living room, den, other), technologies present in the learning environment at the beginning of the observation period (computer, cell phone, television, music players, video game consoles, and handheld video games), and windows open on a computer at the beginning of the observation period (e-mail, Facebook/MySpace, IM/chat, word processor, spreadsheet, PowerPoint, video/YouTube). In addition, a minute-by-minute checklist included observations of the use of the following: (1) e-mail, (2) Facebook/MySpace, (3) IM/Chat, (4) texting, (5) talking on the telephone, (6) television on, (7) music on, (8) music ear buds in ear, (9) reading a book, (10) reading on a website, (11) writing on paper, (12) writing on the computer, (13) eating or drinking, and (14) stretching/walking around as well as an indication of the main activity at that minute. Finally, at each minute observers noted the number of windows open on the computer (counted as zero if no computer was being used).

2.2.2. Post-studying questionnaire

Following the minute-by-minute observations participants were asked a series of questions from the following surveys and scales:

- **Study Strategies Survey:** This 12-item survey includes the meta-cognition items from the Motivated Strategies for Learning Questionnaire (MLSQ; Duncan & McKeachie, 2005) and assessed aspects of how people strategize when they read on a seven-point scale from “not at all true of me” (1) to “very true of me” (7). Sample items on this scale, with a reported Cronbach's $\alpha = .79$, included statements that indicated being confused while studying (e.g., “When reading I often miss important points because I am thinking of other things”) and statements

indicating the use of study strategies (e.g., “When reading I make up questions to help focus my reading”).

- **Preference for Task-Switching Scale:** This included four items taken from the Multitasking Preference Inventory (Poposki & Oswald, 2010), each on a five-point Likert scale (e.g., “I prefer to work on several projects in a day rather than completing one project and then switching to another”). Items were selected from the original 14-question inventory ($\alpha = .88$) by using those with the top four loadings in a factor analysis (Poposki & Oswald, 2010).
- **Technology Attitudes Scale:** Five items were developed to assess various attitudes toward technology use, each assessed on a five-point Likert scale. Questions assessed negative views about technology (makes life more complicated, makes people waste too much time, makes people more isolated) and positive views about technology (makes people closer to their friends and family, allows people to use their time more efficiently).
- **Daily Media Usage Scale:** Participants were asked nine questions concerning their typical daily media and technology usage (going online, using a computer for other than being online, e-mailing, IMing/chatting, telephoning, texting, playing video games, and listening to music) and one additional question on their pleasure reading behavior each on a scale including: not at all, less than an hour, 1 h, 2 h, 3 h, 4–5 h, 6–8 h, 9–10 h and more than 10 h per day. Responses were transformed into hours of use by converting choices given in ranges including not at all (0), less than an hour (.5 h), 4–5 h (4.5 h), 6–8 h (7 h), 9–10 h (9.5) and more than 10 (11).
- **Cell Phone Usage:** Participants were asked to estimate the number of text messages sent and received per month as well as the number of cell phone minutes used per month.
- **Distractors Scale:** This included a count of the number of technology items that were in the participant's study area at the beginning of the 15-min observation period.
- **Social Networking Usage Scale:** Participants indicated how often they used Facebook, MySpace and Twitter as well as how often they read Facebook postings, posted Facebook status updates and posted Facebook photos, each on a four-point scale (very often, somewhat often, rarely, never).
- **School Performance:** Participants were asked their current school grade point average.
- **Qualitative Assessment of Task Switching:** At the end of the post-studying questionnaire, participants were asked about their task switching behavior in two ways. First, they were asked “If you do switch from studying to doing something else, what do you feel is the reason why you switch?” and were given choices including: I get bored, I am alerted to a text message, I am alerted to something on my computer screen, I stop to listen to music, I watch something on television, I get a phone call, I switch to something else or other. Second, in order to simulate a potential study environment where task switching might be a major impediment to performance, they were also asked to imagine that they were reading a print book for a final exam the next day in a class that they had to pass in order to graduate. Then they were given a checklist of activities that they might be doing while they studied including all technology and media activities as well as other potential distractors.

2.3. Procedure

Student observers ($N = 128$) were trained on unobtrusive observation strategies through a series of demonstrations by the lead author. An entire 15-min study session was simulated and the minute-by-minute Studying Observation Form was completed. Overall, 70 students selected and observed three participants, 22 observed two and 36 observed only a single

participant. Student observers selected participants who they knew personally and felt would be comfortable during the observation period. No differences were found between those who observed different numbers of participants on any major variable. Consent was obtained from adult participants and parents of those under 18 years of age plus a personal assent from all minors. IRB approval was given for the study. Upon entering the study area observers explained that the participant would be observed studying something important including homework, an upcoming examination or project, or reading a book for a course for 15 min and that the observer would be seated in the background and observing how they studied. Participants were instructed to select a study environment where they would typically study. The observer explained the process to the participant and discussed placement that would be reasonably unobtrusive while allowing view of any technology and media in the study environment. Participants were simply told that the study involved observations of how people typically study.

3. Results

3.1. Preliminary analyses

Participant observations were done in a variety of locations including living room/den (25%), bedroom bed (23%), kitchen table (22%), bedroom desk (21%) and other (9%). For participants under 18 years of age, parental consent was obtained to determine the studying environment. No differences were found in any of the major variables as a function of study location.

Factor analyses were performed separately on each attitudinal and behavioral scale—Preference for Task-Switching Scale, Study Strategies Survey, and Technology Attitudes Scale—using a criterion of .50 loading for inclusion. Separate scales were produced including: Technology Improves Life ($\alpha = .88$), Preference for Task-Switching ($\alpha = .82$), Study Strategy Use ($\alpha = .87$), and Confusion When Studying ($\alpha = .67$).

Based on the main activity assessed during each observation, each minute's activity was assessed as clearly on task (reading book, reading appropriate website, writing on paper and writing on computer), off task (Facebook, IM, texting, television, music, eating and walking/stretching) or unknown. Two variables were computed from the 15 observations: on-task percentage and average on-task "runs." The former was computed by dividing the number of minutes clearly on-task by 15 while the latter was computed by counting the number of consecutive on-task minutes and dividing these run lengths by the number of such runs. For example, if a participant studied for 4 min, took a break for 2 min, studied for another 6 min and then took a 3-min break, she would be credited with an average on-task run length of 5 min (4 + 6 divided by two runs). In addition, at each minute the number of windows open was noted including specific websites on the computer screen or on the taskbar.

Daily media usage variables were compiled with the following constraints. The nine daily media variables were converted to daily hours and summed to create a Total Daily Media Usage Scale. Total hours for three participants were more than three standard deviations above the mean and were truncated to exactly three standard deviations above the mean on this scale as well as on monthly texting for nine participants and monthly phone minutes for one participant to prevent statistical artifacts due to outliers. In addition, questions concerning social networking yielded two clear factors: Facebook Usage Factor (including frequency of status updates, photo updates and reading other postings) and a Twitter/MySpace Usage Factor (including frequency of daily Twitter and MySpace use).

Finally, distracting activities such as texting or viewing Facebook were coded in two ways: number of minutes they were accessed (out of 15 minute-by-minute observations) and whether or not they were accessed at least once during the 15-min study period.

3.2. Group differences

Table 1 displays the mean scores for each variable including daily media usage, monthly phone use/texting, and individual attitudinal and behavioral scales for each of the four groups. The data show a few strong differences in technology and media use among the various participant groups. High school students appeared to spend more time chatting and texting; middle school students played more video games; and university students used more study strategies. Interestingly, students of all ages used certain technologies the same (online, on computer, e-mail, music, television), consumed the same total daily hours of media and technology, preferred the same level of task switching, had similar attitudes about the role of technology in life, were on-task about the same percentage of time, and had similar length on-task runs.

3.3. On-task performance

Hypothesis 1 predicted that students would maintain on-task behavior for only a short period while studying. On average participants were on task 65% of the time ($SD = .27$). This suggests that during the 15-min observation period the participants were working on their studying task approximately 10 min ($SD = 4.05$ min). On-task percentage at each minute was compared across gender and participant groups in a $2 \times 4 \times 15$ multivariate repeated measures analysis of covariance and polynomial trends were tested. Two covariates were selected—median income and birth year—due to correlations of median income with some independent and dependent variables and age differences noted in Table 1. None of the main effects or interactions was statistically significant. However, as predicted, a polynomial trend—the quartic or fourth-order trend—was statistically significant; $F(1,229) = 5.04$, $p = .036$ (partial eta squared = .021). This relationship is depicted in Fig. 1 where the fourth order trend is reflected in a reduction in on-task percentage at the 4- to 5-min mark, peaking at the 6-min mark, dropping to a low at the 7- to 10-min mark and then climbing again and peaking at about the 14-min mark. This supports Hypothesis 1.

In order to test Hypotheses 2 and 3 and determine which technological and media activities might best predict on-task and off-task behaviors, two hierarchical multiple regressions were performed. In each, the same first hierarchical step removed the effects of gender, family median income, and birth year; the latter was included to partial out age differences in technology use and the former two were included due to correlations with independent and dependent variables. Regressions only differed in the second hierarchy. Table 2 displays the results of these regressions. The left side of Table 2 lists the significant positive and negative task-behavior predictors [$R(25,225) = 4.29$, $p < .001$; R^2 change = .323] including their beta weights when examining *how many times out of the 15 observations* a specific positive activity (in service of studying) or negative activity (as a distractor) occurred. In addition, potential predictors included the following uses of technology and media: monthly cell phone calling and texting, Facebook use, Twitter/MySpace use, total number of windows open during the study period as well as amount of technology available in the studying environment and computer programs open on the computer at the start of studying. It is important to note that, as expected, positive activities such as reading a book, writing on paper or on a computer, and visiting a website (one required for

Table 1
Mean scores and Analysis of Variance F-scores comparing participant age grouping (Tukey's B test used for post-hoc comparisons).

Variable	Middle school	High school	Lower division university	Upper division university	F-score
<i>Technology and media usage variables</i>					
Daily hours online ^a	2.29	3.11	2.34	2.91	2.76*
Daily hours use computer	1.56	2.13	2.17	2.27	1.53
Daily hours e-mail	0.60	1.02	1.06	1.48	2.45
Daily hours IM/chat ^b	1.53	1.76	0.85	1.13	4.26**
Daily hours telephone ^a	0.98	1.51	1.07	1.63	2.70*
Daily hours texting ^c	2.71	4.56	3.46	3.81	2.92*
Daily hours video games ^d	1.85	1.35	0.92	0.56	5.72***
Daily hours music	3.18	3.60	3.45	2.72	1.39
Daily hours television	3.03	2.36	1.95	2.41	2.20
Daily hours reading	0.55	0.72	0.77	0.92	1.18
Total daily media hours ^a	17.74	21.40	17.27	18.91	2.67*
Texts per month ^c	771.16	2010.79	1263.61	1519.49	5.17**
Cell minutes/month ^a	340.00	483.56	320.20	544.85	2.99*
Facebook use ^d	-.68	.14	-.15	.06	6.21***
MySpace/Twitter use	-.01	.14	-.04	-.27	2.38
Open program distractors	0.68	1.53	1.49	1.69	1.99
Total tech distractors at start	2.52	3.20	3.27	2.93	2.30
<i>Attitudinal and behavioral scales</i>					
Tech improves life	.17	.07	-.23	-.17	1.99
Prefer task switching	-.04	.02	.05	.14	0.30
Study strategy use ^e	-.41	-.07	.21	.30	4.72**
Confusion when studying	.08	-.01	.18	-.19	1.53
<i>Task-related behaviors</i>					
On-task percentage	.71	.67	.72	.70	0.97
Average on-task run length	5.92	5.20	6.47	5.58	0.91

* $p < .05$.
 ** $p < .01$.
 *** $p < .001$.
^a No significant differences by Tukey's B-Test.
^b High school > lower-division university students.
^c High school > middle school.
^d Middle school > high school = lower division university students = upper division university students.
^e Upper division university students = lower division university students > middle school.

Table 2
Significant predictors (both positive and negative) of on-task percentage in hierarchical multiple regressions with number of times (out of 15) each technology/activity (on-task and off-task) was used as well as other distractors (left side of the table) and whether the activity occurred at least one time during the 15-min observation period.

Total activity times (out of 15)		Activity occurred at least once in 15 min	
Variable	Beta weight	Variable	Beta weight
<i>Positive</i>			
Viewing website	.227***	Viewing website	.194**
Writing on paper	.207***		
Reading book	.168*		
<i>Negative</i>			
Distractors at start	-.218**	Watching TV	-.186**
Texting hours/day	-.180**	Stretching/walking	-.165**
Stretching/walking	-.179**	Monthly texting	-.133*
Facebook use	-.129*		

* $p < .05$.
 ** $p < .01$.
 *** $p < .001$.

studying) all predicted on-task percentage, which supported Hypothesis 3 since those are precisely the activities that indicate someone is on task. On the other hand, in support of Hypothesis 2, four additional distractor activities predicted reduced on-task behavior including distracting technology available at the start of studying, stretching or walking, hours of daily texting, and Facebook use. Again, the fact that any extra distractor activities were predictors is expected since they define off-task behavior. It is interesting, however, that only those four activities appear to predict inability to stay on task.

The right side of Table 2 examined the same group of predictors except each activity (again positive or negative) was considered as having occurred or not occurred *at least once during the 15-min period* (coded as a "0" if it did not occur and a "1" if it did). The significant regression results [$R(25,225) = 4.45, p < .001; R^2 \text{ change} = .331$] were somewhat similar to those on the left side of the table with only reading appropriate websites as a positive predictor of on-task behavior. It appears that having a television on at least once during studying as well as daily texting behavior and walking around and stretching at least once predicted reduced on-task behavior further supporting Hypothesis 2.

As a further test of Hypothesis 3, on-task behavior was also examined as a function of the four attitudinal variables—Technology Improves Life, Preference for Task Switching, Study Strategy Use, and Confusion When Studying—in the same regression design to determine the predictive impact of attitudes toward technology on on-task behavior. In this case, after factoring out gender, family income and birth year, two attitudinal scales significantly predicted on-task behavior [$R(7,250) = 4.68, p < .001; R^2 \text{ change} = .119$]: Those who preferred to task switch over completing a single task at a time were significantly more likely to be off task [$\beta = .180, p = .005$] and those who did not use study strategies as much were significantly more likely to be off task [$\beta = .130, p = .045$].

3.4. Open windows while studying

A $2 \times 4 \times 15$ multivariate repeated measures analysis of covariance (using median income and birth year as covariates) was performed examining the number of windows open on the

participant's computer as a function of group (middle school, high school, freshman/sophomore university student, junior/senior university student) and gender. The only significant effect was the windows open across minutes [$F(14,242) = 2.03, p = .016$, partial eta squared = .01] with a significant quadratic trend [$F(1,242) = 5.65, p < .05$, partial eta squared = .025]. As shown in Fig. 2, the number of open windows peaks between the 6- and 12-min marks, at roughly the same time that the participants were least likely to be on task as seen in Fig. 1. This lends support for Hypothesis 4.

3.5. On-task runs

On-task runs averaged 5.61 min ($SD = 4.68$) and varied from 1 min to 15 min. Identical to the on-task percentage regression analyses, two hierarchical multiple regressions were performed to examine the best predictors of on-task runs from the technology use (total use on the left side of Table 3; whether used at least once during the 15 min on the right side of Table 3) after first factoring out gender, birth year, and median income. As can be seen in the left side of Table 3, overall texting during the 15 min and stretching and walking around behavior predicted shorter on-task runs. On the right side, however, we see that those participants who texted at least once, used Facebook more in their daily lives, stretched, ate or drank and watched television at least once during the study period showed shorter on-task runs supporting Hypothesis 4.

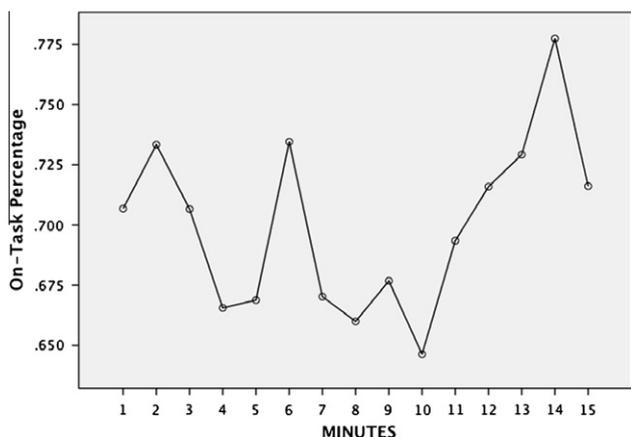


Fig. 1. On-task percentage across 15-min observations.

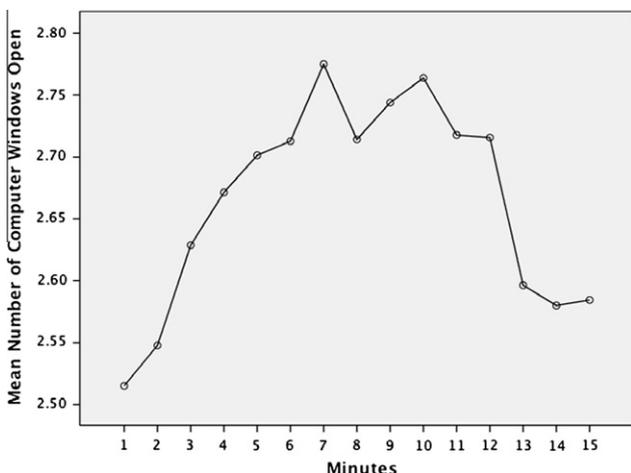


Fig. 2. Mean number of computer windows open across the 15-min study period.

Table 3

Significant predictors (both positive and negative) of average on-task run length in hierarchical multiple regressions with number of times (out of 15) each technology/activity (on-task and off-task) was used as well as other distractors (left side of the table) and whether the activity occurred at least one time during the 15-min observation period.

Total activity times (out of 15)		Activity occurred at least once in 15 min	
Variable	Beta weight	Variable	Beta weight
<i>Positive</i>			
None		Viewing website	.163*
<i>Negative</i>			
Texting	-.207**	Texting	-.273***
Stretching/walking	-.192**	Facebook use	-.184**
		Stretching/walking	-.174**
		Eat/drink	-.156*
		Watching TV	-.125*

* $p < .05$.

** $p < .01$.

*** $p < .001$.

On-task runs were also examined as a function of the four attitudinal variables— Technology Improves Life, Preference for Task Switching, Study Strategy Use, and Confusion When Studying—in the same regression format. In this case, after factoring out gender, family income and birth year, only one attitudinal scale predicted on-task behavior [$R(7,243) = 3.65, p < .001; R^2 \text{ change} = .095$]; Those who preferred to task switch over completing a single task at a time were significantly more likely to have shorter on-task runs [$\beta = .218, p < .001$].

3.6. Preference for task switching

To further test Hypothesis 4 that task switching will be best predicted by technology and/or media behaviors, three separate hierarchical multiple regressions were performed. The first included all typical daily technological activities (including those nine activities in the Daily Media Usage Scale, potential distractors at the beginning of the study period and social network use) entered as potential predictors. The regression model was statistically significant [$R(18,232) = 3.58, p < .001; R^2 = .217$], and three daily technology activities were significant predictors of preference for task switching: number of computer programs open at the beginning of the study period [$\beta = -.313, p < .001$]; hours of daily music [$\beta = -.157, p = .023$]; and Twitter/MySpace use [$\beta = -.143, p = .028$].

The second regression to predict preference for multitasking included the number of times each positive and negative (distracting) activity was engaged in over the 15 min and found no significant predictors [$R(17,233) = 1.56, p > .05$] but in a third multiple regression using the indicators of whether any of the activities occurred even once during the study period there was a significant predictive model [$R(17,233) = 2.02, p < .05; R^2 \text{ change} = .128$] with the only significant predictor being whether music was listened to during the study period [$\beta = -.145, p = .03$].

3.7. School performance

Students reported an average GPA of 3.14 ($SD = .51$) and there were no differences across age groups. GPA was subdivided into three groups—"A" grades (3.51+; 22%), "B" grades (3.00–3.50; 49%) and "C" or lower grades (under 3.00; 30%)—and used as the dependent variable in two hierarchical multiple regressions to test Hypothesis 5 that academic performance will be predicted by technology use in general and social media use in particular. Similar to

Table 4

Significant predictors (both positive and negative) of grade point average group (high–medium–low) in hierarchical multiple regressions with number of times (out of 15) each technology/activity (on-task and off-task) was used as well as other distractors (left side of the table) and whether the activity occurred at least one time during the 15-min observation period.

Total activity times (out of 15)		Activity occurred at least once in 15 min	
Variable	Beta weight	Variable	Beta weight
<i>Positive</i>			
None		None	
<i>Negative</i>			
Stretching/walking	-.135*	Facebook use	-.225**

* $p < .05$.

** $p < .01$.

*** $p < .001$.

earlier analyses, these multiple regressions were performed with technology use and availability as independent variables (total use on the left side of Table 4; whether used at least once during the 15 min on the right side of Table 4) after first factoring out gender, birth year, and median income. Both regression analyses were significant [Total use: $F(24, 224) = 1.73, p = .022$; Use at least once: $F(24, 224) = 2.15, p = .002$]. As can be seen in the left side of Table 4, there were no positive predictors and stretching/walking around was the only significant negative predictor of grade point average. On the right side of Table 4, however, it is apparent that those students who accessed Facebook at least once during the 15-min study period had lower grade point averages.

Grade point average was also examined as a function of the four attitudinal variables—Technology Improves Life, Preference for Task Switching, Study Strategy Use, and Confusion When Studying—in the same regression format. In this case, after factoring out gender, family income and birth year, two attitudinal scales predicted GPA [$R(7, 241) = 7.17, p < .001; R^2 = .172$]: Using studying strategies significantly predicted higher GPAs [$\beta = .184, p = .004$] and confusion while studying significantly predicted lower GPAs [$\beta = -.244, p < .001$].

3.8. Qualitative results

Participants were asked why they task switch and tallies indicated that texting (68%) and boredom (63%) were the top two reasons followed by receiving a phone call (42%), switching to another computer screen (36%) and watching television (31%). Finally, participants were asked about their imagined activities while studying for an important final examination with the following top distracting actions performed by at least one in five participants: texting (48%), listening to music (48%), accessing Facebook (36%), receiving phone calls (22%), watching television (21%), visiting websites (21%) and wearing headphones (20%). It is important to note that 40% of the participants indicated that they would study for a final examination in a quiet location. A discriminant function analysis indicated that those who preferred not to task switch [$\beta = .633, p < .001$] and those who used study strategies [$\beta = .572, p < .001$] were most likely to seek a quiet study location [Wilks' Lambda = .928, $p < .001$].

4. Discussion

4.1. On-task behavior

As predicted, even during a short 15-min observation period, and aware that they were being observed, participants were only capable of maintaining on-task behavior for a short time, averaging

less than 6 min on task before switching. This corroborates studies of computer programmers, office workers and medical students and further validates the difficulties involved in sustaining attention among students. Further, with the exception of getting up to stretch and walk around, participants' switching behavior was most often due to technological distractions including having more technology in their work area at the onset of studying, accessing Facebook, or watching television. This suggests that a combination of the need for emotional gratifications from social media plus similarity between the primary task and distractions present from additional websites might also account for distractions. The need for gratifications is also supported by the result that those who text more often in general were more easily pulled off task. This may suggest that texting provides strong emotional gratification during the day, which carries over into the study period. Similarly, those who were distracted less often—being more on task—were those who performed activities that solidified their studying such as reading their school books, writing or visiting class-related websites.

4.2. Task-switching preferences

With an average of only 10 on-task minutes during the 15-min study period, participants switched from their primary task (studying) to a secondary, distracting task every 5–6 min. The reasons behind this behavior were assessed by examining why someone expressed a general preference to task switch rather than work on a single task until completion. As predicted, participants who had more technology available in the environment as they embarked on their study period preferred task switching to unitasking. From this study alone it is not possible to assess whether having potentially distracting technology in the study environment was due to their task-switching preference, or that their task-switching preferences dictated that they prepare their study environment for that eventuality. Regardless, those who preferred to switch from one task to another more often were precisely those who exhibited a shortened attention span during the study period. It is informative that even given the scenario of studying for a final examination, half the participants texted and listened to music, a third accessed Facebook and a quarter took phone calls and watched television. This suggests their *intention* to task switch is why they load their studying environment with easily distracting, emotionally engaging technologies such as text messaging and Facebook.

4.3. Academic performance

Corroborating the work on the impact of social media on academic performance, participants who accessed Facebook one or more times during the study period had lower grade point averages. This provides partial support for Hypothesis 5 although the second half of this hypothesis—the negative impact of task switching preference on academic performance—was not validated. If, however, the lowest two grade point average groups were collapsed, those with a GPA of 3.51 or above ($N = 56$) demonstrated a significantly stronger preference for unitasking ($M = .26$) than those who had a GPA of 3.50 or less [$N = 205; M = -.01; t(259) = -1.86, p < .05$]. While task-switching preference was not a significant predictor of GPA, having study strategies predicted a higher GPA while being confused while studying predicted a lower GPA.

It is indeed striking that students who had lower GPAs were those who accessed Facebook one or more times during the short study period. From the study design, it is not clear what activities an individual participant was performing on Facebook so it is not possible to assess the rationale for this task-switching behavior.

However, it is likely that the switch from studying to Facebook may have been promoted by the inherent emotional gratification that is engendered by reading posts from friends, posting status updates or commenting on posts or photos.

4.4. Educational implications

It is clear from this research that students task switch often while studying. They even do so during classroom lectures. For example, Tindell and Bohlander (2012) reported that 91% of college students in their study had sent or received a text message in their university class and 62% felt texting should be allowed in class if it does not disturb other students. Rosen et al. (2011) found that while nearly three fourths of participants in a study where student learning was interrupted by text messages, 40% felt it was acceptable to text in class. Coupled with the result that students in the current study task switched mostly to communication modalities, this suggests a strong emotional pull for them to check in with their virtual social network of friends and acquaintances more often than every 15 min. In addition, a recent study by Rosen, Whaling, Rab, Carrier and Cheever (2012) found that 75% of college-age students checked in with their text messages every hour or less and 35% checked their social networks equally often. More telling, 41% of college students felt moderately to highly anxious if they could not check in with their text messages and one in five felt the same if they could not check in with their social networks (Rosen, Cheever, & Carrier, 2012).

With text messaging and social networking being so important to teenagers and young adults that they interrupt their classroom attention as well as their studying attention, what options are there for teachers in dealing with these potentially disruptive technologies? Rosen et al. (2011) found that while moderate texting—receiving and responding to four text messages during a 30-min lecture—did not have a negative impact on learning, excessive texting—receiving and responding to eight texts during the lecture—had a strongly negative effect on learning. Based on these results, Rosen et al. (2011) provided three potential strategies for dealing with multitasking while studying. First, since listening to music while studying did not appear to predict off-task behavior, and was also not predictive of lower grades, parents and teachers might consider allowing students to listen to music while studying. According to the Unified Theory of Multitasking music—and particularly very familiar music—should have a negligible impact on task switching and resumption lag as the task demands are low and for most study material music requires different sensory modalities, which should minimize interference.

Rosen et al.'s (2011) second strategy rests on the understanding that there are no neurological differences between externally driven task-switches and internally-driven task-switches. In addition, Foerde, Knowlton, and Poldrack (2006) found that during task switching there is a shift in neural activity from the hippocampus, which is responsible for purposeful thought processing and memory to the striatum, which is a brain region associated with more rote or habitual learning.

Many educators and parents have restricted the use of smartphones and other technology in the classroom and while studying, and some schools have either banned cell phones or required students to deposit them in a box by the door to be retrieved at the end of class. Coupled with the research showing that students who are used to checking in with their virtual social worlds through texting and social media every 15 min or less and are highly anxious when they cannot check in, this suggests that removing the external distraction does not remove the internal distraction. For younger learners “out of sight” is most definitely not “out of mind” and both internal and external interruptions

may shift neural activity away from areas that provide more thoughtful information processing (Marien, Custers, Hassin, & Aarts, 2012).

Rosen et al. (2012) suggest using “technology breaks” to remove both the internal and external distractions. Similar to a coffee break, a technology break provides the student with periodic opportunities to check in with their technology and quell their internal need to obsess over what they might be missing in their virtual social sphere. A typical technology break involves allowing students to begin class or a study period by briefly checking their smartphones and then silencing them and placing them in their work area in plain sight while they complete a study period. The upside down silent phone prevents the student from being interrupted by auditory and visual alerts and provides instead a stimulus that informs them that they will be able to check in at the next technology break. Rosen et al. (2012) report that trials using an alternating sequence of a 1-min technology break followed by a 15-min lesson or study period boosted attention and focus and enhanced learning.

The third strategy comes from Rosen et al.'s (2011) results which showed that students who waited to read or respond to a text message during lecture performed substantially better than those who opted to provide an immediate reply regardless of when the text was received. This could have reflected a metacognitive strategy to wait until the lecture material was deemed to be of lesser importance and only then addressing the interruptive text message. Metacognition is the knowledge of one's cognitive abilities and the ability to “consciously and deliberately monitor and regulate one's knowledge, processes and cognitive and affective states” (Hacker, Dunlosky, & Graesser, 1998, p. 11). As corroboration, in a study by Wijekumar and Meidinger (2005), students worked on programming exercises while being allowed to use instant messaging. Students who were assessed to possess more metacognitive skills opted to turn off the sounds on their instant messenger and only responded to messages when they were given a break. Students with lower metacognitive abilities allowed themselves to be interrupted whenever an instant message appeared regardless of their current work status.

The bottom line is that students want to multitask or task switch and technology encourages them to do so. Requiring them to untask either in the classroom or while studying will turn out to be a fruitless effort as all this does is shift from external auditory, visual and tactile distractors to an internal, anxiety-laden need to check in with their electronic worlds. As Rosen, Carrier, and Cheever (2010) concluded, “The bottom line is that our students are multitasking and we cannot stop them without placing them in a boring, unmotivating environment. The trick is to develop educational models that allow for appropriate multitasking and that improve learning.” (p. 95). These models include a combination of technology breaks and metacognitive skills that will teach students focus and attention, delayed gratification and knowing when multitasking is appropriate and when it may interfere with the learning process.

4.5. Limitations

This study was limited by the nature of its observational strategy. While observers were trained in a group to observe minute-by-minute behavior and were given a form to monitor behavior, no attempt was made to validate their observations using a second observer for reliability assessment. Further, the observers were known to the participant and were situated in the study area and although they were instructed to sit behind the participant they were not unobtrusive. This could have influenced the studying behavior although it seems likely that it would have made the participant more vigilant in studying rather than being distracted,

which may have inflated the time on the primary task before being distracted. Ideally the study should be replicated with dual unobtrusive observers in a controlled environment. Second, the study was clearly biased in that the participants were not selected randomly and, in fact, were known to the observers. However, this observation strategy was essential in obtaining participation with students studying in their standard home study environment. Second, the study was limited by the selection of grade point average as a measure of academic performance. Other studies have used different measures including performance in the class whose material was being studied. Third, the study was limited by allowing participants to study any material without regard to the type and/or difficulty. This may have influenced the results but without an assessment of the difficulty of the material there is no way to validate this assertion. Fourth, the study is limited in its correlational research design, which does not imply causation. A final limitation concerns the observed use of electronic communications and social media while studying. In this study it was assumed that all such communications were unrelated to the material being studied. It is possible, however, that students were using these tools to communicate with fellow students about the material and not for social purposes. A future study should consider assessing the purpose of using websites to determine their relevance to studying.

References

- Altmann, E. M., & Trafton, J. G. (2002). Memory for goals: An activation-based model. *Cognitive Science*, 26, 39–83.
- Anderson, J. R. (2007). *How can the human mind occur in the physical universe?* New York: Oxford University Press.
- Baddeley, A., Lewis, V., Eldridge, M., & Thomson, N. (1984). Attention and retrieval from long-term memory. *Journal of Experimental Psychology: General*, 113(4), 518–540.
- Bowman, L. L., Levine, L. E., Waite, B. M., & Gendron, M. (2010). Can students really multitask? An experimental study of instant messaging while reading. *Computers & Education*, 54, 927–931.
- Brasel, S. A., & Gips, J. (2011). Media multitasking behavior: Concurrent television and computer usage. *Cyberpsychology, Behavior, and Social Networking*, 14(9), 527–534.
- Cades, D. M., Boehm-Davis, D. A., Trafton, J. G., & Monk, C. A. (2011). Mitigating disruptive effects of interruptions through training: What needs to be practiced? *Journal of Experimental Psychology: Applied*, 17(2), 97–109.
- Cades, D. M., Trafton, J. G., & Boehm-Davis, D. A. (2006). Mitigating disruptions: Can resuming and interrupted task be trained? In *Proceedings of the human factors & ergonomics society annual meeting* (pp. 368–371). Santa Monica, CA: The Human Factors and Ergonomics Society.
- Cades, D. M., Trafton, J. G., Boehm-Davis, D. A., & Monk, C. A. (2007). Does the difficulty of an interruption affect our ability to resume? In *Proceedings of the human factors and ergonomics society 51st annual meeting* (pp. 234–238).
- Cades, D. M., Werner, N. E., Trafton, J. G., Boehm-Davis, D. A., & Monk, C. A. (2008). Dealing with interruptions can be complex, but does interruption complexity matter: A mental resources approach to quantifying disruptions. *Paper presented at the human factors and ergonomics society 52nd annual meeting*, September 22–26, New York, NY.
- Cades, D. M., Werner, N. E., Boehm-Davis, D. A., & Arshad, Z. (2010). Interruptions are disruptive in the real world: Evidence from an office setting. In *Proceedings of the 54th annual human factors and ergonomics society conference*. San Francisco, California: Human Factors and Ergonomics Society.
- Cades, D. M., Kidd, D. G., King, E. B., McKnight, P. E., & Boehm-Davis, D. A. (2010). Factors affecting interrupted task performance. Effects of adaptability, impulsivity and intelligence. In *54th Annual human factors and ergonomics society conference*. San Francisco, California: Human Factors and Ergonomics Society.
- Carr, N. (2010). *The shallows: What the Internet is doing to our brains*. New York: W.W. North & Company.
- 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.
- Common Sense Media (2012). *Social media, social life: How teens view their digital lives*. <<http://www.commonsensemedia.org/sites/default/files/research/social-mediasociallife-final-061812.pdf>>.
- Craik, F. I. M., Govoni, R., Naveh-Benjamin, M., & Anderson, N. D. (1996). The effects of divided attention on encoding and retrieval processes in human memory. *Journal of Experimental Psychology: General*, 125(2), 159–180.
- Csikszentmihalyi, M. (1990). *Flow: The psychology of optimal experience*. New York: Harper & Row.
- Dabbish, L., Mark, G., & Gonzalez, V. (2011). Why do I keep interrupting myself? Environment, habit and self-interruption. In *Proceedings of the 2011 annual conference on human factors in, computing systems* (pp. 3127–3130).
- Duncan, T. G., & McKeachie, W. J. (2005). The making of the motivated strategies for learning questionnaire. *Educational Psychologist*, 40(2), 117–128.
- 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(31), 11778–11783.
- Gonzalez, V. M., & Mark, G. (2004). Constant, constant, multitasking craziness: Managing multiple working spheres. In *Proceedings of CHI '04* (pp. 113–120).
- Hacker, D. J., Dunlosky, J., & Graesser, A. C. (1998). *Metacognition in educational theory and practice*. Mahwah, NJ: Erlbaum.
- Jacoby, L. L. (1991). A process dissociation framework: Separating automatic from intentional uses of memory. *Journal of Memory and Language*, 30(5), 513–541.
- Jacoby, L. L., Woloshyn, V., & Kelley, C. (1989). Becoming famous without being recognized: Unconscious influences of memory produced by dividing attention. *Journal of Experimental Psychology: General*, 118(2), 115–125.
- Judd, T., & Kennedy, G. (2011). Measurement and evidence of computer-based task switching and multitasking by 'Net Generation' students. *Computers & Education*, 56, 625–631.
- Junco, R. (2011). Too much face and not enough books: The relationship between multiple indices of Facebook use and academic performance. *Computers in Human Behavior*, 28(1), 187–198.
- Junco, R., & Cotten, S. R. (2011). Perceived academic effects of instant message use. *Computers & Education*, 56, 370–378.
- Junco, R., & Cotton, S. R. (2012). No A 4 u: The relationship between multitasking and academic performance. *Computers & Education*, 59, 1–10.
- Kessler, S. (2011). 38% of college students can't go 10 minutes without tech [STATS]. *Mashable Tech*. <<http://mashable.com/2011/05/31/college-tech-device-stats/>>.
- Kirschner, P. A., & Karpinski, A. C. (2010). Facebook and academic performance. *Computers in Human Behavior*, 26, 1237–1245.
- Marci, C. (2012, March 28). A (biometric) day in the life: Engaging across media. *Paper presented at Re:Think 2012*, New York, NY.
- Marien, H., Custers, R., Hassin, R. R., & Aarts, H. (2012). Unconscious goal activation and the hijacking of the executive function. *Journal of Personality and Social Psychology*. <http://dx.doi.org/10.1037/a0028955>.
- Mauri, M., Cipresso, P., Balgera, A., Vilamira, M., & Riva, G. (2011). Why is Facebook so successful? Psychophysiological measures describe a core flow state while using Facebook. *Cyberpsychology, Behavior, and Social Networking*, 14(12), 723–731.
- Monk, C. A., Trafton, J. G., & Boehm-Davis, D. A. (2008). The effect of interruption duration and demand on resuming suspended goals. *Journal of Experimental Psychology: Applied*, 14(4), 299–313.
- Moreno, M. A., Jelenchick, L., Koff, R., Eikoff, J., Diermyer, C., & Christakis, D. A. (2012). Internet use and multitasking among older adolescents: An experience sampling approach. *Computers in Human Behavior*, 28, 1097–1102.
- Ophir, E., Nass, C. I., & Wagner, A. D. (2009). Cognitive control in media multitaskers. *Proceedings of the National Academy of Sciences*, 106(35), 15583–15587.
- Oulasvirta, A., Rattenbury, T., Ma, L., & Raita, E. (2012). Habits make smartphone use more pervasive. *Personal and Ubiquitous Computing*, 16(1), 105–114.
- Poposki, E. M., & Oswald, F. L. (2010). The Multitasking Preference Inventory: Toward an improved measure of individual differences in polychronicity. *Human Performance*, 23, 247–264.
- Reimers, S., & Maylor, E. A. (2005). Task switching across the life span: Effects of age on general and specific switch costs. *Developmental Psychology*, 41(4), 661–671.
- Rose, E. (2010). Continuous partial attention: Reconsidering the Role of online learning in the age of interruption. *Educational Technology Magazine: The Magazine for Managers of Change in Education*, 50(4), 41–46.
- Rosen, L. D., Carrier, L. M., & Cheever, N. A. (2010). *Rewired: understanding the iGeneration and the way they learn*. NY: Palgrave Macmillan.
- Rosen, L. D., Cheever, N. A., & Carrier, L. M. (2012). *iDisorder: Understanding our obsession with technology and overcoming its hold on us*. New York, NY: Palgrave Macmillan.
- Rosen, L. D., Lim, A. F., Carrier, L. M., & Cheever, N. A. (2011). An examination of the educational impact of text message-induced task switching in the classroom: Educational implications and strategies to enhance learning. *Psicologia Educativa (Spanish Journal of Educational Psychology)*, 17(2), 163–177.
- Rosen, L. D., Whaling, K., Rab, S., Carrier, L. M., Cheever, N. A. (2012). Is Facebook creating "iDisorders"? The link between clinical symptoms of psychiatric disorders and technology use, attitudes and anxiety. *Computers in Human Behavior*, in press.
- Rouis, S. (2012). Impact of cognitive absorption on Facebook on students' achievement. *Cyberpsychology, Behavior, and Social Networking*, 15(6), 296–303.
- Rouis, S., Limayem, M., & Salehi-Sangari, E. (2011). Impact of Facebook usage on students' academic achievement: Role of self-regulation and trust. *Electronic Journal of Research in Educational Psychology*, 9(3), 961–994.
- Rubin, A. M. (2009). Uses-and-gratifications perspective on media effects. In J. Bryant, & M.B. Oliver (Eds.), *Media effects: Advances in theory and research* (pp. 165–184).
- Salvucci, D. D., & Taatgen, N. A. (2008). Threaded cognition: An integrated theory of concurrent multitasking. *Psychological Review*, 115, 101–130.
- Salvucci, D. D., & Taatgen, N. A. (2011). *The multitasking mind*. New York: Oxford University Press.
- Salvucci, D. D., Taatgen, N. A., & Borst, J. P. (2009). Toward a unified theory of the multitasking continuum: From concurrent performance to task switching, interruption, and resumption. In *Proceedings of the SIGCHI conference on human factors in computing systems: CHI 2009* (pp. 1819–1828). New York: ACM Press.

- Shah, V., Subramanian, S., Rouis, S., & Limayem, M. (2012). A study on the impact of Facebook usage on student's social capital and academic performance. *AMCIS 2012 proceedings*.
- Smith, C. (2012). Facebook S-1 amendment: New stats from Q1 2012 and more. *Huffington Post*. <http://www.huffingtonpost.com/2012/04/23/facebook-s-1-amendment_n_1446853.html>.
- Tindell, D. R., & Bohlander, R. W. (2012). The use and abuse of cell phones and text messaging in the classroom: A survey of college students. *College Teaching*, 60(1), 1–9.
- U.S. Census Bureau (2000). American FactFinder. <http://factfinder.census.gov/home/saff/main.html?_lang=en>.
- Wang, Z., David, P., Srivastava, J., Powers, S., Brady, C., D'Angelo, J., et al. (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., & Tchernev, J. M. (2012). The “myth” of media multitasking: Reciprocal dynamics of media multitasking, personal needs, and gratifications. *Journal of Communication*, 62, 493–513.
- Werner, N. E., Chang, J., Cades, D. M., Khan, H., Boehm-Davis, D. A., & Thi, G. (2011). What makes us resilient to interruptions? Understanding the role of individual differences in resumption. *Proceeding of the Human Factors and Ergonomics Society*, 55(1), 296–300.
- Wijekumar, K., & Meidinger, P. (2005). Interrupted cognition in an undergraduate programming course. *Proceedings of the American Society for Information Science and Technology*, 42(1).
- Wood, E., Zivcakova, L., Gentile, P., Archer, K., De Pasquale, D., & Nosko, A. (2012). Examining the impact of off-task multi-tasking with technology on real-time classroom learning. *Computers & Education*, 58, 365–374.