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Review

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ABSTRACT

Mobile phone multitasking is widely considered to be a major source of distraction in academic performance. This paper attempts to review the emerging literature by focusing on three questions concerning the influence of mobile phone multitasking on academic performance: (a) How does mobile phone multitasking impair learning? (b) Why does mobile phone use impair learning? (c) How to prevent from mobile phone distraction? We use multiple strategies to locate the existing research literature and identified 132 studies published during 1999–2014. The mobile phone multitasking and distractibility are reviewed in three major aspects: distraction sources (ring of mobile phone, texting, and social application), distraction targets (reading and attending), and distraction subjects (personality, gender, and culture). We also compare the results of these studies with the findings on mobile phone multitasking and driving, the earliest area of mobile phone multitasking research. Both limitations of existing research and future research directions are discussed.

1. Introduction

Multitasking can be simply defined as doing more than one thing at a time (Wood et al., 2012). Junco and his collaborators (Junco, 2012; Junco & Cotton, 2012) further defined multitasking as "divided attention and non-sequential task switching for ill-defined tasks as they are performed in learning situations" (Junco, 2012, pp.2237). This definition is closely related to the classical selective attention research of Michael Posner, one of the eminent psychologists of attention. Posner (1990) distinguished two types of attentional task that can help to understand multitasking. The first type is divided attention, which means individuals process more than one stimulus at the same time, resulting in imperfect selections of information (Posner, 1990). The second is rapid attention switching in which individuals only process one stimulus at a time but rapidly shift back and forth between the stimulus (Posner, 1990). In this situation, it both takes more time to process the information (Wood et al., 2012) and results in missing some information during the process of switching between the stimuli.

Building on these thoughtful definitions, in the present article, we defined mobile phone multitasking while learning specifically as both divided attention and rapid task switching between learning and off-task mobile phone use. Based on this definition, if individuals are reading a research article and checking mobile phones frequently for coming emails simultaneously or sequentially, then they are mobile phone multitasking while learning. However, if individuals are using mobile phones to read a research article for learning, then they are doing mobile learning or m-learning rather than mobile phone multitasking with off-task activities while learning.

Three major reasons motivated us to review the current literature: the prevalence of mobile phone multitasking while learning, the complexity of this issue, and the urgency of understanding this issue. First, advances in mobile phone, especially smartphone, and the wide coverage of 3G or even 4G fast speed service made mobile phone no longer just a tool for making phone call or texting. These advances dramatically promoted the number and types of activities in which we can engage in with mobile phone: finding information from website, locating address, connecting to social networks, reading online news, or taking and sharing pictures. Simply put, by using mobile phone, we can access to information at any place and in any time. Firat (2013) defined and compared two groups, digital immigrants and digital natives. Digital immigrants (Firat, 2013) refer to people born before the blooming of digital technology who got used to use paper-based communication and are struggling with catching up with the technology era. Digital immigrants are

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the "net generation" born after 1980 who can access information from anywhere at any time from any sources. Comparing to the digital immigrants group, they have some salient characteristics, including higher access speed, searching for instant pleasure, impatience in linear thinking, and most importantly, higher multitasking ability and continuous partial attention. It is so common for digital natives nowadays to use mobile phone to attend multiple streams of information while reading, doing homework, or listening to the lecture. Some of multiple streams of information are academic related. In the ECAR (Educause Center for Applied Research) study of undergraduate students and information technology (Dahlstrom, 2012), Eden reported the percentage of students using smartphone for academic purpose was about twice as many in 2012 (67%) than in 2011 (37%), through a variety of mobile-friendly institutional service and resources, including grade checking, course websites/syllabus, and course management system (Dahlstrom, 2012). However, often times, when students have access to mobile phone while learning, they are more likely to engage in off-task multitasking behaviors. Tindell and Bohlander (2012) reported 90% of university students in their study said they text messaging during classroom presentation. Murphy and Manzanares (2008) found that when instant messaging used as instructional tool, students engaged in off-task multitasking which negatively impacted learning (Murphy & Manzanares, 2008).

Second, mobile phone multitasking and learning is not a straightforward issue to investigate. For instance, it has been found that different multitasking tasks may produce different interference (Brooks, 1968; Wood et al., 2012). When we engage in two similar tasks, such as taking lecture notes (verbal) and texting (verbal), our performances are more likely to be impaired. However, our performance may not be significantly influenced when the two tasks involved are unrelated, such as taking lecture notes (verbal) and viewing a picture your friend texts you (visual). The first example is called general interference while the second one is specific interference. Therefore, in terms of mobile phone multitasking while learning, it is necessary to discuss the interference taking into account the specific type of tasks involved in, which add the complexity of the problem.

Third, in contrary to the prevalence and complexity of mobile phone multitasking while learning, few studies have explicitly investigated the relationship between mobile phone multitasking and learning outcome. While most of the current studies were self-reported and correlational, researchers started to conduct experimental studies to find out the effect of mobile phone multitasking in real world classrooms. Two review articles have been published to date. In Levine, Waite, and Bowman (2012) review article, they reviewed articles on the effects of mobile media multitasking on academic performance as well as driving, walking, and working. They concluded that media use is positively correlated with trait impulsivity and distractibility but the direction of effects is not clear. A more recent review was conducted by Carrillo and Subrahmanyam (2014). They grouped the current literature on mobile phone multitasking and learning based on the two settings of the studies, in the laboratory or in the real-world classroom, and described the differences between the findings. Studies conducted in the laboratory settings found that multitasking with mobile phone while learning had negative effects on learners' efficiency but not comprehension, while the studies conducted in classroom showed negative effects on learning and recall (Carrillo & Subrahmanyam, 2014).

The present review extended the two existing reviews in three aspects. Firstly, we not only reviewed the empirical evidence on the effect of mobile phone multitasking on learning but also reviewed variety of theories that can be used to explain the effect. Secondly, we referenced findings from the earliest and most productive area in the science of mobile phone multitasking behavior: phoning while driving (Yan, Chen, & Yu, 2013). Thirdly, we took into account the differences among specific type of tasks (i.e. ring of phone, texting, Facebook, etc.) involved in the mobile phone multitasking while learning. This article attempts to review the existing literature to answer the following three questions: How does mobile phone use impair learning? Why does mobile phone use impair learning? How to prevent from the negative effects of mobile phone multitasking while learning?

2. Method

Multiple search strategies were used to locate the existing research, including computer search of electronic databases, manual search of references of identified articles, and consultation with experienced librarian. Multiple major databases, including PsycINFO, Scopus, ERIC, and Education Research Complete, were searched. Three groups of key words were used in the initial literature search. The first group is related to mobile phone, such as mobile phone use, mobile phone use, texting, and mobile phone conversation. The second group is related to multitasking, such as distract, multitask, and media multitask. The third group is related to learning, such as learning, classroom, lecture, and academic performance.

One hundred and four studies explicitly examined mobile phone multitasking while learning have been selected under review, including self-report studies, correlational studies, and experimental studies in both laboratory and real-world classroom settings. Two criteria were used for literature selection. Firstly, the studies included in the review must examine multitasking activity that can be achieved by using mobile phone. Secondly, we included studies that investigated the cell phone use in at least one of the following ways: cell phone conversation, text messaging, social networking (e.g. Facebook or Twitter), physical operations of cell phone (e.g., picking up the phone or dialing the phone), or operations associated with finding online information through cell phone (e.g., locating an address or reading news).

3. How does mobile phone multitasking impair learning?

In general, mobile phone multitasking results in distraction through three major ways, distraction sources (e.g, Campbell, 2006; Shelton, Elliott, Eaves, Lynn, & Exner, 2009; Harman & Sato, 2011; Junco, 2012), distraction targets (e.g., Bowman, Levine, Waite, & Gendron, 2010; Fox, Rosen, & Crawford, 2009), and distraction subjects (e.g., Foehr, 2006; Zhao, Reimer, Mehler, D'Ambrosio, & Coughlin, 2013).

3.1. Distraction sources

3.1.1. Ring of mobile phone

In Campbell (2006) study, he surveyed 176 participants including both faculty and students at an American university. Most faculty and students reported ringing of mobile phone is a serious source of distraction and irritation in classroom. Campbell (2006) believed this finding can be explained at two levels: on the surface level, it is because of the normative expectations of classroom; on the deeper level, mobile phone intrusion in the classroom is a serious problem because mobile phone distraction is believed to have negative impact on learning outcome. Röer's team (Röer, Bell, & Buchner, 2014) asked 26 university students to name a list of annoying sound. Ringing of mobile phone was the second most-mentioned sound listed by 73% of the participants (the first most-mentioned sound was dentist drill). Röer's team explained the annoying nature of mobile phone ringing from the acoustics

perspective. They stated that in order to capture attention, ringtones usually "comprise sound waves in the range from 1 to 5 kHz", similar to horns, fire alerts, and bicycle bells, to which human ear is most sensitive (Röer et al., 2014, pp.34). In addition, the ringing mobile phone can change the frequency and amplitude spectrum to grab human attention. Burns and Lohenry (2010) reported that not only the ringing of mobile phone but also the vibrating of mobile phone were considered as distracting by the participants (Burns & Lohenry, 2010).

Consisted with the self-report findings reported in the above three studies (Burns & Lohenry, 2010; Campbell, 2006; Röer et al., 2014), Shelton et al., 2009 provided experimental evidence to show the distracting effect of ring of mobile phone (Shelton et al., 2009). They conducted four experiments, two in laboratory settings and the other two in real classroom settings. Findings generated by the laboratory experiments indicated the ring of mobile phone had negative impact on participants' performance on cognitive tasks, especially when the ringing was not anticipated (Shelton et al., 2009). This result was then tested in the real-world classroom. Undergraduate participants were listening to lecture on prenatal development while a standard ringtone was ringing for 30 s. The instructor kept lecturing when the mobile phone was ringing. A surprise quiz was given 5 min after the ring. Shelton's group found that students' accuracy rates on information presented while the mobile phone was ringing were significantly lower than that on information presented without ringing interruption (Shelton et al., 2009). Despite of the negative impact on information recall, Smith and his team also identified negative impact on undergraduate participants' ability to recognize semantically related items (Smith, Isaak, Senette, & Abadie, 2011).

Findings from the distracting effects of mobile phone ringing on academic performance are essentially consistent with those of the distracting effects on driving performance. For instance, Finland researchers Haddington and Rauniomaa showed that the ring of the phone, which they called as "prebeginning" of cell phone conversation, also has detrimental consequences on the driving performance (Haddington & Rauniomaa, 2011). They paid particular attention to drivers' actions when preparing for an upcoming telephone conversation while driving in order to understand how drivers solve the challenges of managing and coordinating multiple competing activities (Haddington & Rauniomaa, 2011). Three steps of behavior after the driver hearing ringtone have been identified through coding and analyzing the video recordings took from participants' natural driving in their car: (a) turning gaze from the road to looking for the cell phone; (b) taking their hands of the wheel to reach the phone, and (c) handling the ringing phone. All of these steps require drivers to off-task from driving and increase the chance of car accidents.

3.1.2. Texting

Harman and Sato (2011) conducted a survey study to reveal the relationship between frequency of texting, students' attitude toward texting in class, and their GPA. One-hundred and eighteen undergraduates took the survey in responding to questions such as their average number of text messages received and sent per day, their frequency of checking cell phones per day, and their feel of being comfortable about texting in class (Harman & Sato, 2011). The results showed that the more they received and sent text messages, the lower their GPAs. Surprisingly, they found a positive correlation between GPA and feel of being comfort texting in class and explained that students with high GPA could be confident about their ability to learn outside classroom, which lead them to feel comfortable to texting in class.

Researchers conducted experimental studied to further investigate these relationships (Barks, Searight, & Ratwik, 2011; Ellis, Daniels, & Jauregui, 2010; Gingerich and Lineweaver, 2013). In Barks et al. (2011) study, they randomly assigned 37 college students to a lecture-only group or a lecture-texting group during a ten minutes videotaped lecture and compared these two groups' performance on information retention questions based on the lecture. The score of the lecture-texting group was significantly lower than the lecture-only group, demonstrating the temporary decrement in performance when switching between texting and lecture (Barks et al., 2011). More interestingly, they found students who were less proficient at texting, as measured by their speed of texting, did a better job on the quiz than those who are fast in texting (Barks et al., 2011), possibly because students who text faster might spend more time in shifting different cognitive sets.

Ellis et al. (2010) conducted a similar experimental study with 62 undergraduate business students at a university in Southeastern US. They asked half of participants to turn off the phone while the second half of participants to send text to professor three times during the lecture and then tested students with 20 multiple choice items. They found that non-texting group outperformed texting group regardless of gender and GPA.

Recently, Gingerich and Lineweaver (2014) did two experiments with sixty-seven and fifty-six undergraduates respectively to investigate whether texting during lecture can impair learning. After randomly assigned participants in to a lecture-only group and a lecture-texting group, they not only tested two groups' performance on retention of lecture content but also asked them to predict on how well they would perform on the quiz. It was found the lecture-only group had higher scores on the quiz and felt more confident in predicting their performance.

Similar findings due to cognitive overload have been found in the texting while driving studies. Reading text message impose more cognitive load when the text messages are written in the way of "text-speak", such as we enter "ic" to represent "I see" compared with correctly spelled story (Head, Helton, Russell, & Neumann, 2012). To test their hypothesis, this group of researchers conducted a study to compare participants' performance on monitoring for vibration around their waist in terms of reaction time and correct vibration response, when reading a correctly spelled story and a "text-speak" story. More importantly, as Head, Helton, Russell, and Neumann predicted, when comparing the speed and accuracy of vibration location, the "text-speak" story condition generated more errors than the correctly spelled story condition, indicating that processing the "text-speak" story required more cognitive resources.

3.1.3. Information communication technology (ICT)

There is an inconsistent on whether Facebook associated with lower GPA (Kirschner & Karpinski, 2010; Pasek, More, & Hargittai, 2009). Karpinski and his associates reported the preliminary results of a survey on 102 undergraduates and 117 graduates. They concluded a negative association between Facebook use and students' overall GPA (Kirshner & Karpinski, 2010). Karpinski's 2009 report was soon critiqued by Pasek, More and Hargittai in terms of problems in sampling issue, analysis strategy, and descriptions findings (Pasek, More, & Hargittai, 2009). Pasek and his associates tried to replicate Karpinski's results by including more samples using national representative dataset and controlling for more variables including age, gender, race, and SES. The results of their study did not show the negative relationship between Facebook and GPA.

The studies mentioned above did not specifically note the effect of Facebook while multitasking with other activities. Some scholars began to examine the effect of Facebook from the multitasking perspective (Judd, 2014; Junco, 2012; Junco & Cotten, 2012). They have shown that multitasking with Facebook were negatively

predictive of students' overall semester GPAs, but other mobile phone multitasking activities, such as email, talking on a cell phone, or online searching were not. Junco and his associates (Junco, 2012; Junco & Cotten, 2012) investigated the relationship between different types of college students' real-world in-class multitasking with ICTs and their academic performance. The ICTs included texting, Facebook, email, instant message, talking on a cell phone, as well as online searches for contents that is irrelevant to the course. They collected the response from 1774 college students on their demographic information, high school grade point average, internet skills, and their frequency of involving in each type of multitasking based on a five-point Likert scale. Junco's team then used students' overall semester GPAs as dependent variable and conduct a hierarchical regression analysis to find out which ICTs multitasking variables predicted the semester GPAs, after controlling for demographic variables, high schools GPAs, and internet skills. Based on the result, Junco's team separated different types of multitasking with ICTs into three levels: high frequency (texting), moderate frequency (Facebook, emailing, searching irrelevant content) and low frequency (instant message and talking on phone). Among these different ICTs, only Facebook and texting during class were related to students' overall semester GPAs (Junco, 2012; Junco & Cetton, 2012).

Why Facebook is such a key contributor to multitasking behavior among college students? Ames (2013) conducted a qualitative study to understand how Stanford students managed their iPhone multitasking through the technosocial perspective. She interviewed 57 students, observed on-campus for 30 h, and surveyed 177 students at Stanford University. Through this study, she identified three concepts that contributed to college students' multitasking with iPhone: (a) the social need of constantly connecting with others; (b) the pecking order of who is well connected and who is poorly connected; and (c) the deliberated isolation from mobile phone multitasking to reduce the negative effect. Judd (2014) looked closely to students' computer-based activity usage logs at an Australian university during two months. He divided the usage logs into 20 min segment and then classified each segment into focused, sequential, or multitasking based types of activities. According to Judd, focused segment referred to segment involving no more than two tasks. Sequential segment involved no more than three non-repeated tasks. Multitasking segment had more than one repeated tasks (Judd, 2014, pp.196). Three major results were found from the data analysis on usage logs. First, Facebook was the second most common computer-based activity, compared with previewing PDF files, using word processor, using web searching engine and email. Second, different from non-Facebook sections, Facebook sections showed significantly more short duration tasks per session. Third and most importantly, Facebook use is positively related to multitasking behavior. Among other computer-based activities, Facebook sections included significantly more multitasking behaviors and less focused behaviors. As a result, Judd concluded that Facebook use is the contributing factor for task switching and multitasking behaviors.

3.2. Distraction target

3.2.1. Reading

Concurrent instant messaging use while reading have been found to have negative effect on reading speed but not reading comprehension (Bowman et al., 2010; Fox et al., 2009). Bowman et al. (2010) investigated the effect of instant messaging while reading an article. Eighty-nine college students were randomly assigned to three conditions: receiving/responding five instant messages before reading, receiving/responding five instant messages while reading, and no instant messages. The reading article on personality disorders was adapted from a psychology textbook. Bowman's team recorded and compared the time it took students from three conditions to read the article and their performance on a reading comprehension and retention test. They also collected students' information on frequency of instant message use while study in daily lives. It was found that participants who instant messaged while reading took 22%–59% greater time to finish their reading than those who instant messaged before reading or did not instant messaged at all, even after deducting the time spent on instant messaging (Bowman et al., 2010). However, they did not find significant difference on three groups' performance on the reading comprehension test. Bowman's team considered that participants may re-read certain part of the article after interrupted by the instant message. Although re-reading increase reading time, it can actually make up deficits in participants' comprehension.

In Fox et al. (2009) study, they also found that participants in the condition of reading while instant messaging took longer time to read the passage, answer the follow-up questions on reading, and complete the entire test. However, their reading comprehension performance on recognition memory test and recall memory test were equivalent to participants in the reading-only condition. In addition, they found certain interaction effect due to the difficulty of reading: participants who read GRE-level passages have significant lower scores in free-recall questions but not in multiple choice questions than those who read SAT-level passages.

3.2.2. Attention

Using mobile phone during lecture has been found to have negative impact on students' note taking and knowledge recalling. Kuznekoff and Titsworth (2013) conducted an experimental study to investigate the effect of texting and posting using mobile phone while listening to lecture on students attending (i.e. lecture listening, note taking, recall of knowledge). They asked undergraduate participants to watch a video lecture and take notes as they did in normal lectures. One third of the 54 undergraduate participants were assigned to control group while the remaining participants were assigned to either low-distraction group, receiving 12 messages or posts through mobile phone during lecture, or high-distraction group, receiving 24 messages or posts. After the video lecture, Kuznekoff and Titsworth tested students' learning through a free recall test and a multiple choice test. Participants' lecture notes were coded based on the number of lecture statements covered in the notes. The results showed that, compared to the low and high distraction group, students in the control group were able to write done 62% more information in their notes and scored significantly higher in the recall test and multiple choice test (Kuznekoff & Titsworth, 2013). In another study (Ophir, Nass, & Wagner, 2009), a group of scholars from Stanford University have also found that chronically heavy and light media multitaskers have systematic differences in information processing styles. Heavy media multitaskers have difficulty to avoid distraction from irrelevant tasks. Therefore, their scores on a task-switching ability test were surprisingly lower than those of light media multitaskers.

3.3. Distraction subject

3.3.1. Personality

It is often believed that people who are best able to multitasking are more likely to engage in multitasking behaviors. In fact, a study conducted by Sanbonmatsu and his associates revealed the opposite: people who are good at multitasking are also the persons who are good at avoid multitasking. In Sanbonmatsu, Strayer, Medeiros-Ward, and Watson (2013) study, they identified three motivations and its corresponded personalities that can predict greater

multitasking behaviors. The three motivations include: (a) multitasking is rewarding than doing one thing at a time, (b) multitasking is more interesting and challenging, and (c) multitasking is an inevitable result of failing to block out distraction. The three corresponded personalities are impulsive, high sensation seeking, and poor executive control. Impulsivity was defined as "a predisposition toward rapid, unplanned reactions to internal or external stimuli without regard to the negative consequences of these reactions" (Barratt & Patton, 1983, as cited by Sanbonmatsu et al., 2013). Impulsive people values strong rewards and are less sensitive to lose. They believe multitasking can potentially bring them more gains. High sensation seeking people enjoy the varied and complex sensation that multitasking produce even at the cost of efficiency. People with poor executive control ability usually find it is difficulty to block out distractions in order to focus only on one thing. In Sanbonmatsu's study, participants with high impulsivity level, high sensation seeking tendency, and low executive control ability are more likely to overstate their multitasking ability and report more multitasking behaviors.

Foehr (2006) analyzed survey data on media multitasking collected from a nationally representative sample of 2032 8–18 years old students. After correlating participants' self-reported media multitasking behaviors with personality traits, he found that sensation-seeking personality traits, as measured by risk-taking activities questions, can predict media multitasking, after controlling for other predictors, such as race, education, media exposure, gender, and income. Similar to Sanbonmatsu et al. (2013), Foehr (2006) believed that "sensation seekers" seek adventures and exciting experiences by media multitasking (Foehr, 2006).

Studies on phoning while driving also revealed despite of the dual-tasking condition caused by phoning while driving, behavioral characteristics of frequent-cell-phone-using drivers also predict the higher crash risk (Zhao et al., 2013). Zhao's team conducted observational and self-reported studies to investigate the association between frequent cell phone users with other measurable risky driving behavior. They found that the frequent cell phone users have higher acceptance rate of faster and aggressive driving behaviors and higher scores on the violation subscale, indicating greater willingness to break traffic rules (Zhao et al., 2013). Moreover, after observing frequent cell phone users' driving performance on the highway of Interstate 93, they found that this group of drivers are more likely to drive in a higher speed in the left lane, change lanes more frequently, and use more hard-braking while driving (Zhao et al., 2013).

3.3.2. Gender

In Foehr's (2006) study, as described above, he reported that, compared with boys, girls are more likely to be media multitasking in the classroom. Stoet, O'Connor, Conner, and Laws, (2013) conducted two experiments to test if women are better than men at multitasking. They found women outperformed men on a computer-based task-switching paradigm as well as devising strategies for finding a lost key (Stoet et., 2013). Contradicted results were found from the study of phoning while driving. The two nationwide online surveys conducted by Hallet, Lambert, and Regan (2011, 2012) revealed that, compared with females, males reported higher frequency on sending and reading text messages while driving in New Zealand.

3.3.3. Culture

Kononova (2013) conducted a study to compare the media multitasking behaviors of young people in US, Russia, and Kuwait. She found that participants US and Kuwait reported significantly more media multitasking behaviors than those in Russia (Kononova, 2013). Bowman, Waite, and Levine (2014) are among the first to compare mobile phone related multitasking while learning among Malaysian and American students. They assessed 238 American college students and 359 Malaysian college students in terms of their amount of media (e.g., mobile phone, television, computer) use, amount of reading activities (both print and online), study habit, media multitasking patterns while learning, academic distractibility, and impulsiveness. They found at least three salient differences between Malaysian students and their American peers. Firstly, Malaysian students reported more media use and instant messaging activities than American students. Secondly, Malaysian students were more likely to multitask with both electronic and non-electronic activities while learning for non-academic purpose. Last but not least, entertainment and pursing personal interests were the major focus for Malaysian students when they multitasked whereas social communication were the major focus of American students' multitasking while learning.

3.3.4. Information motives

Hwang, Kim, and Jeong (2014) made one of the first attempt to differentiate the motives for involving in different types of multitasking, including TV-base multitasking, Internet-based multitasking, as well as mobile-based multitasking. They recruited 462 Korean adults and conducted an online survey examining their motives for multitasking based on general multitasking behaviors (i.e., frequency of multitasking), content-specific multitasking behaviors (i.e., news, entertainment, or advertising), and medium-specific multitasking behaviors (i.e., TV, internet, print media, or mobile media). The results indicated that the participants are more likely to involve in mobile phone multitasking if their motives for multitasking is information seeking and exchanging (Hwang et al., 2014). In other words, mobile phone multitasking can be predicted by information motives. Hwang and his associates (2014) believed that besides the traditional function of mobile phones such as texting and making phone call, the use of smartphones promotes constant searching for information while doing other things.

4. Why does mobile phone multitasking impair learning?

4.1. Cognitive theory of multimedia learning approach

Mayer and Moreno (2003) developed the cognitive theory of multimedia learning approach based on the dual channel assumption, the limited capacity assumption, and the active processing assumption. This theory is among the earliest and best efforts in understanding how and why multitasking affect learning. According to this theory, when in the multimedia context, learners are exposed to both words and pictures, which belong to two different information processing channels, auditory/verbal channel and visual/pictorial channel. Meaningful learning requires substantial cognitive processing in both channels while learners have limited capacity. Mayer and Moreno (2003) distinguished three types of cognitive demands involved in the multimedia learning process: essential processing, incidental processing, and representational holding. Essential processing refers to the selection, organization, and integration of information in order to make sense of the learning materials. In contrary, incidental processing are not required for understanding of the materials, such as background music or decorative cartoon. Representational holding enables learners to hold information in working memory for a while.

Similar to multimedia learning, mobile phone multitasking while learning also involves different information processing channels with learners' limited capacities. For instance, while students sitting in the classroom, they need essential processing to make sense of the lecture as well as the representational holding to hold lecture content in mind in order to take notes or make

association between prior knowledge and new knowledge. Off-task mobile phone use can be viewed as incidental processing. Therefore, when students are using mobile phone during the lecture, their incidental processing may consume much capacity, resulting in cognitive overload. In order to reduce the cognitive load, the capacity for essential processing and representational holding is decreased, which obstruct the deeper cognitive processing and learning (Junco, 2012; Junco & Cotten, 2012).

4.2. Continuous partial attention approach

Firat (2013) believed that multitasking and continuous partial attention are two different concepts. Multitasking emphasizes simultaneously conducting two or more task in order to be more effective and successful, while continuous partial attention refers to both the desire of missing nothing and the interaction with everything, which usually leads to loss of focus and high-level stress (Firat, 2013). In essence, this approach distinguishes the positive or successful consequence from the negative or failed consequence of performing multiple tasks at the same time. For example, when a student sitting in the classroom, listening to the lecture, taking notes using laptop and putting a cell phone asides the laptop, he or she is aware of many things at the same time: teachers' lecture, new email notifications on the screen of a laptop, as well as possible vibrations of cell phone showing a new short message is coming. This is an illustration of partial attention: each thing takes partial attention of that student, causing problems of focusing. Therefore, for digital natives, digital world generates both positive outcome (multitasking ability) and negative outcome (continuous partial attention) (Firat, 2013).

Similar to Firat (2013)'s approach to distinguish the positive and negative consequence of multitasking, Bell and her associates (Bell, Compeau, & Olivera, 2005) developed a conceptual model to understand the social implications of technological multitasking through identifying factors that can explain why multitasking is encouraged in some situations and not others. They found both individual factors (in terms of polychronicity) and situational factors (in terms of task relevance, group interdependence, and time urgency) can influence individuals' perceptions of others' multitasking behavior (Bell et al., 2005). For instance, people who multitask with technology for high time urgency and task-relevant activities will be perceived by co-workers as "more competent, dedicated, and socially attractive" than people who multitask with low time urgency and non-task relevant activities (Bell et al., 2005, p.3).

4.3. Unified theory of the multitasking continuum approach

There are two types of multitasking behaviors in terms of the time spent or multitasking continuum, concurrent multitasking, which refers to a situation when the time interval between two difference tasks is very short or even negligible (e.g., driving while talking to passenger or listening to lecture while taking notes), and sequential multitasking, which refers to a situation when the time interval between two difference tasks is relatively long (e.g., writing an article and then reading emails or cooking and then washing fruits). Salvucci and Taatgen proposed a unified theory of human multitasking, which aim to account for both concurrent and sequential multitasking (Salvucci & Taatgen, 2008; Salvucci, Taatgen, & Borst, 2009). This unified theory consists of three components.

The first component, the ACT-R cognitive architecture theory, contributed to the unified theory by providing assumptions and descriptions on variety of independent yet interactive cognitive modules, including (a) the declarative memory module storing factual knowledge, episodic knowledge, as well as task instruction, (b) the goal module that sets goal and monitors the process, (c) the problem representation module that keeps partial information that may be needed later it the process, and (d) the procedural module that connects and control the information flow among different modules. Because each module can only work on one single task at a time, these modules can actually act as a source of interference in multitasking (Salvucci et al, 2009). For instance, a new friend of you just told you his phone number. You repeat that number in your mind and want to save it to your mobile phone as soon as possible. However, the first thing you have to do is to unlock your cell phone by entering the pin number. At this very moment, keeping the phone number in your mind may interference with retrieving your cell phone pin number, because both behaviors require your declarative module.

This leads to the crux of the second component of unified theory of human multitasking, the threaded cognition theory, which explains how multiple tasks compete, interfere, and share the modules. Salvucci and his associates hypothesized that if two tasks or treads need the same module, one tread must wait until the other tread finishes (Salvucci & Taatgen, 2008; Salvucci et al, 2009). For example, keeping the phone number in mind must wait its turn to use declarative module when retrieving the cell phone pin number, which would slow processing. If they are sharing the declarative module at the same time, the interference between these two behaviors may make your either entering the wrong pin number or saving the wrong phone number.

The third component, the memory-for-goals theory, concerns with the recovery/resume time of the initial task after interrupted by another task (Altmann & Trafton, 2002). Based on this theory, the original task will take much time to recover and complete if interruptive tasks occurs. For instance, a friend of you calls in when you are writing an essay. Then, you pause your writing and have a nice conversation with friend. However, after you hang up the phone and resume your writing, you will find that it takes times for you to go back to your train of thoughts.

4.4. Inattention blindness and attentional blink approach

Theories that have guided the study of phoning while driving could also be used to explain mobile phone multitasking and learning. Strayer, Watson, and Drews (2011) generated a framework for conceptualizing the sources of driver distraction. In their framework, they attributed three factors that cause the driver distraction, namely, visual factor, manual factor, and cognitive factor. They further differentiated different level of multitasking situations in terms of their demands on the visual, manual, and cognitive resources. For example, Strayer et al. (2011) considered listening to a radio program while driving as a low-level multitasking situation because it demands little visual, manual, and cognitive resources. Driving while manipulating a touchscreen devise, such as smartphone, on the other hand, was regarded as a high-level multitasking situation that required substantial visual, manual, and cognitive processing simultaneously. Their framework hypothesized that high level multitasking situation are more likely to generate car accidents compared with the low level multitasking situation, which only place little demand on visual, manual, and cognitive resources (Strayer et al., 2011). Based on this framework, Strayer et al. (2011) raised and tested the hypothesis of inattention blindness, which refers high level multitasking situation, such as having mobile phone conversation while driving, distracts driver's attention to process information necessary to drive safely. If we apply this hypothesis to learning setting, we could assume that using mobile phone to text or manipulate Facebook while learning has negative impact on the learning effectiveness.

5. How to best prevent from mobile phone distractibility?

5.1. Raise public awareness

It is important to make students correctly understand their actual multitasking ability and to recognize that the habit of constantly engaging in multitasking activities may have profound impacts on basic cognitive abilities (Ophir et al., 2009; Sanbonmatsu et al., 2013). This could be the first preventive strategy to decrease the negative impact of mobile multitasking on learning. Schlehofer's team (Schlehofer et al., 2010) revealed that people's actual multitasking ability is adversely correlated with their perceived multitasking ability. That means people usually tend to overestimate their multitasking ability. Furthermore, students who multitask during the lecture often are not aware the negative impact of this behavior on their learning (Hammer et al., 2010). Hammer and his associates (2010) asked 127 technological college students on their opinions on using mobile phones during lecture for non-academic purpose. Although 90% of students admit mobile phone use may distract students' attention in the class, 75% of students believed non-academic usage of mobile phone is legitimate and no harm to their learning. Ophir and his associates (2009) found that people frequently engage in media multitasking were more likely to have lower scores on a variety of cognitive laboratory tasks. Cain and Mitroff (2011) identified that heavy media multitaskers have a wider attentional scope to ignore task-irrelevant information than low media multitaskers (Cain & Mitroff, 2011). Firat (2013) believed that it is important to develop the ability to turn off the computer or put down the mobile phone and enhancing self-regulation skills because digital natives should develop their multitasking ability but not their continuous partial attention experience.

5.2. Practice dual-task skills

Several researchers documented for the first time the potential benefits of mobile phone multitasking. For example, Atchley and Chan (2011) reported that engaging in cell phone conversations when driving may prevent drivers from decreasing attention caused by the monotony of driving. By using a driving simulator, they assigned 45 undergraduate students into three multitasking conditions and measured their changes in vigilance in terms of lane keeping, vehicle control, and reaction time. The three conditions included: (a) driving without cell phone conversations, (b) driving with continuous cell phone conversations, and (c) driving with cell phone conversations only at the end of the task, when the vigilance was the lowest. The results indicated that, with the decline in vigilance, participants' lane keeping performances were declined over time. However, having a cell phone conversation, when vigilance was the lowest, could improve participants' stability in lane keeping. They also found that, toward the end of the driving task, having a cell phone conversation was associated with both fewer roadway infractions and better steering variability, compared with drivers without cell phone conversations or with continuous cell phone conversations. Nevertheless, despite of these benefits of strategically using cell phone conversations on driving performance, the authors were cautious when drawing conclusions. Similarly, Becic and his team (Becic, 2009) found that, for a routinized task, the second task improved the performance, but for a task that requires a great amount of attention, the secondary task imposed costs.

In regard to this potential benefit of mobile phone multitasking, as well as to decrease the negative impact of mobile multitasking on learning, some scholars believed that the negative impact of multitasking can be overcome by practicing dual-task skills (Meyer, & Kieras, 1997). They proposed that, when declarative knowledge is converted to procedural knowledge through practice, the two tasks can be performed at the same time (Meyer, & Kieras, 1997; Schumacher & Lauber, 1999). Nevertheless, Broadbent, Cooper, FitzGerald, and Parkes (1982) claimed that, although dual-task can be improved with practice, interferences still occur when task were difficult. Wood's team (Wood et al., 2012) reported that repeated practice with technologies did not improve performance over time. Empirical evidence from the studies of mobile phone use while driving may further shed lights on this issue. Cooper, Strayer, and City (2008) asked two groups of drivers, one group reported high frequency of cell phone use while the other group reported low cell phone use in their daily driving, to participate in nighty-minutes simulated dual tasking practices in four successive days. Their performance on crashes, following distance, break reaction time, and speed compliance in the dual task conditions were then measured to test if there were any improvements resulted from the previous practices sessions. However, they were not able to find significant improvements among these two groups, indicating that dual task practice may not eliminate the detrimental effects of phoning on driving.

5.3. Develop effective policy

The third preventive strategy to decrease the negative impact of mobile multitasking on learning is to develop effective policy to regular distracting behavior at school in general and at classroom in particular. As an emerging fielded of research (Gao, Yan, Zhao, Pan, & Mo, 2014), studies on mobile phone policies started to find out the perception of faculty and students on mobile phone policy (Campbell, 2006) and the effectiveness of mobile phone policy (Gao et al., 2014; Hopke & Marsh, 2011; Wei & Wang, 2010). Campbell (2006) conducted a survey with ninety-six students and eighty faculty members from different disciplines to understand their perception of mobile phones use in classroom. He designed and included items in the survey that specifically addressed the issue of mobile phone policy both at the school level and a classroom level, such as “I would agree with a university policy against mobile phone use (i.e. talking, text messaging, etc.) during class time”, “I would agree with an instructor's policy against mobile phone use (i.e. talking, text messaging, etc.) during class time”, and “I would agree with a university policy against mobile phones ringing during class time” (Campbell, 2006,pp.23). In general students and faculty members supported the policies of mobile phone restriction in classroom. Among other age groups, younger participants aged 18–23 provided significantly less support for mobile phone policies.

Several studies addressed the effectiveness of mobile phone policy (Gao et al., 2014; Hopke & Marsh, 2011; Wei & Wang, 2010). For instance, in Hopke and Marsh (2011) study, they surveyed one hundred and eighty nigh university students on their knowledge of mobile phone policy in a particular course and their corresponding mobile phone use in that course. Hopke and Marsh (2011) found clearly-stated mobile phone policy on syllabus decrease students' mobile phone use in the classroom. Gao and his associates (2014) reported elementary, middle and high schools teachers participated in their study did not consider mobile phone school policy has effectively reduced students' mobile phone use and prevented students from distraction. In a study conducted by Wei and Wang (2010), they closely examined if teachers' verbal and nonverbal intervene with students' mobile phone use during lecture can moderate students' mobile phone use. However, they did not find the relationship between high level of teacher immediacy behavior and students' reduced mobile phone use. They believed that college

students' use of text messaging is mostly explained by their mobile phone use habit (Wei & Wang, 2010).

6. Conclusion

This paper attempts to review the emerging literature by focusing on three specific questions concerning the influence of mobile phone multitasking on academic performance. First, regarding how mobile phone multitasking impairs learning, the existing literature indicates that mobile phone multitasking results in distraction through three major ways: distraction sources, distraction targets, and distraction subjects. Distraction sources include ring of mobile phone, texting, and social networking such as Facebook use and instant message use. Second, the existing literature we have reviewed offers several theoretical explanations why mobile phone multitasking impairs learning. According to the cognitive theory of multimedia learning approach (Mayer & Moreno, 2003), mobile phone multitasking may impair learning because mobile phone use takes up the limited capacity of learners' information processing channels and leaves insufficient space for meaningful learning. According to the continuous partial attention approach (Firat, 2013), it is not multitasking but continuous partial attention that leads to loss of focus and high-level stress. From the unified theory of multitasking continuum perspective (Salvucci & Taatgen, 2001; Salvucci & Taatgen, 2008; Salvucci et al, 2009), mobile phone multitasking impairs learning for three possible reasons: (a) Both mobile phone using and learning require the same cognitive module but this cognitive module can only process one task at a time; (b) to process mobile phone using and learning in one cognitive module, one task must wait for the other, leading to the compete and interfere of the two tasks; and (c) the recovery and resume time of the initial task after interrupted by another task makes learning takes longer time when interrupted with mobile phone use. Third, the existing literature suggests a few strategies to prevent from mobile phone distractibility, including (a) raising public awareness of the negative impact of mobile phone multitasking on learning, (b) practicing dual-task skills while the effectiveness of this strategy is not clear, and (c) developing effective policy.

Does multitasking with mobile phones affect learning? As presented at the beginning of this review, we were motivated to seek answer for this question because (a) the prevalence of mobile phone multitasking while learning; (b) the complexity of this issue; and (c) the urgency of understanding this issue. These three motivations are satisfied through reviewing the existing literature. Firstly, we found mobile phone multitasking is prevalent among learners, for both genders and in different cultures, nowadays through ringing of mobile phone, texting, and social networking while they are reading and attending to lectures, especially for those who are impulsive, high sensation seeking, poor executive control as well as those who values information seeking and exchanging. Secondly, the present review indicates that this question deserves a sophisticated rather than straightforward answer. As indicated by our review, multitasking with mobile phones do distract learning via different ways and different mechanisms and the distraction can be prevented and intervened with different strategies. On the other hand, however, one will arrive at different assessments when taking into account characteristics of various mobile phone use, characteristics of various learning tasks, and characteristics of various learners. For instance, Facebook use is negatively predictive of students' overall semester GPAs (Judd, 2014; Junco, 2012), whereas mobile phone multitasking with email, with phone talking, or with online searching were not (Junco, 2012; Junco & Cotten, 2012). Thirdly, the study of mobile phone multitasking in learning generally is still in the early stage. Self-reported data and correlational design are a norm rather than an exception, which make it difficult to determine directions and mechanisms of the causal relations between mobile phone multitasking and academic performance. Further systematic research programs are needed to fully understand the mobile phone multitasking phenomenon and help learners to avoid potential multitasking distractions and develop effective multitasking skills in the modern society.

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