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Gender differences in multitasking experience and performance

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Abstract

There is a widespread stereotype that women are better at multitasking. Previous studies examining gender difference in multitasking used either a concurrent or sequential multitasking paradigm and offered mixed results. This study examined a possibility that men were better at concurrent multitasking while women were better at task switching. In addition, men and women were also compared in terms of multitasking experience, measured by a computer monitoring software, a self-reported Media Use Questionnaire, a laboratory task-switching paradigm, and a self-reported Multitasking Prevalence Inventory. Results showed a smaller concurrent multitasking (dual-task) cost for men than women and no gender difference in sequential multitasking (task-switching) cost. Men had more experience in multitasking involving video games while women were more experienced in multitasking involving music, instant messaging, and web surfing. The gender difference in dual-task performance, however, was not mediated by the gender differences in multitasking experience but completely explained by difference in the processing speed. The findings suggest that men have an advantage in concurrent multitasking, which may be a result of the individual differences in cognitive abilities.

Keywords

Gender difference; multitasking; dual-task performance; task switching; experience

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Introduction

Multitasking is very common in daily life, and the study of multitasking has far fetching implications on the understanding of human performance and well-being. Two aspects of multitasking have been studied extensively, including dual-task performance (e.g., Dux et al., 2009; Pashler, 1994; Schumacher et al., 2001; Strayer & Johnston, 2001), that is, performing more than one task at the same time (e.g., driving while talking on cell phone) and task switching (e.g., Mayr & Kliegl, 2003; Monsell, 2003; Rogers & Monsell, 1995), that is, rapidly switching between tasks (e.g., toggling between writing and viewing videos online). In dual-task paradigms, the stimulus of the second task is usually presented before one explicitly responds to the first task, such that there is an overlap of the stimulus presentation to response production period between the two tasks. In the task-switching paradigms, the stimulus of the second task is always presented after one has responded to the first task. In the literature, there are several variants of task-switching paradigms that differ in the components of task switching. Specifically, task switching has been defined as switching between judgements, stimulus dimensions, stimulus-response mappings, response sets, and stimulus set in a recent study on individual differences in task switching (von Bastian & Druey, 2017).

Gender differences in multitasking ability

Human gender differences continue to be a very important and interesting topic in both public discussion and scientific research. In the past decades, gender differences were extensively studied in many domains, including physical health (e.g., Naugler et al., 2007), mental health (e.g., Weissman & Klerman, 1977), hemisphere specialisation (Hirnstein, Hugdahl, & Hausmann, 2019; Hiscock et al., 2001), personality (e.g., Costa et al., 2001), economic preferences (e.g., Croson & Gneezy, 2009), decision-making

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(e.g., Byrnes et al., 1999), mate selection (e.g., Buss, 1989), cognition (e.g., Denno, 1982; Linn & Petersen, 1985), and so on.

There seems to be a widespread belief that women are better at multitasking than men in the general public. The media (e.g., Fisher, 1999; Hambrick et al., 2010; Pease & Pease, 2003) tended to portray women as being better at multitasking than men. A more recent online survey of 488 participants from various ethnic backgrounds (the United States, the United Kingdom, Germany, the Netherlands, Turkey, and others) revealed that 50% of participants believed in gender differences in multitasking, and among them, 80% believed that women were better multitaskers (Szameitat et al., 2015). Another recent study (Strobach & Woszidlo, 2015) examined 241 young and older German participants and found that gender stereotype in multitasking existed, and over 80% of the stereotype holders believed that women performed better in multitasking situations than men.

Despite the great interest from the general public in this topic and the widespread belief that women are better at multitasking, it is surprising that scientific studies for gender differences in multitasking were relatively scarce and the findings were inconsistent. Hambrick et al. (2010) found that men outperformed women in SynWin (Elsmore, 1994), a relatively complex concurrent multitasking paradigm, but this advantage was fully mediated by the video game playing experience. Colom et al. (2010) found that men outperformed women in intelligence, working memory capacity, and multitasking performance on two concurrent multitasking paradigms. The first one was a divided attention paradigm that assessed the total workload in performing two different tasks simultaneously. The second one was a funnel task that required participants to figure out how to guide three dots towards a funnel simultaneously. Mäntylä (2013) found in his study that men outperformed women in a concurrent multitasking paradigm in terms of performance of the four component tasks, but the gender difference was fully mediated by the gender difference in spatial ability. Recently, a similar study (Mäntylä et al., 2017) showed that men outperformed women in a concurrent multitasking paradigm involving spatial relational processing with a higher combined score of the four component tasks. On the contrary, Stoet et al. (2013, Experiment 1) found that women outperformed men in a task-switching paradigm which required participants to switch back and forth between a shape task and a filling task. More specifically, women got a smaller mixing cost, calculated as the reaction time (RT) difference between the single-task trials in pure blocks and task-repeat trials in mixed blocks, than men in the task-switching paradigm. Ren et al. (2009) also found that women showed lower switch costs than men in a task-switching paradigm that consisted of a Go/No Go task and a flanker task. Moreover, other studies showed that there were no gender differences in multitasking ability (Hirnstein, Larøi, & Laloyaux, 2019; Strayer et al., 2013; Tschernegg et al., 2017).

Different processing limitations underlying multitasking

In one of our previous studies (Lui & Wong, 2020), we performed exploratory factor analyses (EFAs) to examine whether multitasking costs measured in concurrent multitasking (e.g., dual-task) and task-switching paradigms reflect one general or multiple separable processing limitations. We revealed three different processing limitations underlying multitasking, namely response selection, retrieval and maintenance of task information, and task-set reconfiguration. The response selection limitation refers to the limitation in choosing more than one response at the same time, which occurs in concurrent multitasking paradigms (see Pashler, 1994 for a review). For example, in a dual-task paradigm, RT of trials involving two tasks (i.e., dual-task trials) was typically longer than RT of trials involving only one task (i.e., single-task trials) because there was a bottleneck in selecting two responses concurrently. Therefore, the response selection limitation can be measured by the dual-task cost which is the RT difference between dual-task trials and single-task trials. The second and third processing limitations are typically regarded as limitations in two stages of task switching, in which participants were asked to alternate between two tasks (e.g., Monsell, 2003). The retrieval and maintenance of task information (Mayr & Kliegl, 2003) refers to the process of retrieving task information from long-term memory into working memory and maintaining the information in working memory. This continues until task set reconfiguration (Mayr & Kliegl, 2003; Rogers & Monsell, 1995), which refers to the process of reconfiguring the cognitive system for a new task. The limitations in task switching can be measured by switch cost, which is the RT difference between trials that are different to the previous trial (i.e., switch trials) and trials that are the same as the previous trial (i.e., repeated trials). More importantly, it was found that these processing limitations were weakly correlated with each other, suggesting that they were measuring different aspects of multitasking ability.

The inconsistent findings about gender differences in multitasking could result from the possibility that men and women are superior at different aspects of multitasking respectively. A curious pattern from previous gender difference studies is that all studies showing an advantage for men have adopted concurrent multitasking paradigms (Colom et al., 2010; Hambrick et al., 2010; Mäntylä, 2013; Mäntylä et al., 2017), while the two studies showing an advantage for women (Ren et al., 2009; Stoet et al., 2013) have adopted task-switching paradigms. The studies showing no gender differences in multitasking either used complex multitasking paradigms containing elements of both concurrent multitasking and task switching (Strayer et al., 2013) or did not contrast the multitasking performance to a single-task condition in the measurements (Tschernegg et al., 2017), or both (Hirnstein, Larøi, & Laloyaux, 2019). It is therefore possible that gender difference depends on the type of multitasking ability concerned. This was partly supported by Lui and Wong's (2020) finding that males were associated with a smaller response selection limitation closely tied to dual-task costs than females, but no gender difference was found in retrieval and maintenance of task information related to task-switching costs. A recent study (Hirsch et al., 2019) examined gender differences in concurrent multitasking and task switching at the same time and found no gender differences in either paradigm after controlling for gender differences in working memory, processing speed, spatial abilities, and fluid intelligence. However, multitasking experience, which may be a critical factor influencing multitasking ability was not examined (more discussion in the next section). In this study, we included both a dual-task paradigm and a task-switching paradigm as measures of multitasking ability. Apart from multitasking ability, we also measured multitasking experience and asked whether gender differences in multitasking experience could explain gender differences in multitasking ability.

Gender differences in the amount of multitasking experience

Another interesting question concerns the source of gender differences in multitasking ability. Hambrick et al. (2010) found that video game playing experience fully mediated the gender difference in multitasking ability while Mäntylä (2013) showed that the gender difference in spatial ability fully explained the gender difference in multitasking ability. However, it is surprising that no studies have examined whether gender differences in the amount of multitasking experience could account for gender differences in multitasking ability.

From the evolutionary perspective, there was a rigid labour division between men and women to adapt to the demands of the environment. For example, Silverman and Eals (1992) proposed the Hunter–Gatherer Hypothesis, suggesting that the natural selection process favoured hunting-related skills in men and gathering-related skills in women. More recently, Offer and Schneider (2011) found that mothers on average spend 10 more hours per week than fathers in multitasking involving housework and child care. Sayer (2007) further pointed out the gender differences in multitasking at home was enlarged for parents who were employed for long hours. Mothers who faced the greatest employment time demands used multitasking as a strategy to squeeze tasks in very little time, whereas the level of fathers' working hours did not have any effects on their multitasking at home. Besides, it has been found that women switched between categories more frequently than men in performing a verbal fluency task (Lanting et al., 2009; Weiss et al., 2006). Recently, studies on media-based multitasking behaviour suggested that teenage boys spent more time in playing video games than girls, but teenage girls spent more time than boys in media multitasking (Cotten et al., 2014; Foehr, 2006; Rideout et al., 2010). The media involved either do not require continuous attention (e.g., instant messaging, email, and websites) or are not very attention demanding (e.g., music). All of these studies seem to suggest that women are more habitual multitaskers than men. From the differential-experience perspective, gender differences in multitasking experience may therefore lead to gender differences in multitasking ability. It is therefore interesting to examine whether gender differences in the amount of multitasking experience is one of the sources of gender differences in multitasking ability.

Gender differences in the effect of multitasking experience on multitasking ability

Another possibility is that it is the qualitatively different multitasking experience, not the difference in the amount of multitasking experience, that causes gender differences in multitasking ability. Research has suggested that multitasking experience could affect different cognitive abilities including multitasking ability, with again mixed findings. Ophir et al. (2009) devised a media multitasking questionnaire to assess the extent to which an individual uses multiple media at the same time. Surprisingly, they found that heavy media multitaskers performed worse in task switching than light media multitaskers. In the same study, heavy media multitasking was also associated with worse performance in other cognitive tasks that measure one's ability to filter out irrelevant information when attending to visual stimulations and when updating content in working memory. It was concluded that a prolonged experience of multitasking with media was associated with a breadth-biased processing style and weakened ability to filter out irrelevant stimuli and tasks (Lin, 2009). It has also been shown that during a visual search task, heavy media multitaskers were less able to filter out apparently irrelevant information from the auditory modality (Lui & Wong, 2012).

On the contrary, Minear et al. (2013) showed that heavy and light media multitaskers performed at similar levels in tasks involving selective attention, working memory update, and task switching. Baumgartner et al. (2014) showed that heavy media multitaskers were better (not worse) at ignoring irrelevant distractions measured in a flanker task, though they did not have any advantage in task switching. Moreover, in Alzahabi and Becker's (2013) study, heavy media multitasking was associated with better performance in task switching. It is therefore difficult to conclude from the inconsistent findings whether multitasking experience is associated with better or worse task-switching ability.

One could attribute the conflicting findings of the effects of multitasking experience on multitasking ability to differences in specific task settings, characteristics of participants, the time at which the studies were conducted, and so on (Alzahabi & Becker, 2013; van der Schuur et al., 2015). A potential factor that has been overlooked concerns the type of multitasking experience. For example, gender differences have been found not only in terms of the amount but also the type of multitasking. Offer and Schneider (2011) suggested that fathers' multitasking at home involved less housework and child care. Studies on media-based multitasking behaviour (Cotten et al., 2014; Foehr, 2006; Rideout et al., 2010) suggested that teenage girls spent more time on multitasking with social networking sites, music, and online reading, whereas boys spent more time on playing games. It is therefore important to examine whether gender would moderate the effect of multitasking experience on multitasking ability. This would in turn provide another explanation for gender differences in multitasking ability.

Different methods in measuring multitasking experience

Measures of multitasking experience have been very limited until recently. This is because of the difficulty in developing a measure that is reliable, comprehensive, cost-effective, and suitable for different groups of individuals, as discussed below. The majority of studies of chronic multitasking adopted the media multitasking questionnaire devised by Ophir et al. (2009). One advantage of self-reports like this is their ability to cover a wide range of behaviours. Also, given the prevalence of media nowadays, one could argue that media multitasking is representative of multitasking at least in more developed parts of the world. However, the validity of the questionnaire depends on whether individuals have good insight and memory of the details of their multitasking behaviour. The questionnaire requires one to report, for the past year, the average number of hours spent each week in each of 11 primary media, as well as the extent to which one uses the other media at the same time as each primary medium. This amount to over 100 numbers to fill in, and the validity of responses are questionable. First, it is sometimes hard for participants to distinguish between primary and secondary media. Second, some tasks such as listening to music may be more passive when they are engaged as secondary tasks and thus the situation may not be as demanding as a multitasking experience. Indeed, past studies have shown that humans tended to overestimate their ability to multitask (Sanbonmatsu et al., 2013), underestimate their task-switching frequency (Brasel & Gips, 2011), know little about their susceptibility relative to others to performance impairment due to multitasking (Finley et al., 2014), and fail to choose the ideal combination of tasks that would result in minimal costs during multitasking (Nijboer et al., 2013). One could therefore question the adequacy of relying on self-reports alone to measure multitasking experience.

In response to the shortcoming of self-reports, other multitasking experience measures based on behaviours have become more popular in recent years. Recording of computer usage is one common method. Grace-Martin and Gay (2001), for example, gave university students laptop computers to track their web browsing behaviour for a semester. It was found that those who spent more time on web browsing while attending class also obtained lower final grades. Rosen et al. (2013) observed middle school, high school, and college students studying for 15 min in their usual study environment. They found that those with a positive attitude towards task switching tended to have more distracting technologies (computer, cell phone, television, video games, etc.) available during study and also were less able to stay on a task (e.g., reading a book and writing on paper) for long. Other studies used computer software to log switches between content on computers to characterise multitasking behaviour (e.g., Judd & Kennedy, 2011; Spink et al., 2006; Yeykelis et al., 2014). Unlike self-reports, monitoring computer usage does not require an individual to have detailed insight of their multitasking behaviour. Besides, experience measurement can occur in a more natural and private setting (e.g., home) without the constraint of proper computer use expected in work or school environment (Benbunan-Fich et al., 2011). One may argue that this method focused heavily on multitasking within a single device (computer) and may thus provide a very limited and situation-specific measure of multitasking experience. However, given the rapid enhancement of the functions of computers and the prevalence of computer usage, computer-mediated multitasking could account for most instances of multitasking, especially for the younger generation.

Another behaviour-based method involves direct observations of one's multitasking tendency in a laboratory to infer one's chronic multitasking experience. Reissland and Manzey (2016), for example, asked participants to perform two tasks (odd/even discrimination for digits, consonant/vowel discrimination for letters). While performing one task, the participants could always preview the other task and were free to decide when to switch to the other task. A large individual difference was observed in terms of the tendency to switch. Calderwood et al. (2014) asked college students to study or complete homework assignments in a laboratory for 3 hr, during which video cameras and an eye tracker were used to monitor multitasking behaviour. Multitasking was frequent and was associated with lower study/homework motivation as well as negative affect. Brasel and Gips (2011) had participants come to a laboratory for 30 min with a computer connected to the internet and a television set, and used video cameras to record how their eye gaze switched between the two media. It was found that young college students switched more than older college staff, and participants in general underestimated their switching frequency by almost 90%. It is debatable whether the tendency measured in a laboratory reflects chronic experience in daily life. But if that is the case, then laboratory observations could be another objective method that shares the advantages of recording of computer usage, yet could be less time-consuming and less intrusive.

Overall, various measures of multitasking experience have their pros and cons. This study will benefit from the use of multiple multitasking experience measures.

The current study

There were four objectives in this study. First, we examined whether women and men differ in concurrent and sequential multitasking ability. Second, we used multiple measures of multitasking experience and examined whether there were gender differences in the amount of multitasking experience. Third, we examined whether gender differences in the amount of multitasking experience could explain gender differences in multitasking ability by performing mediation analyses. In the mediation analyses, we also controlled for possible gender differences in five additional cognitive abilities that were found to be associated with multitasking performance including processing speed, working memory capacity, working memory update, inhibition, and interference control (Hirsch et al., 2019; Lui & Wong, 2020; Redick et al., 2016). Finally, we examined whether the effects of multitasking experience on ability depends on gender by performing moderation analysis.

A group of participants' multitasking experience and ability were measured. Four experience measures were used, including two detailed self-reports, computer usage tracking, and behavioural observations in a laboratory. We first evaluated the reliability of each measure on repeated testing (except for the reliability of Multitasking Prevalence Inventory which was evaluated by calculating the Cronbach's alpha), and then the correlations between these measures to know the extent to which they tapped on overlapping aspects of multitasking experience. The multitasking ability was measured by two paradigms including a dual-task paradigm and a task-switching paradigm to indicate different aspects of multitasking ability. Participants' video game playing experience was also measured as an additional experience measurement.

Method

Participants

One hundred and twenty-nine university students from The Chinese University of Hong Kong, including 60 men and 69 women were recruited with monetary compensation to participate in the experiment (approved by the Survey and Behavioural Research Ethics Committee). The participants were between 18 and 31 years old (M=20.16, SD=1.94). All reported normal or corrected-to-normal visual acuity and no perceptual or cognitive disorders. This sample size was determined for two reasons. First, as the path analyses and structural equation modelling (SEM) involved eight measurement variables (gender, four multitasking experience measures, video game playing experience, and two multitasking ability indicators), 120 subjects would be required to achieve a subject-to-variables ratio of 15, which was considered to be good for SEM analyses (Nunnally & Bernstein, 1967). Second, this sample size enabled detection of a medium effect size with Cohen's d=.5 with a statistical power of .8. The effect size with Cohen's d=.5 is within the range of effect sizes (.27–.82[1]) found in previous gender difference studies in multitasking (Hambrick et al., 2010; Mäntylä, 2013; Mäntylä et al., 2017; Stoet et al., 2013). It is also similar to the effect size used for power analysis in a similar recent study examining gender differences in both dual-task and task-switching paradigms was 0.6 (Hirsch et al., 2019). In addition, with the large number of tasks involved and measurement of personal computer usage, higher rates of attrition and of subject filtering (due to the failure to follow instructions) were expected. As a result, we planned to recruit about 130 participants and retain around 120 of them in the final sample.

Among the 129 participants, 7 of them were discarded due to poor performance in at least one of the multitasking paradigms (below 70% accuracy although within 3 SD of the mean accuracy of all participants), and 3 of them were discarded as their number of switches were more than 3 SD of the mean switches in the laboratory switching tendency observation paradigm. Another 2 participants were discarded because they got less than 2 hr data, and the data were recorded in only one or two occasions out of the 4-week period. Data of the remaining 117 participants whose age were between 18 and 31 (M=20.27, SD=2.00), including 56 males (age: M=20.26, SD=1.83) and 61 females (age: M=20.29, SD=2.18), were subjected to further analyses.

Procedure

All participants were tested on four measures of multitasking experience and two measures of multitasking ability and five additional short measures of other cognitive abilities. The purpose of measuring the five additional cognitive abilities is to explore whether there are gender differences in other cognitive abilities and also control for such gender differences when examining gender differences in multitasking ability. Apart from the computer usage monitoring measure of multitasking experience, which was done by installing a computer monitoring software on participants' personal computer for 4 weeks, all other measures were done in the laboratory and in the same sequence for all participants. The laboratory testing lasted for about 4.5 hr in total and was completed in three sessions with a 2-week separation between consecutive sessions. In Session 1, participants first filled in the media use questionnaire followed by performing the laboratory switching tendency paradigm and a processing speed test. Afterwards, they answered two video game playing questions and filled in the Multitasking Preference Inventory (MPI). At the end of Session 1, they were given the computer monitoring software and instructions of how to instal the software in their personal computer. In Session 2, participants filled in again the media use questionnaire and performed again the laboratory switching tendency paradigm for calculating the test–retest reliability. Afterwards, participants performed a task-switching paradigm with 2:1 cue to task mappings, a flanker task, and a stop signal task. In Session 3, participants performed an equal-priority dual-task paradigm, a letter memory task, and an operation span task.

Participants received a fixed amount of monetary compensation for the participation in the study, plus an extra bonus based on their performance in the laboratory switching tendency observation paradigm. All personal information and measures of this study were kept strictly confidential in the laboratory computers that can only be accessed by the authors. Participants' identity will not be disclosed in the material that is published.

Multitasking experience measure 1—computer usage monitoring

A computer usage monitoring software—ActivTrak (http://activtrak.com/) was installed on the participant's personal computer for 4 weeks. The software can monitor the usage of a computer and create an activity log of it. The activity log provides information about which software are being activated at a given time. In the data file, each row represents one record. When the participants switched between task (e.g., from Microsoft Word to Microsoft Excel or from one website to another website using the same browser), a new record was created. The columns contain variables that mark the information about the record including time, date, software name, URL, and title bar name. Apart from these variables of interest, no other information about the tasks was examined.

A switching index, indicating the number of switches per hour between tasks was calculated by dividing the total number of switches by the total duration (in hours). The total number of switches is simply the count of records minus 1 and total duration is the sum of duration of the records.

Multitasking experience measure 2—media use questionnaire

The media use questionnaire was developed by Ophir et al. (2009) to assess people's amount of media multitasking experience. Part 1 of the questionnaire asks about the number of hours one spends each week for the last year in using 11 primary media, including print media, television, computer-based video, music, non-music audio, video or computer games, telephone and mobile phone voice calls, instant messaging, text messaging, e-mail, web surfing, and other computer-based applications. Part 2 requires the participant to fill in a media multitasking matrix with the number 0, 1, 2, or 3 to indicate how often one uses each of the other media (including SMS—short message service for mobile phones) at the same time with a primary medium. A formula was used to calculate, for each participant, a media multitasking index (MMI) to indicate the mean number of media the participant is engaged in concurrently. Participants filled in this questionnaire twice in the first and second sessions respectively.

Multitasking experience measure 3—laboratory switching tendency observation

This paradigm aims at observing one's natural task-switching tendency as a proxy of one's previous multitasking experience. Participants were asked to perform four tasks (calculation, visual search, text entry, and modified Stroop task) displayed on the computer screen simultaneously. The calculation task was either a two-digit addition or subtraction task. The visual search task required participants to judge whether a target word was appeared in a list of 10 words. In the text entry task, participants listened to a six-string word and were required to enter the word using an onscreen keyboard. The modified Stroop task required participants to judge either the colour or name of a coloured word. Figure 1 shows a screen shot of this paradigm containing the display of the four tasks. Participants were required to complete 200 trials for each task and they can freely switch between the tasks. All responses were made via computer mouse clicking. The total number of switches served as the indicator of one's task-switching tendency. Participants performed this paradigm twice in the first and second sessions, respectively. Participants got extra $20 bonus if they got higher than 90% accuracy for each task.

Multitasking experience measure 4—the MPI

The MPI was developed by Poposki and Oswald (2010) to assess one's polychronicity which is the preference for multitasking as opposed to performing only one task at a time. In the MPI, participants were asked to rate 14 items on a 5-point Likert-type scale indicating to what extent they agree or disagree with the statements. For example, "I

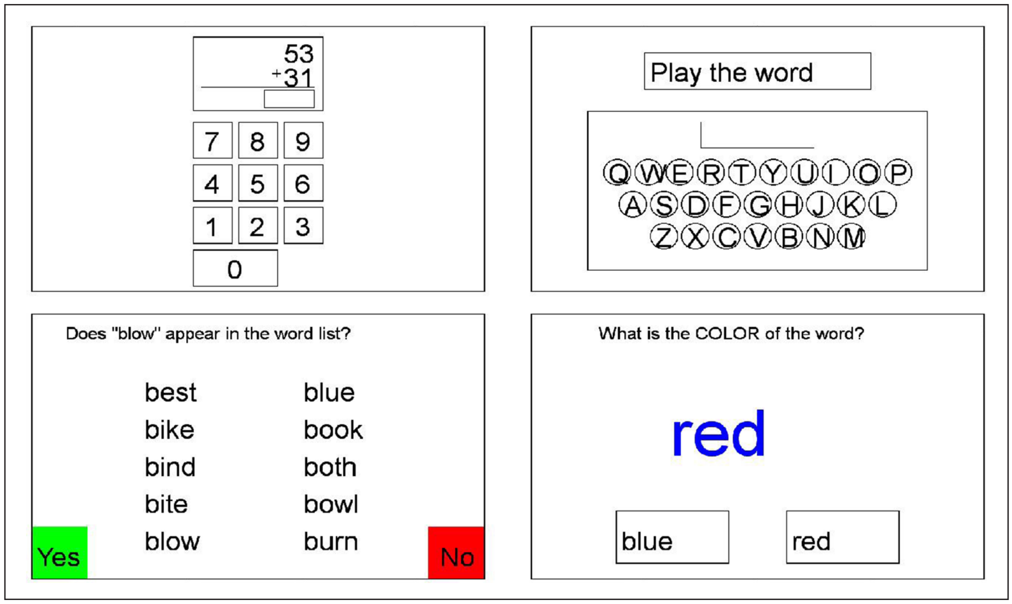

Figure 1. A screen shot of the laboratory switching tendency paradigm.

prefer to work on several projects in a day, rather than completing one project and then switching to another" and "When I have a task to complete, I like to break it up by switching to other tasks intermittently." The total score of the 14 items was used to indicate their preference for multitasking. The MPI serves as another proxy of one's previous multitasking experience in this study.

Video game playing experience

Two questions adopted from Hambrick et al. (2010) were used to assess participants' video game playing experience and skill. The first one asked participants about the number of hours they spent on playing video games per week in the past year. The second one asked participants to rate their video game playing skill compared to others in a 1 to 7 scale (1 = *very poor* to 7 = *very good*). The two video game playing indices were combined as one indicator representing the amount of video game playing experience by averaging the *z*-scores.

Multitasking ability measure 1—task-switching paradigm with 2:1 cue to task mappings

The task-switching paradigm was adopted from Mayr and Kliegl (2003). The paradigm used two cues for each task to indicate which task to perform for each trial. This resulted in three types of trials in the mixed-task blocks. In non-switch trials, both cue and task were identical to that of the previous trial. In cue-switch trials, the cue was different to the previous trial, but the task remained the same. In the task-switch trials, both the cue and task were different to that of the previous trial. The task cue was presented 300 ms after the preceding response and lasted for 200 ms until the presentation of the stimulus which could be a circle, a square, or a triangle of about the same size (i.e., the side length of the square was 1 cm), and it could appear in green, blue, or red. Participants had to indicate the colour of an object if the task cue was the letter G or S, and had to indicate the shape of the object if the task cue was the letter B or W by pressing the keys 1, 2, and 3 on the numeric keyboard, respectively, using their index, middle, or ring finger. Stimuli remained on the screen until the participant made the response.

There were two single-task blocks and one mixed-task block with 30 trials each in the practice session. In the test session, there were eight mixed-task blocks with 90 trials each. Task instructions as well as the stimulus-response mappings were presented at the beginning of each block. Stimuli, tasks, and cues were selected randomly for each trial with two constraints: (1) the number of the three types of trials (task-switch trials, cue-switch trials, and non-switch trials) was equal and (2) there were no trials with direct repetition of both the task and target stimulus.

Participants' RT and accuracy were recorded. The task-switch cost was calculated by subtracting the RT of the cue-switch trials from that of the task-switch trials and, while the cue-switch cost was calculated by subtracting the RT of the non-switch trials from that of the cue-switch trials.

Multitasking ability measure 2—equal-priority dual-task paradigm

The equal-priority dual-task paradigm adopted from Schumacher et al. (2001) required participants to perform two tasks concurrently with equal priority. One task was an auditory-vocal (AV) task, in which a low (220 Hz), medium (880 Hz), or high (3,520 Hz) tone occurred for 40 ms, and participants were required to say "one," "two," or "three," respectively, in response. The other task was a visual-manual (VM) task, in which a character string (O--, -O-, or --O) appeared at the centre of a computer screen and participants responded on a keyboard with their right ring, index, or middle finger, respectively.

There were four pure blocks (two per task and in an alternating order starting with the AV task) consisting of only single-task trials for a task and five mixed blocks consisting of single-task trials for both tasks as well as dual-task trials interleaved randomly. The single-task trials in pure blocks were termed as homogeneous single-task trials, and the single-task trials in mixed blocks were termed as heterogeneous single-task trials. In dual-task trials, participants viewed three dashes for 500 ms followed by the simultaneous presentation of stimuli of the two tasks. Participants were instructed to respond to the two tasks as accurately and fast as possible with equal priority, and not to constrain the serial order of their responses. The inter-trial interval was 2 s in both types of blocks. Participants performed two pure blocks and one mixed block as practice. Each pure block consisted of 45 homogeneous single-task trials (15 for practice blocks) while each mixed block consisted of 18 dual-task (6 for practice blocks) and 30 heterogeneous single-task trials (15 per task, 10 for practice blocks). Stimuli were presented in the same amount of trials within each condition and were not repeated in two consecutive trials. Feedback about the accuracy and RT was given after each trial in the practice session, and feedback about the number of correct responses, and mean RTs were given after each block in the test session. At the beginning of each block, participants were told which type the block would be.

The dual-task cost was calculated by subtracting the RT of heterogeneous single-task trials in the mixed blocks from that of the dual-task trials. The heterogeneity cost was calculated by subtracting the RT of homogeneous single-task trials in the pure blocks from the RT of heterogeneous single-task trials in the mixed blocks.

Additional cognitive ability measure 1—Eriksen flanker task

The flanker task adopted from Wostmann et al. (2013) is a measure of interference control. In each trial, a central fixation cross was presented for 500 ms followed by the presentation of a white arrow in the middle of a black screen which lasted for 1,000 ms. In the neutral, congruent, and incongruent conditions, the white arrow was flanked on each side by two white squares, or two other identical arrows point in the same or opposite direction, respectively. Participants were required to judge the direction of the white arrow in the middle by pressing the corresponding arrow key on the keyboard. There were one practice block of 10 trials and two test blocks of 120 trials each with same number of trials for each condition and each response. The trials were presented in a randomised order with a 1,000 ms inter-trial interval. The flanker cost was calculated by subtracting the RT of the congruent condition from that of the incongruent condition.

Additional cognitive ability measure 2—stop signal task

The stop signal task adopted from Miyake et al. (2000) is a measure of inhibition ability. There were two blocks in the task. The first block consisted of 48 trials. For each trial, participants viewed a fixation point for 500 ms followed by a word presented up to 1,500 ms. Participants were required to categorise the word as either an animal or non-animal as accurate and fast as possible. The difference obtained by subtracting 225 ms from the mean RT of this first block was then used as the time at which the stop signal occurred for the stop trials of the second block. The second block consisted of 192 trials. In the second block, participants were instructed to keep performing the same categorization task as the first block except that they should not respond for the trials that they heard a tone as the stop signal. The dependent variable for this task was the proportion of non-response trials for the stop trials.

Additional cognitive ability measure 3—letter memory task

The letter memory task adopted from Miyake et al. (2000) is a measure of working memory update. For each trial, a random number of letters were presented serially for 2,000 ms per letter. Participants were instructed to rehearse out loud the last presented four letters during the presentation of the letters. At the end of the trial, they were required to recall the last four letters of the presentation list of the trial. There were two practice trials with five and seven letters each and 12 test trials (5, 7, 9, or 11 letters). The dependent variable was the number of correctly recalled letters.

Additional cognitive ability measure 4—operation span task

The operation span task adopted from Engle et al. (1999) is a measure of working memory capacity. For each trial, participants viewed 2–5 equation-word pairs (e.g., Is $3 \times 3 - 5 = 4$? apple) and were instructed to read aloud and verified the equations followed by reading aloud the words. The equation-word pairs were presented to participants serially and each equation remained on the computer screen until participants made the verification response. In addition, participants were required to keep the words in mind and recalled all the words in the order of presentation at the end of the trial. The participants were instructed to start reading the equation as soon as it appeared in their normal speed. Participants performed three practice trials at set size 2 followed by 12 target trials with set size ranged from 2 to 5. The dependent variable was the proportion of correctly recalled words.

Additional cognitive ability measure 5—processing speed

A letter comparison task (adopted from Hambrick et al., 2010) and a symbol comparison task were used to measure processing speed. Participants were required to judge whether pairs of letters or symbols separated by an underscore (e.g., Ѧбҭ _ Ꮒ Ϭҭ) were the same or different as accurate and fast as possible by putting a tick or a cross, respectively, in a box next to the stimuli. The test consisted of four parts (two for letter comparison and two for symbol comparison) with 30 s for each part. The score of processing speed was calculated by subtracting the number of incorrectly answered items from the number of correctly answered items.

Statistical analyses

To examine whether there were gender differences in multitasking ability and experience, we performed independent-sample *t*-tests. All RT measures were mean RT calculated basing on correct trials only. We also reported Bayes factors of the gender differences. Bayes factor was first introduced by Jeffreys (1935). It is defined as the likelihood ratio of the likelihood of the two competing hypotheses such as the null and research hypotheses. If the value of Bayes factor is equal to 1, it indicates that the data equally supports the research hypothesis and the null hypothesis. Bayes factors between 1 and about 3 (or between 1/3 and 1 for null hypothesis) have been proposed to provide weak evidence for the research hypothesis, Bayes factors between 3 and 10 (or between 1/10 and 1/3 for null hypothesis) have been suggested to provide substantial evidence for the research hypothesis and Bayes factors larger than 10 (or smaller than 1/10 for null hypothesis) have been suggested to provide strong evidence for the research hypothesis (Kass & Raftery, 1995; Wetzels et al., 2011).

The reliability of individual measures was computed before subsequent mediation and moderation analyses. For computer switching, MMI, and laboratory switching, test–retest reliability was computed. For MPI, Cronbach's Alpha was used. For other multitasking and cognitive ability measures, split-half reliability (odd and even trials) was estimated with adjustments according to the Spearman–Brown formula. Similarly, the 4-week computer usage monitoring data were divided into two halves for reliability calculation. The first half contained the data of the first 2 weeks and the second half contained the data of the last 2 weeks. As a result, the middle time point of the two halves was equal to 2 weeks which was same as the time difference between the first test and retest of the other two multitasking experience measures. However, nine participants who got less than 1 hr computer monitoring data in one of the halves were excluded in the reliability analysis.

To examine whether gender differences in the amount of multitasking experience can explain gender differences in multitasking ability, we performed mediation analyses both before and after controlling for the five additional cognitive measures. If we find a direct effect of gender on multitasking ability and no indirect effects through the multitasking experience measures, we can conclude that gender differences in multitasking ability cannot be explained by gender differences in multitasking experience. In contrast, if we find only indirect effect but no direct effects, we can conclude that gender differences in multitasking ability is completely explained by gender differences in multitasking experience. Finally, if we find both direct and indirect effects, we can conclude that gender differences in multitasking ability is partly explained by gender differences in multitasking experience.

Finally, we performed a moderation analysis to examine whether the effects of multitasking experience on ability are different between males and females. If yes, this would suggest that gender differences in multitasking ability may not only come from the amount of multitasking experience but also come from the qualitatively different multitasking experience such as the different types of media multitasking behaviour engaged by males and females.

Results

Gender differences in multitasking ability

We first checked the reliability of the multitasking ability and experience measures (Table 1). As the cue-switch cost and the task-switch cost showed relatively lower reliability (.62 and .63 respectively), the total switch cost was used as the indicator of switch cost in the subsequent analyses. In addition, the reliabilities of multitasking costs in terms of accuracy were very low, ranging from .26 to .56; hence, the accuracy costs were also excluded in the subsequent analyses. The low reliabilities of the accuracy costs were predictable, given the ceiling performance of both the task-switching paradigm and the dual-task paradigm (95% and 97% mean accuracy, respectively). Apart from the laboratory switching tendency and the accuracy measures, all other measures showed good reliabilities ($\geqslant 0.7$).

Independent-samples *t*-tests were performed to examine gender differences in the ability measures (Table 1). Male participants showed a significantly smaller dual-task

Table 1. Descriptive statistics, reliability, and gender differences of all the measures.

Measures	Males	Females	*t*-score	*p*-value	*d*	BF_{10}	Reliability
Ability							
Dual-task cost (ms)	282 (19)	357 (20)	–2.69	.008	–.5	4.80	.90
Dual-task cost (%)	0.37 (.02)	0.44 (.02)	–2.28	.025	–.43	1.97	.87
Heterogeneity cost (ms)	134 (15)	137 (15)	–0.14	.89	–.03	0.20	.90
Heterogeneity cost (%)	0.23 (.02)	0.21 (.02)	0.56	.58	.10	0.23	.90
Switch cost (ms)	673 (43)	623 (39)	0.87	.39	.16	0.28	.84
Switch cost (%)	0.62 (.04)	0.56 (.03)	1.24	.22	.23	0.39	.76
Dual-task cost in accuracy	–0.01 (.00)	–0.01 (.00)	–0.21	.83	–.04	0.20	.26
Heterogeneity cost in accuracy	0.00 (.00)	0.00 (.00)	–0.27	.79	–.05	0.20	.56
Switch cost in accuracy	–0.02 (.00)	–0.01 (.00)	2.10	.04	.39	1.40	.29
Experience							
Computer switching	89 (5.5)	99 (4.8)	–1.29	.20	–.24	0.42	.74
MMI	2.54 (.19)	3.38 (.19)	–3.11	.002	–.58	13.92	.84
Laboratory switching tendency	10.4 (1.6)	11.0 (1.0)	–0.32	.75	–.06	0.21	.56
MPI	37.9 (.9)	37.7 (1.2)	0.11	.91	.02	0.20	.88
Video games	0.42 (.10)	–0.39 (.08)	6.27	<.001	1.16	1.51e+6	–
Cognitive							
Flanker	100.6 (33.2)	105.4 (38.7)	–.71	.48	–.13	0.25	.88
Stop signal	0.80 (.14)	0.76 (.15)	1.45	.15	.27	0.51	.83
Letter memory	35.43 (7.40)	33.75 (7.61)	1.21	.23	.22	0.38	.71
Operation span	0.72 (.12)	0.73 (.12)	–0.29	.78	–.05	0.20	.72
Processing speed	26.68 (5.10)	25.07 (3.66)	1.98	.05	.37	1.13	.91

MMI: media multitasking index; MPI: Multitasking Preference Inventory.
Values in the parentheses represent the standard errors of the means (SEMs). Dual-task cost (%), heterogeneity cost (%), and switch cost (%) are percentage changes of dual-task cost, heterogeneity cost, and switch cost, respectively, in comparison to the baseline condition. The valid sample size for reliability analysis for computer switching was 108, and the valid sample size for reliability analysis for all other measures was 117.

cost than female participants, $t(115)=–2.69$, $p=.008$, $d=–.5$, $BF_{10}=4.80$. In contrast, gender differences in heterogeneity cost and switch cost were not significant $t(115)=–0.14$, $p=.89$, $d=–.03$, $BF_{10}=.20$, and $t(115)=–0.87$, $p=.39$, $d=.16$, $BF_{10}=.28$, respectively. Although female participants showed a significant smaller switch cost in accuracy than male participants, the reliability of this measure is very low (.29) probably due to the ceiling performance of the task-switching paradigm (95% accuracy averaged across conditions). In addition, the switch costs in accuracy as well as its gender difference were very small in magnitude. Therefore, we excluded this accuracy measure from the interpretation and subsequent analyses.

It is possible that the significant gender difference in the dual-task cost was caused by the gender difference in the general performance level as reflected in the single-task condition. For example, the dual-task cost for a person can be larger (e.g., 200 ms) simply because s/he responded more slowly in general (e.g., 2,000 ms for single-task trials and 2,200 m for dual-task trials), as opposed to another faster person with a numerically smaller cost (e.g., 150 ms) that is actually more substantial (e.g., 350 vs. 500 ms for single- and dual-task trials). To control for the potential individual difference in the general performance level, we calculated the percentage change of RT in comparison to the baseline condition for the dual-task cost, the heterogeneity cost, and the switch cost as additional indicators and performed again the independent-samples *t*-tests. The results were qualitatively the same such that male participants showed a significantly smaller dual-task cost than female participants, $t(115)=–2.28$, $p=.025$, $d=–.42$, $BF_{10}=1.97$, while no gender differences were found for the heterogeneity cost and the switch cost (*p*-values > .22).

Gender differences in multitasking experience

Independent-samples *t*-tests were also performed to examine gender differences in the experience measures (Table 1). Male participants showed a significantly smaller MMI than female participants, $t(115)=–3.11$, $p=.002$, $d=–.58$, $BF_{10}=13.92$, and higher video game playing experience than female participants, $t(115)=6.27$, $p<.001$, $d=1.16$, $BF_{10}=1.51e+6$. Gender differences in other multitasking experience measures were not significant (*p*-values > .20).

To further explore the pattern of gender difference in multitasking experience, we calculated MMI for each cell of the media multitasking matrix of the Media Use Questionnaire and performed independent-samples *t*-tests to examine gender differences in each cell. Men showed significantly more experience in multitasking involving video games, whereas women showed more experience in multitasking involving music, instant messaging, and web

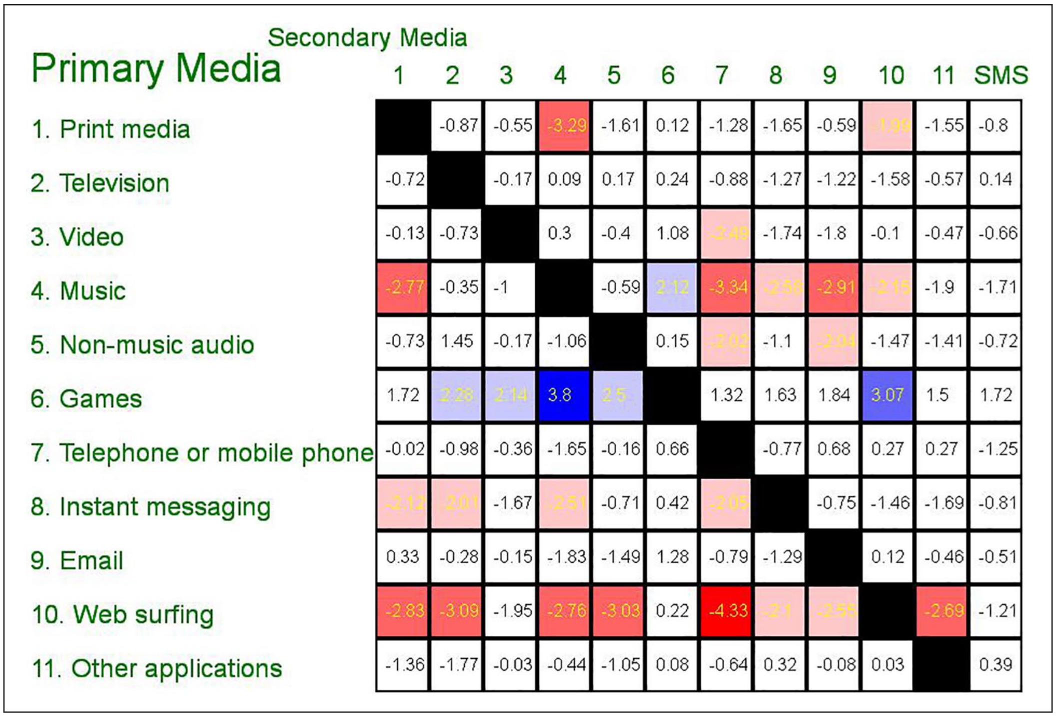

Figure 2. A matrix showing gender differences in the media multitasking indices for different combinations of media.
Numbers represent *t*-scores, with positive values indicating more experience in men. Significant gender differences are marked in blue (more experience in men) and red (more experience in women) colours with higher saturation indicating more significant differences: high saturation indicates *p*-values smaller than .001, medium saturation indicates *p*-values in between .001 and .01, and low saturation indicates *p*-values in between .01 and .05.

Table 2. Correlations among the multitasking experience indicators and among the ability indicators.

Experience	Computer switching	MMI	Laboratory switching tendency
Computer switching	–	–	–
MMI	.06 (.50)	–	–
Laboratory switching tendency	.03 (.75)	.02 (.81)	–
MPI	.07 (.44)	.10 (.31)	.31 (.001)
Ability	**Dual-task cost**	**Heterogeneity cost**	**Switch cost**
Dual-task cost	–	–	–
Heterogeneity cost	.36 (<.001)	–	–
Switch cost	.22 (.017)	.13 (.18)	–

MMI: media multitasking index; MPI: Multitasking Preference Inventory.
P-values are included in the parentheses.

surfing as primary media (Figure 2). The gender difference pattern is highly consistent with that found in previous studies (Cotten et al., 2014; Foehr, 2006; Rideout et al., 2010).

Whether gender differences in amount of experience can explain gender differences in ability

We first examined the overlap between different multitasking experience measures and between different multitasking ability measures to determine if certain measures need to be combined. Table 2 shows the correlations among the four multitasking experience indicators and among the three multitasking ability indicators. For the experience measures, there was only one significant correlation found between MPI and laboratory switching tendency, $r(115) = .31$, $p < .001$, $BF_{10} = 36.19$, which were both measuring one's natural multitasking tendency. Apart from this, the remaining five correlations were very small and not significant, suggesting largely independent aspects of multitasking experience in the measures. For the ability measures, the dual-task cost was weakly correlated with the heterogeneity cost, $r(115) = .36, p < .001, BF_{10} = 315.44$, and the switch cost, $r(115) = .22, p = .017, BF_{10} = 1.96$. This

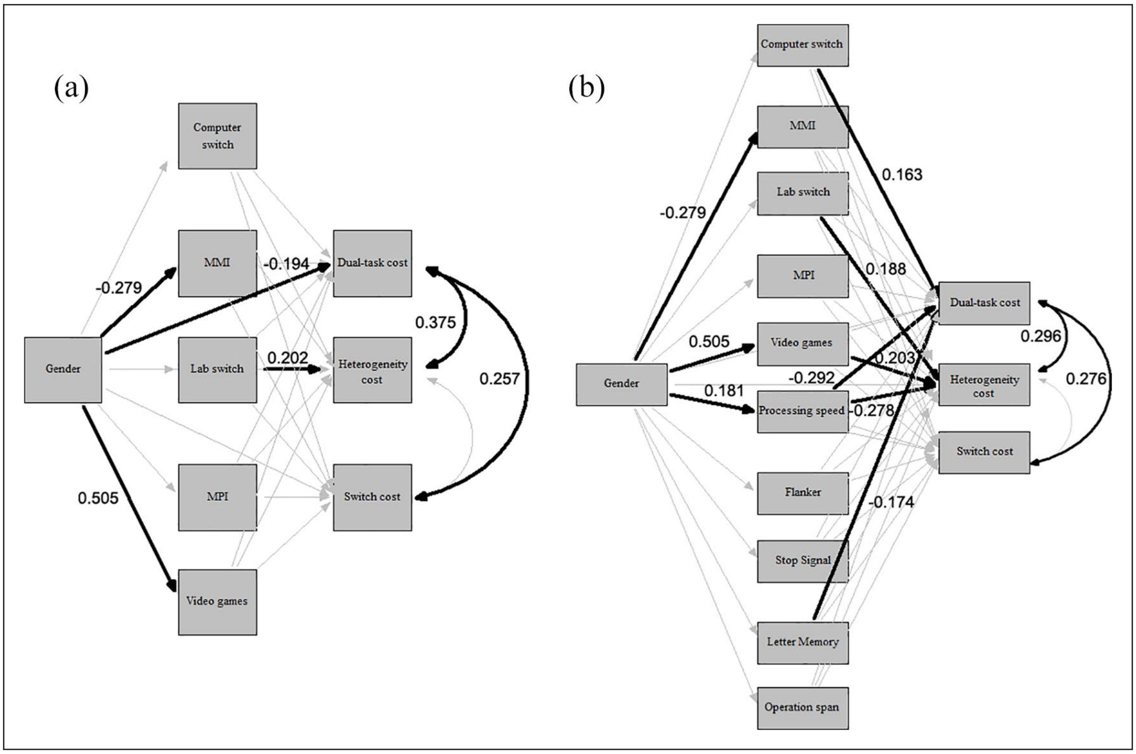

Figure 3. The path analysis models (a) the model with multitasking experience variables as the mediators and (b) the model with multitasking experience variables and cognitive measures as mediators.
Thick lines represent significant paths while thin lines represent non-significant paths. Only significant standardised coefficients were shown in the figure. Positive (negative) values indicate a larger (smaller) amount of experience or multitasking cost, or better (poorer) cognitive performance for males.

was consistent with the low correlation between factors underlying concurrent and sequential multitasking costs (r values = .20) in our previous study (Lui & Wong, 2020). The heterogeneity cost was not significantly correlated with the switch cost, $r(115) = .13$, $p = .18$, $BF_{10} = .28$. Thus, the ability measures should represent different aspects of multitasking ability.

To examine whether the gender differences in multitasking ability were mediated by the amount of personal experiences including multitasking experience and video game playing experience, a path analysis was performed which used the dual-task cost, the heterogeneity cost, and the switch cost as the dependent variables, gender as the predictor, and the multitasking experience measures, and video game playing experience as mediators. Figure 3a shows the path analysis model with the significant parameter estimates. Among the experience measures, consistent with results of the independent-samples t-tests, there were significant gender differences in MMI, $\beta = -.279$, $B = -0.839$,[2] $z = -3.126$, $p = .002$, and video game playing, $\beta = .505$, $B = 0.806$, $z = 6.299$, $p < .001$, such that male participants engaged in significantly less media multitasking and more video game playing than females. For the dual-task cost, there was a significant total effect for gender, $\beta = -.243$, $B = -74.289$, $z = -2.702$, $p = .007$, such that male participants showed a significantly smaller dual-task cost than female participants. Importantly, the indirect effect of gender on the dual-task cost was not significant, $\beta = -.049$, $B = -14.916$, $z = -.804$, $p = .42$ while the direct effect was marginally significant, $\beta = -.194$, $B = -59.373$, $z = -1.821$, $p = .069$, indicating that the gender difference in the dual-task cost could not be explained by their difference in the amount of multitasking experience and video game playing experience. For the heterogeneity cost, no significant gender differences were found in terms of total effect ($\beta = -.013$, $B = -3.033$, $z = -.143$, $p = .886$), direct effect ($\beta = -.103$, $B = -23.480$, $z = -.955$ $p = .340$), or indirect effect ($\beta = .089$, $B = 20.448$, $z = 1.39$, $p = .165$). Similarly, for the switch cost, no significant gender differences were found in terms of total effect ($\beta = .080$, $B = 50.245$, $z = .869$, $p = .385$), direct effect ($\beta = .061$, $B = 38.169$, $z = .551$, $p = .582$), or indirect effect ($\beta = .019$, $B = 12.076$, $z = .313$, $p = .754$).

To explore whether the qualitatively different media multitasking pattern found between males and females (as shown in Figure 2) can explain the gender difference in multitasking ability, we calculated two additional MMIs representing two specific types of media multitasking experience: (1) multitasking involves video games and (2) multitasking involves music, instant messaging, and web surfing. The first MMI was calculated by adding the MMIs of all the cells involving video games as primary media, while the second MMI was calculated by adding the MMIs of all the cells involving music, instant messaging, and web surfing as primary media except those involving video games as secondary media. We then performed again the mediation analysis using these two MMIs to replace the original MMI in the path model. Significant gender differences were found in the two types of MMIs with males showing significantly more experience in the MMI for video games, $\beta = .404$, $z = 3.114$, $p = .002$, but significantly less experience in the MMI for music, instant messaging, and web surfing, $\beta = –2.111$, $z = –4.298$, $p < .001$. However, these two MMIs cannot explain the gender difference in the dual-task cost, $\beta = –74.289$, $–z = 2.702$, $p = .007$, as indicating by a non-significant indirect effect, $\beta = 1.533$, $z = .071$, $p = .943$, and a significant direct effect, $\beta = –75.823$, $z = –2.221$, $p = .026$.

As shown in Table 1, male participants showed significantly faster processing speed than female participants, $t(115) = 1.98$, $p = .05$, $BF_{10} = 1.13$. They did not differ significantly in all other measures of cognitive abilities. Nevertheless, an additional mediation analysis was performed including the five additional cognitive measures as mediators to control for possible gender differences in these cognitive abilities. As shown in Figure 3b, among the cognitive abilities, the only significant gender difference was found in processing speed such that males responded significantly faster than females, $\beta = .181$, $B = 1.613$, $z = 1.987$, $p = .047$. For the dual-task cost, after including the cognitive abilities, there was a significant total effect ($\beta = –.249$, $B = –74.289$, $z = –.2.767$, $p = .006$), and a marginally significant indirect effect ($\beta = –.121$, $B = –35.975$, $z = –1.735$, $p = .083$) while the direct effect became non-significant ($\beta = –.128$, $B = –38.314$, $z = –1.277$, $p = .202$). This suggested that the gender difference in dual-task performance was mediated by the cognitive abilities. For the heterogeneity cost, again, no significant gender differences were found in terms of total effect ($\beta = –.013$, $B = –3.033$, $z = –.143$, $p = .886$), direct effect ($\beta = –.079$, $B = –18.037$, $z = –.757$, $p = .449$), or indirect effect ($\beta = .065$, $B = 15.004$, $z = .915$, $p = .360$). For the switch cost, again, no significant gender differences were found in terms of total effect ($\beta = .080$, $B = 50.245$, $z = .864$, $p = .388$), direct effect ($\beta = .088$, $B = 55.496$, $z = .795$, $p = .427$), or indirect effect ($\beta = –.008$, $B = –5.251$, $z = –.123$, $p = .902$).

Whether effects of experience on ability depends on gender

The next analysis concerned whether gender moderated the effect of experience (multitasking experience and video game playing experience) on the dual-task cost and the switch cost. The moderation effect was examined by performing multiple group analysis for male participants and female participants. Figure 4 shows the model for the multiple group analysis. In Model 1, no parameters were set to be equal across groups. In Model 2, all paths from the experience indicators to the two multitasking costs were set to be equal between the two groups. The Lagrange multiplier test (LM test) was performed on the constraints set in Model 2 to examine if any of the constraints should be released. Models 1 and 2 both had a non-significant overall chi-square, $\chi^2(20) = 23.277$, $p = .275$ and $\chi^2(35) = 40.37$, $p = .245$, respectively. Both the univariate and cumulative multivariate statistics of the LM test on Model 2 suggested keeping all the constraints. As a result, Model 2 which was a simpler model than Model 1 and had similar goodness-of-fit, $\Delta\chi^2(15) = 17.093$, $p = .313$, was preferred. In Model 2, only laboratory switch tendency significantly predicted the heterogeneity cost, $\beta = .154$, $B = 2.352$, $z = 2.36$, $p = .018$, such that more laboratory switches were associated with a larger heterogeneity cost. All other effects of experience on multitasking ability were not significant, p-values $> .05$. In other words, for both males and females, individual differences in multitasking experience, in general, could not explain individual differences in multitasking ability.

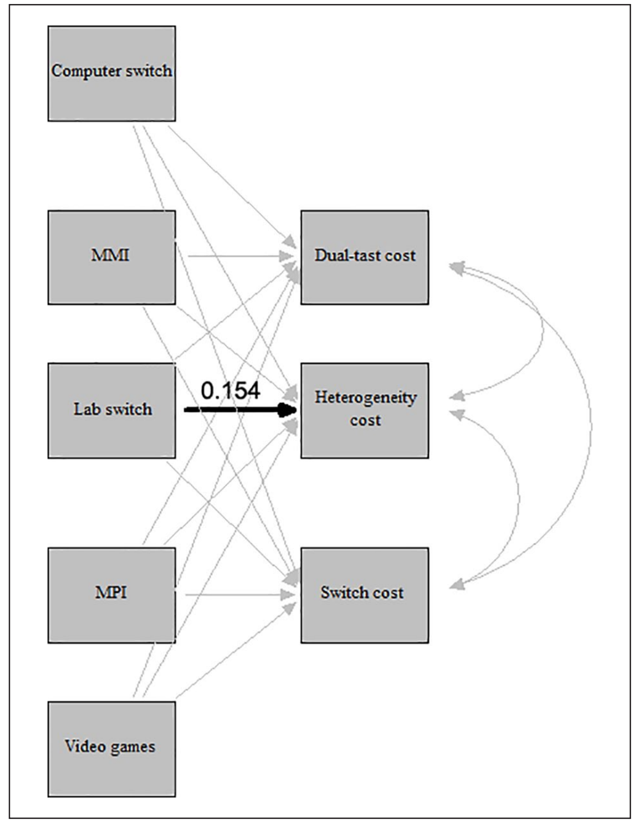

Figure 4. Moderation analysis.
Thick lines represent significant paths while thin lines represent non-significant paths. Only significant standardised coefficients were shown in the figure.

Discussion

Research findings in the literature regarding gender differences in multitasking ability were inconsistent. A possibility was that men were superior at concurrent multitasking, whereas women were superior at task switching. This study examined gender differences in multitasking ability using both a dual-task and a task-switching paradigm. Experience measures including multitasking experience and video game playing experience were included as mediators and moderators and five additional cognitive abilities measures were also included as mediators to figure out the source of gender differences in multitasking ability, if there is any.

Gender differences in multitasking ability and experience

The first analysis examined whether there were gender differences in concurrent and sequential multitasking ability. In terms of concurrent multitasking, it was found that men showed a smaller dual-task cost than women for the dual-task paradigm which is consistent with the studies showing that men outperformed women at concurrent multitasking paradigms (Colom et al., 2010; Hambrick et al., 2010; Mäntylä, 2013; Mäntylä et al., 2017). In addition, the men's advantage in the dual-task paradigm cannot be explained by their faster responses in the single-task condition as indicated by the significant gender difference found in the dual-task performance in terms of the percentage change in comparison to the single-task condition.

For task-switching ability, no significant gender difference in the switch cost was found. This is different from the women's advantage in task switching found in Stoet et al. (2013). It should be noted that the indicator where women's advantage in task switching was found was mixing cost but not switch cost in Stoet et al. (2013). In addition, the sample size of this study (N=117), while larger than that of Hirsch et al. (2019) which found no gender difference in either dual-task or task-switching performance (N=96), was smaller than that of Stoet et al. (2013) (N=231). One may question whether the non-significant result was simply due to a smaller sample size of this study. We compared the effect sizes of the gender differences in switch cost and dual-task cost of this study against the effect size of the gender difference in mixing cost of Stoet et al. (2013). The effect size of gender difference in switch cost of this study was smaller than that of mixing cost in Stoet et al. (2013) (Cohen's d=.16 vs. Cohen's d=.27). It was also much smaller than the effect size for concurrent multitasking in this study (Cohen's d=.50 for a smaller dual-task cost found in males than females). We performed a power analysis and found that it would have required a sample size of 1,230 to enable detection of the current effect size with a power of .8. Therefore, even if a women's advantage in task switching exists, the advantage is much smaller than the men's advantage in concurrent multitasking. The current finding was also consistent with the exploratory results of Lui and Wong (2020) which found that males were associated with a smaller response selection limitation which was manifested in the concurrent multitasking paradigms, but no gender differences were found in retrieval and maintenance of task information which were manifested in the task-switching paradigms.

For multitasking experience, women engaged in significantly more media multitasking and less video game playing than men. There was no gender difference in the multitasking preference, the time spending on computer switching, or laboratory switching. To further explore gender differences in each type of media multitasking behaviour, we calculated MMI for each cell of the media multitasking matrix of the Media Use Questionnaire and examined gender differences in each cell. We found that men were associated with more experience in multitasking involving video games, whereas women were associated with more experience in multitasking involving music, instant messaging, and web surfing as primary media. These results are highly consistent with previous studies which suggested that teenage boys spent more time playing video games than girls, whereas teenage girls spend more time than boys in media multitasking involved instant messaging, music, email, and websites (Cotten et al., 2014; Foehr, 2006; Rideout et al., 2010).

Gender difference in dual-task cost cannot be explained by differences in multitasking and video game playing experience

Another important question concerns whether gender differences in the amount of multitasking experience can account for gender differences in multitasking ability. Surprisingly, inconsistent with Hambrick et al. (2010), the men's advantage in dual-task performance was not mediated by the differences in the amount of media multitasking experience and video game playing experience. One possible reason is that, the tasks we used in the dual-task paradigm are relatively simple and the dual-task cost measured in this study may reflect a more pure response selection bottleneck. In contrast, the SynWin paradigm used in Hambrick et al. (2010) is a relatively complicated multitasking paradigm which requires participants to handle four complex tasks (a math calculation task, a letter recognition task, a visual monitoring task, and an auditory monitoring task) simultaneously. Three of the four tasks involve visual stimuli in which there could be also interference in visual stimulus perception which is purposely avoided in the dual-task paradigm. Some tasks require also additional calculation and memory processes to complete in comparison with the simple stimuli classification tasks used in this study. Particularly noteworthy is that the overall performance in the SynWin paradigm, instead of the performance in a dual-task condition compared to that in a single-task condition, is used to indicate multitasking ability. The skills set required in such a paradigm may thus be more mixed and it may not be surprising that gender difference in the SynWin performance was found to be related to gender difference in video game playing experience. Thus, a conclusion of this study is that men seems to be better at response selection and this advantage cannot be explained by gender difference in the amount of multitasking experience nor gender difference in the amount of video game playing experience.

Why would the gender difference in multitasking ability not be explained by gender difference in the amount of multitasking and video game playing experience? A possibility is that the effects of multitasking experience on multitasking ability are different between males and females and the differential effects lead to the gender difference in multitasking ability. The moderation analysis examined this possibility by comparing the effects of experience on multitasking ability between males and females. No significant moderation was found for both dual-task cost and switch cost (all $p\mathrm{s} > .05$) suggesting that gender difference in multitasking ability cannot be explained by potential differential effects of multitasking experience.

To examine whether gender differences in specific media multitasking experience (as shown in Figure 2) can explain the gender difference in multitasking ability, we calculated two additional MMIs representing two specific types of media multitasking experience: (1) multitasking involves video games and (2) multitasking involves music, instant messaging, and web surfing. We then performed again the mediation analysis by using these two MMIs to replace the original MMI in the path model. Although significant gender differences were found in the two types of MMIs with males showing more experience in the MMI for video games but less experience in the MMI for music, instant messaging, and web surfing, these two MMIs cannot explain the gender difference in the dual-task cost. To conclude, the current findings do not support the prediction from the evolutionary and differential-experience perspectives that women are better multitaskers because they engage in more multitasking behaviours than men. In contrast, men are better at concurrent multitasking and this advantage cannot be explained by the gender differences in multitasking experience.

Gender difference in dual-task cost was explained by differences in processing speed

Males were found to have faster processing speed than females; therefore, it is possible that the gender difference in the dual-task cost was caused by the gender difference in the processing speed. As a result, an additional mediation analysis was performed including both the multitasking experience and cognitive ability measures as the mediators. In this analysis, the significant gender difference in the dual-task cost (the total effect) became non-significant (direct effect) after controlling for the mediators, suggesting that the cognitive abilities fully mediated the effect of gender on the dual-task cost. In other words, males performed better than females in the dual-task paradigm because their processing speed was faster than females.

Although the current findings have suggested that males have an advantage relative to females in concurrent multitasking and this could be a result of the individual differences in cognitive abilities rather than in multitasking experience, we need to be cautious in interpreting the results. The following section discussed the validity of the results through three aspects: (1) whether this study has captured all types of multitasking experiences, (2) whether different types of multitasking abilities were adequately measured, and (3) whether gender differences in all variables that would potentially affect differences in multitasking abilities were controlled.

Use of multiple multitasking experience measures

Four multitasking experience indicators were used in this study including computer switching, MMI, laboratory switching, and MPI. The only significant correlation among the four multitasking experience indicators was found between laboratory switching and MPI probably because both indicators were measuring people's natural tendency towards multitasking. Another possibility is that participants' responses to the MPI were influenced by their switching tendency in the laboratory switching paradigm which was performed earlier in the same session. We cannot exclude the second possibility since a fixed task sequence was adopted in this study to prevent differences in task order from cancelling out the individual differences. All other correlations were not significant, suggesting that the indicators are targeting at different aspects of multitasking experience. The two natural tendency measures likely cover part of instead of the whole spectrum of one's multitasking experience, as there are also other factors influencing one's multitasking behaviours such as nature of the work engaged, time pressure of the tasks at hand, and amount of interruptions encountered. In addition, computer switching and media multitasking differ in the way of assessment and also in the device involved. Each measurement has its merit and insufficiency: computer switching is an relatively objective measurement but limited to a single device; the media use questionnaire covers a large range of media multitasking situations but is vulnerable to the problem of self-report; the two natural tendency measures can cover multitasking behaviours that are not assessed by the other two measurements but cannot cover the whole spectrum of multitasking behaviours. In any case, the use of multiple experience measures is beneficial as they complement each other.

Although multiple multitasking experience measurements were adopted in this study, they may be still unable to capture all types of multitasking experience. Due to the rapid evolution of technology, smart phone has become another population device that is widely and frequently used in daily life. As a result, multitasking within smart phone or between smart phone and other devices could possibly occupy an unneglectable portion of time. Besides, the two specific MMIs we calculated in the exploratory analyses, including the MMI for video games and the MMI for music, instant messaging, and web surfing, are also vulnerable to the problem of self-report and cover only a small range of media multitasking situations. Hence, it is still possible that there are gender differences in other aspects of multitasking experience which lead to the gender difference in dual-task performance. It would be a great challenge for researchers to devise reliable and valid measurements in the future that can cover most, if not all, of the multitasking experiences and provide index for each specific qualitative aspect of multitasking experience.

Multifaceted nature of multitasking ability

Dual-task performance and task switching are two research areas of multitasking that have been developing quite independently in the literature, with few empirical studies of the relationship between the two. The small correlation found between the dual-task cost and the switch cost, and the presence and absence of gender difference associated with the two multitasking costs respectively, suggest that dual-task and task-switching performance are very likely two separate aspects of multitasking ability, supporting the multifaceted nature of multitasking ability proposed by our previous study (Lui & Wong, 2020). Any study assessing multitasking ability or comparing group differences in multitasking ability should hence cover these different aspects of multitasking ability to obtain a more complete picture.

Compared with many previous studies in examining gender differences, we took a step further and included both dual-task and task-switching paradigms for the same participants (similar to Hirsch et al., 2019). However, there was only one task for measuring dual-task performance and one for task-switching performance. Although the two measures showed good reliabilities, variables measured by single-task indicators are undoubtedly contaminated by certain amount of task specific variances. This would lower the possibility to find the relationship between multitasking habit and multitasking ability if there is a relationship between the two. Future studies should use multiple indicators for each aspect of multitasking ability to examine the effects of multitasking habits as mediators and moderators of gender differences in multitasking performance.

In addition, future studies should include a wider range of multitasking situations. As discussed, there are complex multitasking situations that are quite different to the simple multitasking paradigms used in this study. This study also did not include interruption paradigms (Bai et al., 2014; Trafton et al., 2003) and self-initiated task-switching paradigms (e.g., Reissland & Manzey, 2016) that allows more strategic planning. Hence, this study cannot exclude possible female advantages on other types of multitasking situations. Conclusions on gender differences in multitasking experience and possible mediation effects of multitasking experience could be different when a more comprehensive set of multitasking paradigms are included in future studies.

Other potential mediators for gender differences in multitasking abilities

This study has examined potential mediation effects of four types of multitasking experiences and five cognitive abilities for gender differences in multitasking abilities. However, the processing speed was measured only by the letter and symbol comparison tasks. As it was suggested that woman demonstrated superior processing speed in tasks involving digits, letters, and rapid naming, while men were faster on RT tests and finger tapping (Roivainen, 2011), it would be better to include a more comprehensive set of measures of processing speed. In addition, there are still some other variables that can potentially affect males and females' multitasking performance such as the social economic status, intelligence, and females' phase of monthly cycle which were not assessed and controlled in this study. It should be noted that while these variables can potentially explain the gender differences found in this study, they are unlikely the whole story as this study did not find gender differences in every multitasking measures and cognitive abilities. For example, males and females did not differ in the operation span task, a typical working memory capacity measure, while it was found that intelligence was related to working memory capacity to a similar extent as to multitasking ability (Redick et al., 2016). Nevertheless, future studies should control for more of these variables to increase the validity and hence interpretability of the findings.

Conclusion

This study represents the first attempt to examine, in the same study, gender differences in different aspects of multitasking ability, the role of the amount of multitasking experience in mediating gender differences in multitasking ability, and the role of gender in moderating the effects of multitasking experience on multitasking ability. The findings suggest that men are better at response selection while there is no observable gender difference in task switching. Consistent with previous studies, men were found to be more experienced in video games playing and multitasking with video games, whereas women were found to be more experienced in media multitasking especially in media multitasking with music, instant messaging, and web surfing. However, the men's advantage in response selection cannot be accounted for by either gender difference in the overall amount of multitasking experience or gender differences in specific aspects of multitasking such as multitasking for video games and multitasking for music, instant messaging, and web surfing. Instead, the men's advantage in response selection was completed explained by difference in the processing speed.

Data availability

The data that support the findings of this study are openly available in the Open Science Framework at https://osf.io/3SVBW/.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. This article does not contain any studies with animals performed by any of the authors.

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Informed consent

Informed consent was obtained from all individual participants included in the study.

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Notes

1. Cohen's d=.27 in Stoet et al. (2013); Cohen's d=.32 and .37 in Hambrick et al. (2010); Cohen's d=.59 (transformed from partial eta-squared) in Mäntylä, 2013; Cohen's d=.82 (computed using the reported descriptive statistics) in Mäntylä et al. (2017).
2. The square of the standardised coefficient (B) represents the amount of the explained variance.

References

Alzahabi, R., & Becker, M. W. (2013). The association between media multitasking, task-switching, and dual-task performance. *Journal of Experimental Psychology: Human Perception and Performance*, *39*(5), 1485–1495. https://doi.org/10.1037/a0031208

Bai, H., Jones, W. E., Moss, J., & Doane, S. M. (2014). Relating individual differences in cognitive ability and strategy consistency to interruption recovery during multitasking. *Learning and Individual Differences*, *35*, 22–33. https://doi.org/10.1016/j.lindif.2014.07.002

Baumgartner, S. E., Weeda, W. D., van der Heijden, L. L., & Huizinga, M. (2014). The relationship between media multitasking and executive function in early adolescents. *The Journal of Early Adolescence*, *34*(8), 1120–1144. https://doi.org/10.1177/0272431614523133

Benbunan-Fich, R., Adler, R. F., & Mavlanova, T. (2011). Measuring multitasking behavior with activity-based metrics. *ACM Transactions on Computer-human Interaction*, *18*(2), 1–22. https://doi.org/10.1145/1970378.1970381

Brasel, S. A., & Gips, J. (2011). Media multitasking behavior: Concurrent television and computer usage. *Cyberpsychology, Behavior, and Social Networking*, *14*(9), 527–534. https://doi.org/10.1089/cyber.2010.0350

Buss, D. M. (1989). Sex differences in human mate preferences: Evolutionary hypotheses tested in 37 cultures. *Behavioral and Brain Sciences*, *12*(1), 1–14. https://doi.org/10.1017/S0140525X00023992

Byrnes, J. P., Miller, D. C., & Schafer, W. D. (1999). Gender differences in risk taking: A meta-analysis. *Psychological Bulletin*, *125*(3), 367–383.

Calderwood, C., Ackerman, P. L., & Conklin, E. M. (2014). What else do college students "do" while studying? An investigation of multitasking. *Computers & Education*, *75*, 19–29. https://doi.org/10.1016/j.compedu.2014.02.004

Colom, R., Martinez-Molina, A., Shih, P. C., & Santacreu, J. (2010). Intelligence, working memory, and multitasking performance. *Intelligence*, *38*(6), 543–551. https://doi.org/10.1016/j.intell.2010.08.002

Costa, P. T., Jr., Terracciano, A., & McCrae, R. R. (2001). Gender differences in personality traits across cultures: Robust and surprising findings. *Journal of Personality and Social Psychology*, *81*(2), 322–331. https://doi.org/10.1037//0022-3514.81.2.322

Cotten, S. R., Shank, D. B., & Anderson, W. A. (2014). Gender, technology use and ownership, and media-based multitasking among middle school students. *Computers in Human Behavior*, *35*, 99–106. https://doi.org/10.1016/j.chb.2014.02.041

Croson, R., & Gneezy, U. (2009). Gender differences in preferences. *Journal of Economic Literature*, *47*(2), 448–474. https://doi.org/10.1257/jel.47.2.448

Denno, D. (1982). Sex differences in cognition: A review and critique of the longitudinal evidence. *Adolescence*, *17*(68), 779–788.

Dux, P. E., Tombu, M. N., Harrison, S., Rogers, B. P., Tong, F., & Marois, R. (2009). Training improves multitasking performance by increasing the speed of information processing in human prefrontal cortex. *Neuron*, *63*(1), 127–138. https://doi.org/10.1016/j.neuron.2009.06.005

Elsmore, T. F. (1994). SYNWORK1: A PC-based tool for assessment of performance in a simulated work environment. *Behavior Research Methods, Instruments, & Computers*, *26*(4), 421–426. https://doi.org/10.3758/BF03204659

Engle, R. W., Tuholski, S. W., Laughlin, J. E., & Conway, A. R. A. (1999). Working memory, short-term memory, and general fluid intelligence: A latent-variable approach. *Journal of Experimental Psychology: General*, *128*(3), 309–331.

Finley, J. R., Benjamin, A. S., & McCarley, J. S. (2014). Metacognition of multi-tasking: How well do we predict the costs of divided attention? *Journal of Experimental Psychology: Applied*, *20*(2), 158–165. https://doi.org/10.1037/xap0000010

Fisher, H. E. (1999). *The first sex: The natural talents of women and how they are changing the world*. House Incorporated.

Foehr, U. G. (2006). *Media multitasking among American youth: Prevalence, predictors and pairings*. Henry J. Kaiser Family Foundation.

Grace-Martin, M., & Gay, G. (2001). Web browsing, mobile computing and academic performance. *Educational Technology & Society*, *4*(3), 95–107.

Hambrick, D. Z., Oswald, F. L., Darowski, E. S., Rench, T. A., & Brou, R. (2010). Predictors of multitasking performance in a synthetic work paradigm. *Applied Cognitive Psychology*, *24*(8), 1149–1167. https://doi.org/10.1002/acp.1624

Hirnstein, M., Hugdahl, K., & Hausmann, M. (2019). Cognitive sex differences and hemispheric asymmetry: A critical review of 40 years of research. *Laterality: Asymmetries of Body, Brain and Cognition*, *24*(2), 204–252. https://doi.org/10.1080/1357650X.2018.1497044

Hirnstein, M., Larøi, F., & Laloyaux, J. (2019). No sex difference in an everyday multitasking paradigm. *Psychological Research*, *83*, 286–296. https://doi.org/10.1007/s00426-018-1045-0

Hirsch, P., Koch, I., & Karbach, J. (2019). Putting a stereotype to the test: The case of gender differences in multitasking costs in task-switching and dual-task situations. *PLOS ONE*, *14*(8), e0220150. https://doi.org/10.1371/journal.pone.0220150

Hiscock, M., Perachio, N., & Inch, R. (2001). Is there a sex difference in human laterality? IV: An exhaustive survey of dual-task interference studies from six neuropsychology journals. *Journal of Clinical and Experimental Neuropsychology*, *23*(2), 137–148. https://doi.org/10.1076/jcen.23.2.137.1206

Jeffreys, H. (1935). Some tests of significance, treated by the theory of probability. *Proceedings of the Cambridge Philosophical Society*, *31*(2), 203–222.

Judd, T., & Kennedy, G. (2011). Measurement and evidence of computer-based task switching and multitasking by "net generation" students. *Computers & Education*, *56*(3), 625–631. https://doi.org/10.1016/j.compedu.2010.10.004

Kass, R. E., & Raftery, A. E. (1995). Bayes factors. *Journal of the American Statistical Association*, *90*(430), 773–795. https://doi.org/10.1080/01621459.1995.10476572

Lanting, S., Haugrud, N., & Crossley, M. (2009). The effect of age and sex on clustering and switching during speeded verbal fluency tasks. *Journal of the International Neuropsychological Society*, *15*(2), 196–204. https://doi.org/10.1017/S1355617709090237

Lin, L. (2009). Breadth-biased versus focused cognitive control in media multitasking behaviors. *Proceedings of the National Academy of Sciences of the United States of America*, *106*(37), 15521–15522. https://doi.org/10.1073/pnas.0908642106

Linn, M. C., & Petersen, A. C. (1985). Emergence and characterization of sex differences in spatial ability: A meta-analysis. *Child Development*, *56*(6), 1479–1498. https://doi.org/10.2307/1130467

Lui, K. F. H., & Wong, A. C.-N. (2012). Does media multitasking always hurt? A positive correlation between multitasking and multisensory integration. *Psychonomic Bulletin & Review*, *19*(4), 647–653. https://doi.org/10.3758/s13423-012-0245-7

Lui, K. F. H., & Wong, A. C.-N. (2020). Multiple Processing Limitations Underlie Multitasking Costs. *Psychological Research*, *84*, 1946–1964. https://doi.org/10.1007/s00426-019-01196-0

Mäntylä, T. (2013). Gender differences in multitasking reflect spatial ability. *Psychological Science*, *24*(4), 514–520. https://doi.org/10.1177/0956797612459660

Mäntylä, T., Coni, V., Kubik, V., Todorov, I., & Del Missier, F. (2017). Time takes space: Selective effects of multitasking on concurrent spatial processing. *Cognitive Processing*, *18*(3), 229–235. https://doi.org/10.1007/s10339-017-0799-4

Mayr, U., & Kliegl, R. (2003). Differential effects of cue changes and task changes on task-set selection costs. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *29*(3), 362–372. https://doi.org/10.1037/0278-7393.29.3.362

Minear, M., Brasher, F., McCurdy, M., Lewis, J., & Younggren, A. (2013). Working memory, fluid intelligence, and impulsiveness in heavy media multitaskers. *Psychonomic Bulletin & Review*, *20*(6), 1274–1281. https://doi.org/10.3758/s13423-013-0456-6

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex "frontal lobe" tasks: A latent variable analysis. *Cognitive Psychology*, *41*(1), 49–100. https://doi.org/10.1006/cogp.1999.0734

Monsell, S. (2003). Task switching. *Trends in Cognitive Sciences*, *7*(3), 134–140. https://doi.org/10.1016/S1364-6613(03)00028-7

Naugler, W. E., Sakurai, T., Kim, S., Maeda, S., Kim, K., Elsharkaway, A. M., & Karin, M. (2007). Gender disparity in liver cancer due to sex differences in MyD88-dependent IL-6 production. *Science*, *317*(5834), 121–124. https://doi.org/10.1126/science.1140485

Nijboer, M., Taatgen, N. A., Brands, A., Borst, J., & van Rijn, H. (2013). Decision making in concurrent multitasking: Do people adapt to task interference? *PLOS ONE*, *8*(11), e79583. https://doi.org/10.1371/journal.pone.0079583

Nunnally, J. C., & Bernstein, I. H. (1967). *Psychometric theory*. McGraw-Hill.

Offer, S., & Schneider, B. (2011). Revisiting the gender gap in time-use patterns: Multitasking and well-being among mothers and fathers in dual-earner families. *American Sociological Review*, *76*(6), 809–833. https://doi.org/10.1177/0003122411425170

Ophir, E., Nass, C., & Wagner, A. D. (2009). Cognitive control in media multitaskers. *Proceedings of the National Academy of Sciences of the United States of America*, *106*(37), 15583–15587. https://doi.org/10.1073/pnas.0903620106

Pashler, H. (1994). Dual-task interference in simple tasks: Data and theory. *Psychological Bulletin*, *116*(2), 220–244.

Pease, A., & Pease, B. (2003). *Why men can only do one thing at a time and women never stop talking*. Orion.

Poposki, E. M., & Oswald, F. L. (2010). The Multitasking Preference Inventory: Toward an improved measure of individual differences in polychronicity. *Human Performance*, *23*(3), 247–264. https://doi.org/10.1080/08959285.2010.487843

Redick, T. S., Shipstead, Z., Meier, M. E., Montroy, J. J., Hicks, K. L., Unsworth, N., & Engle, R. W. (2016). Cognitive predictors of a common multitasking ability: Contributions from working memory, attention control, and fluid intelligence. *Journal of Experimental Psychology: General*, *145*(11), 1473–1492. https://doi.org/10.1037/xge0000219

Reissland, J., & Manzey, D. (2016). Serial or overlapping processing in multitasking as individual preference: Effects of stimulus preview on task switching and concurrent dual-task performance. *Acta Psychologica*, *168*, 27–40. https://doi.org/10.1016/j.actpsy.2016.04.010

Ren, D., Zhou, H., & Fu, X. A. (2009). A deeper look at gender difference in multitasking: Gender-specific mechanism of cognitive control. In *Proceedings of the 5th international conference on natural computation* (Vol. 5, pp. 13–17). Institute of Electrical and Electronics Engineers. https://doi.org/10.1109/ICNC.2009.542

Rideout, V. J., Foehr, U. G., & Roberts, D. F. (2010). *Generation M2: Media in the lives of 8-to 18-year-olds*. Henry J. Kaiser Family Foundation.

Rogers, R. D., & Monsell, S. (1995). Costs of a predictable switch between simple cognitive tasks. *Journal of Experimental Psychology: General*, *124*, 207–231.

Roivainen, E. (2011). Gender differences in processing speed: A review of recent research. *Learning and Individual Differences*, *21*(2), 145–149. https://doi.org/10.1016/j.lindif.2010.11.021

Rosen, L. D., Carrier, L. M., & Cheever, N. A. (2013). Facebook and texting made me do it: Media-induced task-switching while studying. *Computers in Human Behavior*, *29*(3), 948–958. https://doi.org/10.1016/j.chb.2012.12.001

Sanbonmatsu, D. M., Strayer, D. L., Medeiros-Ward, N., & Watson, J. M. (2013). Who multi-tasks and why? Multi-tasking ability, perceived multi-tasking ability, impulsivity, and sensation seeking. *PLOS ONE*, *8*(1), e54402. https://doi.org/10.1371/journal.pone.0054402

Sayer, L. C. (2007). Gender differences in the relationship between long employee hours and multitasking. In B. A. Rubin (Ed.), *Workplace temporalities* (pp. 403–435). Emerald Group Publishing. https://doi.org/10.1016/S0277-2833(07)17013-8

Schumacher, E. H., Seymour, T., Glass, J., Fencsik, D., Lauber, E., Kieras, D., & Meyer, D. (2001). Virtually perfect time sharing in dual-task performance: Uncorking the central cognitive bottleneck. *Psychological Science*, *12*, 101–108. https://doi.org/10.1111/1467-9280.00318

Silverman, I., & Eals, M. (1992). Sex differences in spatial abilities: Evolutionary theory and data. In J. Barkow, L. Cosmides & J. Tooby (Eds.), *The adapted mind: Evolutionary psychology and the generation of culture* (pp. 533–549). Oxford University Press.

Spink, A., Park, M., Jansen, B. J., & Pedersen, J. (2006). Multitasking during web search sessions. *Information Processing and Management*, *42*(1), 264–275. https://doi.org/10.1016/j.ipm.2004.10.004

Stoet, G., O'Connor, D. B., Conner, M., & Laws, K. R. (2013). Are women better than men at multi-tasking? *BMC Psychology*, *1*, e18. https://doi.org/10.1186/2050-7283-1-18

Strayer, D. L., & Johnston, W. A. (2001). Driven to distraction: Dual-task studies of simulated driving and conversing on a cellular telephone. *Psychological Science*, *12*(6), 462–466. https://doi.org/10.1111/1467-9280.00386

Strayer, D. L., Medeiros-Ward, N., & Watson, J. M. (2013). Gender invariance in multitasking: A comment on Mäntylä (2013). *Psychological Science*, *24*(5), 809–810. https://doi.org/10.1177/0956797612465199

Strobach, T., & Woszidlo, A. (2015). Young and older adults' gender stereotype in multitasking. *Frontiers in Psychology*, *6*, e1922. https://doi.org/10.3389/fpsyg.2015.01922

Szameitat, A. J., Hamaida, Y., Tulley, R. S., Saylik, R., & Otermans, P. C. (2015). "Women are better than men": Public beliefs on gender differences and other aspects in multitasking. *PLOS ONE*, *10*(10), e0140371. https://doi.org/10.1371/journal.pone.0140371

Trafton, J. G., Altmann, E. M., Brock, D. P., & Mintz, F. E. (2003). Preparing to resume an interrupted task: Effects of prospective goal encoding and retrospective rehearsal. *International Journal of Human-Computer Studies*, *58*(5), 583–603. https://doi.org/10.1016/S1071-5819(03)00023-5

Tschernegg, M., Neuper, C., Schmidt, R., Wood, G., Kronbichler, M., Fazekas, F., Enzinger, C., & Koini, M. (2017). FMRI to probe sex-related differences in brain function with multitasking. *PLOS ONE*, *12*(7), e0181554. https://doi.org/10.1371/journal.pone.0181554

van der Schuur, W. A., Baumgartner, S. E., Sumter, S. R., & Valkenburg, P. M. (2015). The consequences of media multitasking for youth: A review. *Computers in Human Behavior*, *53*, 204–215. https://doi.org/10.1016/j.chb.2015.06.035

von Bastian, C. C., & Druey, M. D. (2017). Shifting between mental sets: An individual differences approach to commonalities and differences of task switching components. *Journal of Experimental Psychology: General*, *146*(9), 1266–1285. https://doi.org/10.1037/xge0000333

Weiss, E., Ragland, J. D., Brensinger, C. M., Bilker, W. B., Deisenhammer, E. A., & Delazer, M. (2006). Sex differences in clustering and switching verbal fluency tasks. *Journal of the International Neuropsychological Society*, *12*(4), 502–509. https://doi.org/10.1017/S1355617706060656

Weissman, M. M., & Klerman, G. L. (1977). Sex differences and the epidemiology of depression. *Archives of General Psychiatry*, *34*(1), 98–111.

Wetzels, R., Matzke, D., Lee, M. D., Rouder, J. N., Iverson, G. J., & Wagenmakers, E. J. (2011). Statistical evidence in experimental psychology: An empirical comparison using 855 *t* tests. *Perspectives on Psychological Science*, *6*(3), 291–298. https://doi.org/10.1177/1745691611406923

Wostmann, N. M., Aichert, D. S., Costa, A., Rubia, K., Moller, H. –. J., & Ettinger, U. (2013). Reliability and plasticity of response inhibition and interference control. *Brain and Cognition*, *81*(1), 82–94. https://doi.org/10.1016/j.bandc.2012.09.010

Yeykelis, L., Cummings, J. J., & Reeves, B. (2014). Multitasking on a single device: Arousal and the frequency, anticipation, and prediction of switching between media content on a computer. *Journal of Communication*, *64*(1), 167–192. https://doi.org/10.1111/jcom.12070