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Self-efficacy Matters More Than Interruptions In a Sequential Multitasking Experiment

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Interruptions and multitasking have received a great deal of attention from researchers. The present study is the first to examine task self-efficacy along with interruptions in an experimental multitasking framework. Perceptions of resumption lag times and task rehearsal were also examined. Participants (*N*= 110) completed a primary task (puzzle) with some being interrupted to pursue a secondary task (a word search) either once or four times. Uninterrupted participants completed the puzzle 26% faster than those interrupted once and 30% faster than those interrupted four times. However, self-efficacy predicted performance much more strongly than did interruptions, and therefore should receive more attention in future studies. Participants generally disagreed that they experienced resumption lags or task rehearsal. Practically, the results indicate that training to the point of high self-efficacy on tasks will do more to enhance performance than would eliminating interruptions. In reality, such training is likely easier to accomplish.

Interruptions and multitasking are ubiquitous aspects of work and life, and are often considered to be deleterious to performance of tasks. Trafton and Monk's (2008) review showed that most studies found that interruptions increased task completion time, with a few exceptions (e.g., Speier et al., 1999; Speier, Vessey & Valachich, 2003). Our overview of interruptions and multitasking research revealed some interesting patterns

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as well as gaps in the literature. First, most experimental designs included multiple interruptions, however, frequency of interruptions have not been varied as an experimental manipulation. It is reasonable to postulate that interruption frequency would play an important role in task performance, so it is an interesting variable to investigate. Second, most experimental designs focused on performance of a primary task. Interrupting tasks are not treated as variables of interest, and performance on interrupting tasks is not a point of focus. In work and everyday life interrupting tasks, which can be characterized as secondary tasks, may also be important to performance. Theoretically, to the extent that interruptions involve switching between a primary and secondary task, secondary task performance should experience the same effects as primary task performance. Third, with a few exceptions, research designs largely focused on experimental manipulations without including individual characteristics that could affect performance. Studies that included working memory and interest showed that those characteristics played a role in multitasking performance. In other literatures, self-efficacy (belief in one's ability to perform a task) predicted performance in a variety of contexts, including academics and work (Bassi, Steca, Delle Fave, & Caprara, 2007; Stajkovic & Luthans, 1998). Therefore self-efficacy is a promising characteristic that is theoretically relevant.

The present study examined the role of self-efficacy in a multitasking experiment. Interruption frequency was explicitly included as a design variable. The measures included psychological perceptions of theoretically relevant variables of resumption lag and task rehearsal, which also merit study. The next sections overview research and theory related to multitasking, resumption lag and task rehearsal. The potential roles of interruption frequency, secondary task performance and individual characteristics including self-efficacy are also explained.

Aspects of Multitasking

Simultaneous multitasking refers to performing tasks which require attention at the same time (e.g., listening to a lecture and reading a text message). Sequential multitasking, also called parallel multitasking, task switching, and task interleaving, refers to switching attention back and forth between tasks (Meyer & Kieras, 1997; Wickens & McCarley, 2008). With some exceptions, previous research found that multitasking increases time to perform a primary task. Trafton and Monk's (2008) review of the applied literature concluded that most studies found that interrupted primary tasks took longer to complete than uninterrupted tasks, which Wickens and McCarley referred to as a switch cost. Subsequent studies provided further evidence that sequential multitasking increased performance time (Bowman, Levine, Waite, & Gendron, 2010; Fox, Rosen, & Crawford, 2009; Leroy, 2009). However, a subset of studies found that when the secondary, interrupting task was simple, boring, or repetitive, participants worked faster after switching back to the primary task, resulting in no net increase in time to complete the primary task (Mark, Gudith, & Klocke, 2008; Ratwani & Trafton, 2006; Speier et al., 1999; Speier, Vessey & Valachich, 2003). Overall, Trafton and Monk concluded that switch costs were lower when interruptions were simple, brief, dissimilar from the primary task, could be postponed, or if retrieval cues (place markers or reminders about where to restart) were available. Even very brief interruptions (3 to 18 seconds) increased the time it took to resume a primary task, which is also referred to as a resumption lag time, or response latency (Hodgetts & Jones, 2006b; Hodgetts, Vachon & Tremblay, 2014; Monk, Trafton, & Boehm-Davis, 2008; Trafton & Monk, 2008). Altmann, Trafton & Hambrick (2013) found that interruptions averaging 4.4 seconds increased response latencies, but interruptions of 2.8 seconds did not. In a multiple regression analysis, Grundgeiger, Sanderson, MacDougall, and Venkatesh (2010) found that longer interruptions resulted in increased resumption lag times. Therefore, the duration and nature of the interrupting secondary task are relevant, and the evidence regarding switch costs is mixed, although it appears that interruptions must be extremely brief in order to reduce or eliminate switch costs.

Multitasking Theory and Research

Two theories have focused specifically on explaining switch costs resulting from sequential multitasking. Memory for goals theory (Altmann & Trafton, 2002) posits that individuals engaging in a primary task develop a cognitive goal of task completion. An interruption causes memory for that goal to decay, and interferes with resuming the process, which results in increased errors (Trafton, Altmann, & Ratwani, 2011). Resuming the primary task results in a lag time which represents the time it takes to retrieve the goal from memory, before it is entirely forgotten. Longer interruptions should result in more decay, and therefore higher resumption lag times. Repeated interruptions should add to resumption lags. The construct of resumption lag time (Altmann & Trafton), has also been referred to as response latency (Altmann et al., 2013). Typically, studies have measured actual lag time by computer monitoring. For tasks where such monitoring is not feasible, perceptions of resumption lags can be captured, presuming that individuals would be aware of lags. Perceptions are important because if individuals are unaware that interruptions increase task completion time, they likely would not take steps to limit interruptions.

A second theory posits that switching from a primary to a secondary task results in an attention residue (Leroy, 2009) when thoughts about the primary task remain (primary task rehearsal) and interfere with performance of the secondary task. The same can happen when switching from the secondary task back to the primary task (secondary task rehearsal). Completing a primary task should result in a form of closure which leaves little or no residue (rehearsal). If there is such an effect, presumably individuals would be aware of it. Therefore it is important to measure perceptions of primary and secondary task rehearsal.

Although many studies have shown that interruptions increase task completion time, no studies have measured participants' awareness of interruption effects, either through perceptions of resumption lag time, or task rehearsal. Further, neither memory for goals nor attention residue theories can account for results that have resulted in no net switch costs because participants sped up work on the primary task after returning to it (Mark et al., 2008; Ratwani & Trafton, 2006; Speier et al., 1999; Speier et al., 2003).

Frequency of Interruptions and Secondary Task Performance

Frequent interruptions are common in work and everyday life. For example, a naturalistic observation study revealed that technology workers averaged an interruption every three minutes throughout the day (Gonzalez & Mark, 2004). Nurses averaged 2.6 interruptions per 25 minutes of administering drugs to patients, and spent an average of 11% of their time on interruptions (Kreckler, Catchpole, Bottomley, Handa, & McCulloch, 2008). Therefore, for each half hour, 3 minutes and 30 seconds were devoted to interrupting tasks. If there is a switch cost, theories predict that multiple interruptions should result in cumulative switch costs, and therefore increase task completion time, although some studies have found otherwise (e.g., Ratwani & Trafton, 2006). Previous experimental studies have not systematically varied interruption frequency in order to determine its effects.

Secondary tasks are typically included as an aspect of methodological design, not variables of interest. Therefore, performance on secondary tasks has not been examined in previous work. However, to use an employment example, it is probable that many secondary tasks are job-related (Gonzalez & Mark, 2004; Grundgeiger et al., 2010; Jett & George, 2003), and may be equally or more important than the primary task (e.g., an alarm sounding during a pilot's preflight check, a nurse interrupted by a colleague's question about a patient). Theoretically, secondary tasks should be subject to the same cognitive constraints as primary tasks, therefore, the same theories can be used to make predictions about secondary task performance. For example, if an individual switches between a primary and secondary task multiple times, then we would predict a switch cost resulting in reduced performance on the secondary task. Therefore, studying interruption frequency and secondary task performance will add to knowledge.

Individual Characteristics

Multitasking studies have typically focused on the effects of experimental manipulations without regard to individual characteristics in participants. The few exceptions produced interesting results. For example, working memory capacity predicted performance in several multitasking situations (Conway, Cowan, & Bunting, 2001; Engle, 2002; Hambrick, Oswald, Darowski, Rench, & Brou, 2010; Parasuraman, 2011). Conard and Marsh (2014) showed that interest in the task correlated with learning, independently of interruptions. Self-efficacy is another individual characteristic which has been widely researched, yet is largely unexplored in the realm of multitasking performance. Bandura (1977) defined self-efficacy as one's belief in how well one can execute courses of action to produce desired outcomes in future situations. Although the concept of general self-efficacy has an appeal, Bandura (2012) noted that self-efficacy varies across activity domains and even across sub-facets of those domains. "Consequently, there is no single all-purpose measure of self-efficacy with a single validity coefficient" (Bandura, 2012, p. 15). Therefore, researchers develop narrow self-efficacy measures tailored to specific tasks and behaviors. Those specific self-efficacy measures correlated with performance in many areas, including academics (Bassi et al., 2007), work (Stajkovic & Luthans, 1998), salary, and career progression (Abele & Spurk, 2009). Self-efficacy can develop through several channels, particularly through previous experience with performing a task (Maddux & Gosselin, 2012). When a person believes they are good (or poor) at a specific task based on previous experience, that belief also correlates with future task performance. Hambrick et al. (2010) found that a 2-item composite measure of video game skill and experience, which they termed "video game experience", predicted performance in a video game-like task. Those self-ratings of skill and experience are quite similar to measures of task specific self-efficacy. Cades, Boehm-Davis, Trafton, and Monk (2011) found that practice with specific primary and secondary (interrupting) task pairs improved task performance. Practice would likely increase self-efficacy. These two sets of results point to the importance of focusing on self-efficacy as a key variable in multitasking research.

The Present Study

The present study used a sequential multitasking paradigm, where the primary task was to complete a jigsaw puzzle, and the secondary task was a word search puzzle. These tasks have visual-spatial and psychomotor components, and utilize a wide variety of cognitive processes used in work and everyday life. Interruption frequency was systematically varied to allow comparisons. Task specific self-efficacy was measured, as were perceptions of resumption lag time, task rehearsal, and secondary task performance in order to further assess theoretical constructs. We predicted that participants in an uninterrupted condition would complete the jigsaw puzzle significantly more quickly than those in the one interruption and multiple interruption conditions, and that the one interruption condition would be faster than the multiple interruption condition. We further predicted that participants would perform worse on the secondary task with one or multiple interruptions than when uninterrupted. We also predicted that self-efficacy would correlate with task performance, and would add to the prediction of puzzle completion time, over and above interruptions. Lastly, we predicted that perceptions of resumption lag time and task rehearsal would increase with interruption frequency.

The present study advances our understanding of multiple multitasking constructs. First, it focuses on both primary and secondary task performance. Second, interruption frequency was systematically varied in order to allow comparison of effects. Third, it included an individual characteristic (self-efficacy) that has not been studied in this context. Fourth, including perceptions of resumption lag time and task rehearsal allowed further investigation of theoretical predictions.

METHOD

Participants. Participants were 110 full-time undergraduates recruited from business and psychology courses (60 women, 50 men, age M = 20.9, SD = 3.5, 24 freshmen, 4 sophomores, 19 juniors, 63 seniors). Participants received course credit and could opt to do an alternate assignment.

Materials and Measures. Materials consisted of a jigsaw puzzle, a word search puzzle, and a questionnaire that assessed demographics, individual differences, and general responses to the experimental process. The primary task was a 100 piece Hello Kitty jigsaw puzzle designed for ages 5 and over. Pretesting with eight volunteers, (high school age, undergraduates, and adults) indicated that the puzzle could be completed in 15 to 25 minutes, uninterrupted. Trafton and Monk (2008) called for researchers to identify the types of tasks and interruptions, to aid interpretation of results. In ergonomic terms, jigsaw puzzle assembly is a visual and psychomotor task that requires planning and organizing, focused attention, exhaustive visual search with serial processing of a free field. Also required are target identification, visual comparison (compare pieces to complete picture), short and long-term working memory, and decision making (Wickens & Hollands, 2000; Wickens & McCarley, 2008). Notably, assembling a jigsaw puzzle requires a complex array of basic cognitive skills important for many everyday tasks (e.g., driving, playing sports) as well as many jobs such as baggage X-ray screening, manufacturing assembly, human-computer interaction, industrial inspection, and crime scene analysis (Wickens & McCarley, 2008). Puzzles are also used in cognitive ability assessments such as the Wechsler Adult Intelligence Scale, and in studies of working memory (Giofre, Mammarella, Ronconi, & Cornoldi, 2013).

The secondary, interrupting task was a one page word search puzzle that contained the names of all 50 United States embedded in a 22 x 22 matrix of letters. A guide at the top of the page listed the state names in alphabetical order. The task required visual search and cognitive processing of letters and words. Importantly, the word search could be scored (number of words found), resulting in a measure of performance on both the secondary and primary tasks.

The tasks were chosen because they require fundamental cognitive skills important in work and everyday life. The tasks required no specialized training and could be accomplished in a reasonable amount of time. Further, they engaged participants by requiring sustained attention and motivation Also participants were not likely to be expert in either specific task.

Participants completed a questionnaire that assessed demographics, jigsaw puzzle experience, puzzle self-efficacy, and perceptions of resumption lag time and task rehearsal. All items were measured on a five-point scale where 1 = strongly disagree, 3 = neutral, neither agree nor disagree, and 5 = strongly agree.

Because self-efficacy measures must be tailored to specific domains, we designed a five-item scale. Cronbach's alpha reliability analyses showed that a three-item scale had higher reliability, (Cronbach's alpha = .74 compared to .53 for the five items) therefore it was used in subsequent analyses. That reliability is comparable to that found in similar three-item subscales of the Kuder Task Self-Efficacy Scale (Lucas, Wanberg, & Zytowski, 1997). The three items were, I was motivated to complete the jigsaw puzzle, I am skilled at jigsaw puzzles, I like to do jigsaw puzzles. These items tap the belief in a specific ability, as well as the motivational state aspects of specific self-efficacy (Chen, Gully, & Eden, 2001)

Individual items measured two aspects of perceived resumption lag time. They were r*esumption difficulty* (it was difficult to get back into the flow after the interruption) and *resumption ease* (I quickly refocused on the puzzle after the interruption). In the present study, primary task rehearsal could occur when switching from the primary to secondary task, and secondary task rehearsal could occur when switching from the secondary to the primary task. The item "I was thinking about the puzzle while doing the word search" measured primary task rehearsal. The item "I was thinking about the word search when I went back to doing the puzzle" measured secondary task rehearsal.

Procedure. Participants were randomly assigned to one of three conditions, i.e., uninterrupted, one interruption, and four interruptions. All participants were measured on their net time to complete the puzzle (subtracting out any time for interruptions and transitioning between tasks). For all participants, the puzzle pieces were thoroughly mixed, and placed in a pile on a work table. The box cover with the image of the complete puzzle was placed on the table to be used as a guide. Participants were alone in a windowless room while they worked.

Trafton and Monk's (2008) review indicated that interrupting tasks tend to be less disruptive if they are simple, brief (a few seconds), repetitive, could be postponed, and have retrieval cues available. Interruptions that take the person to another context are more disruptive (Grundgeiger et al., 2010; Hodgetts & Jones, 2006b; Monk et al., 2008). In order to maximize disruptiveness, the interrupting task in the present study was complex, lengthy (a minute or more), engaging, non-repetitive, could not be postponed, and changed the context. The interruption was accomplished by way of an intrusion (as defined by Jett & George, 2003). Participants in the uninterrupted condition completed the puzzle without interruption and signaled that they were finished, whereby the experimenter stopped the timer, took the participant to another work station, and allowed four minutes to work on the word search. Four minutes approximated the Kreckler et al. (2008) finding regarding percent of time spent on interruptions.

For the single interruption condition, the experimenter entered the room and stopped the participant after approximately six minutes of work on the puzzle, stopped the puzzle timer, brought the participant to another work station, and asked him or her to work on the word search, then left. This step produced a change in context and prevented further work on the puzzle (Hodgetts & Jones, 2006a). After four minutes, the experimenter reentered the room, had the participant stop working on the word search and took him or her back to work on the puzzle, and restarted timing for the puzzle. Therefore puzzle completion time was not contaminated with time to transition between tasks. The procedure for the multiple interruptions condition was similar to the second condition, except that the experimenter interrupted the participant to work on the word search four times, for one minute each time, equaling a total of four minutes. Approximately three minutes were allowed in between interruptions, paralleling Gonzalez & Mark's (2004) findings. Participants then completed the questionnaire.

RESULTS

Preliminary Analyses

Although the random assignment to conditions resulted in different numbers of participants across conditions, there were no significant differences in recent experience (number of puzzles completed in the last six months) F (2, 108) = 0.81, p >.05 nor in puzzle self-efficacy F (2, 108) = 0.89, p > .05. Although they differed in size, the conditions did not differ in recent experience with puzzles, or in self-efficacy. Recent experience correlated -.25 (p < .01) with puzzle completion time, but only correlated .10 (p > .05) with puzzle self-efficacy.

Table 1 shows descriptive statistics and correlations. Puzzle completion time was negatively correlated with puzzle self-efficacy (r = -.52). The magnitude of that correlation indicates a very large effect size, higher than the 80th percentile benchmark for correlations between psychological characteristics and performance (Bosco, Aguinis, Singh, Field, & Pierce, 2014). Puzzle completion time was also negatively correlated with word search performance, indicating that participants who were faster on the puzzle also tended to do better on the word search. Neither of the resumption lag time measures correlated significantly with puzzle or word search performance. Both primary and secondary task rehearsal were significantly correlated with puzzle completion time, but not word search performance. Puzzle self-efficacy was negatively correlated with resumption difficulty. Puzzle self-efficacy was also positively correlated with word search score.

Table 1. Means, SDs, Ns, and Correlations between Study Variables

Measure	*M*	*SD*	*N*	1	2	3	4	5	6	7
1. Puzzle Completion time (min)	24.41	9.57	109							
2. Word Search Score	9.27	2.91	110	-.25**						
3. Puzzle Self-Efficacy	3.64	0.82	110	-.52**	.22*					
4. Word search distracted	2.76	1.22	109	-.18	.06	-.02				
5. Resumption difficulty	2.35	1.16	86	.07	-.05	-.23*	.29**			
6. Resumption ease	3.96	1.29	85	.18	-.08	-.03	.00	-.38**		
7. Primary task rehearsal	2.72	1.41	109	-.22*	.08	.15	.44**	.07	.03	
8. Secondary task rehearsal	2.15	1.16	85	-.24*	.07	-.12	.21	.25*	-.37**	.14

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

Puzzle Completion Time

Table 2 displays the descriptive statistics, ANOVA, and *t*-test results for major variables. The hypothesis that puzzle completion time would be fastest in the uninterrupted condition, followed by the single interruption condition, and the multiple interruption condition was partly supported. There was a significant main effect for interruptions. Post hoc Bonferroni comparisons indicated that the uninterrupted condition was significantly (26%) faster than the single interruption condition, which was not significantly (4%) faster than the multiple interruption condition. Interestingly, the means showed an asymptotic pattern in that one interruption added 5.2 minutes to puzzle completion time, while four interruptions added 6.0 minutes, compared to those who were uninterrupted. The effect size d = .54, was moderate, and power of 0.71 was slightly lower than Cohen's recommendation of power = 0.80.

Secondary Task Performance

The hypothesis that score on the word search task would be lower in the single and multiple interruption conditions than in the uninterrupted condition was not supported. As shown in Table 2, the one-way ANOVA showed that there was no significant main effect on word search scores.

Table 2. Group Means, Standard Deviations, ANOVA and t-test Results for Major Study Variables

	Uninterrupted $N = 25$ M (SD)	One Interruption $N = 48$ M (SD)	Four Interruptions $N = 36$ M (SD)	F (2,107)	t (82)
Puzzle completion time (min)	20.1_a (5.4)	25.3_{ab} (9.2)	26.1_b (11.4)	3.39*	
Word search score	9.2 (2.8)	9.0 (2.9)	9.6 (3.0)	0.44	
Perceived resumption lag					
Resumption difficulty		2.1 (1.0)	2.6 (1.2)		-2.3*
Resumption ease		4.1 (1.1)	3.8 (1.5)		1.2
Task rehearsal					
Primary task rehearsal	1.75_a (1.1)	2.9_b (1.4)	3.1_b (1.4)	8.3**	
Secondary task rehearsal		2.1 (1.1)	2.2 (1.3)		-0.28

Note. Row means that do not share subscripts differ at $p < .05$ in the Bonferroni comparisons. Perceived resumption lag items and secondary task rehearsal were measured in two conditions and tested with t-tests. *$p < .05$. **$p < .01$.

Perceived Resumption Lag Time, and Task Rehearsal

Table 2 presents the results for perceived resumption lag, primary and secondary task rehearsal. Two items measured aspects of perceived resumption lag. These items were not relevant for the uninterrupted condition and therefore were measured for the single and multiple interruption conditions only. *Resumption difficulty* was significantly higher for the multiple interruption condition than for the single interruption condition. Note that both means were near the "disagree" point of the scale, meaning participants in either condition did not perceive much difficulty. *Resumption ease* showed no significant difference between the multiple interruption condition and single interruption condition. Both means were near the "agree" point of the scale, indicating that participants in both conditions believed they quickly refocused. Overall, the evidence for perceptions of resumption lag time is mixed, and the means for both items indicate that interrupted participants generally did not *perceive* much of a lag from the interruptions and they felt that they quickly refocused.

Two items measured aspects of task rehearsal. Primary task rehearsal (thinking about the puzzle when doing the word search) was significantly lower in the uninterrupted condition than in both interrupted conditions, but was not significantly different between the two interrupted conditions, based on post hoc Bonferroni comparisons. Secondary task rehearsal (thinking about the word search while doing the puzzle), which was applicable only to the two interrupted conditions, also did not show a significant difference between those groups. For both types of task rehearsal, the means were on the neutral to disagree end of the scale, indicating that participants did not engage in much task rehearsal.

Interruptions and Puzzle Self-Efficacy

Results supported the hypothesis that self-efficacy would predict puzzle completion time, over and above the interruption effect. Table 3 shows the multiple regression results. Because the two interrupted conditions did not differ substantially or significantly according to the post hoc Bonferroni comparison, and in order to improve power and interpretability, the interrupted conditions were combined. In the first step of the regression, the dummy coded uninterrupted/interrupted variable significantly predicted puzzle completion time. In the second step, the interruption variable and puzzle self-efficacy were both regressed on puzzle completion time, and both significantly predicted puzzle completion time. R^2 values indicate that the interruption manipulation accounted for 6% of the variance in puzzle completion time, while puzzle self-efficacy accounted for an additional 24% of the variance, a significantly greater percentage ($\Delta R^2 = .24$, $F(1, 106) = 36.23$, $p < .001$). Power for the multiple regression analysis exceeded 0.99 as calculated by G*Power version 3.1.9.2 (Faul, Erdfelder, Buchner, & Lang, 2009).

The B-weights in step 2 show that, holding self-efficacy constant, interruptions added an average of 4.24 min (4 min 15 sec) to puzzle completion time. By plugging the B-weights in Table 3, step 2 into the multiple regression equation, where the constant was 42, we can predict that a person in the uninterrupted condition with high self-efficacy (averaged 5 on the 5-point scale) would complete the puzzle in 13 min 15 sec, whereas a person with low self-efficacy (averaged 2 on the 5-point scale) would take 30 min 30 sec, more than twice as long. In an interrupted condition, a person with high self-efficacy would be predicted to complete the puzzle in 17 min 29 sec, whereas a person with low self-efficacy would take 34 min 44 sec.

Table 3. Multiple Regression of Interruptions and Self-Efficacy on Puzzle Completion Time

Variable	b	β	95% CI Lower	95% CI Upper	*R*	R^2
Step 1						
Uninterrupted/interrupted	5.59	.24**	1.32	9.86	.24	.06
Step 2						
Uninterrupted/interrupted	4.24	.18*	0.54	7.97		
Puzzle self-efficacy	-5.75	-.49***	-7.64	-3.86	.55	.30

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

DISCUSSION

Puzzle completion in both interrupted conditions took significantly longer than the uninterrupted condition. In practical terms, the difference was sizable. The single interruption condition took 25.9% longer and the four interruptions condition took 29.8% longer than the interrupted condition. Most organizations would consider that to be a very large cost. For example, for a machine assembler with a mean wage of $17.36 per hour (O*Net, 2014), a 30% increase in task completion time would cost the employer $5.20 per hour, $10,836 per year. For a registered nurse, the cost rises to $19,641 per year, and for an information technology manager, $24,342 per year. In the present study, the cost of interruptions occurred even though the ongoing task could be resumed at the last step completed (the last piece inserted). The cost would be even higher for tasks without a clear restarting point (Wickens & McCarley, 2008).

The size of the interruption effect is similar to Bowman et al. (2010) who measured a 21.7% time increase when a roughly 30 min reading passage was interrupted by instant messages. In both studies, the measure of time begins with the start of the primary task and ended with the completion, netting out the time spent on interruptions. Another way to measure time lost to interruptions, resumption lag (Altmann &Trafton, 2002), measures the time to restart the primary task after an interruption. Resumption lag is directly attributable to an interruption and is time lost on task. Some studies have found resumption lag to be only 1-2 secs, and usually less than 10% of the total time of the interruption (Monk &Trafton, 2008, Hodgetts &Jones, 2006b). A four-minute interruption should not have a resumption lag of five mins, therefore something else is accounting for poorer completion time. It could be that the placement of the interruption, at six minutes into the puzzle, was too early to establish a flow for the participant. The primary task type (puzzle completion or reading) and length (roughly 30 minutes) of primary task may influenced the results.

As expected, there was a large difference in puzzle completion time between no interruptions and one interruption, which supports the memory for goals predictions because it was a long interruption (four minutes), and it would not seem to have allowed much rehearsal during the lag time or during the secondary task. Surprisingly, there was a relatively small, nonsignificant difference between one interruption and four interruptions. Based on previous research, the present procedures were designed to maximize disruptiveness and therefore should have substantially increased time. There are several possible explanations. Participants may have reduced their resumption lag time, and/or worked faster on the primary task after returning to it, perhaps because of environmental cues, a practice effect, or what we term a "home stretch" effect. For example, it is possible that participants in the multiple interruption condition began anticipating the interruptions, and used environmental cues such as leaving a puzzle piece they were working on in a staging area to help resume the puzzle. Also, participants may have worked faster after the second, third and fourth interruptions, as has happened in some studies (Mark, Gudith, & Klocke, 2008; Ratwani & Trafton, 2006; Speier et al., 1999; Speier et al., 2003). For example, Ratwani and Trafton (2006) found that participants transcribing numbers had higher resumption lag times for the first step after the interruption, but on subsequent steps, they were actually faster than uninterrupted participants. If this happened in the present study, then it could explain why participants mostly disagreed that they had resumption lag times. Another possibility is that the multiple interruptions allowed for a "practice effect" in that early interruptions amounted to practicing the resumption of the jigsaw puzzle, which allowed participants to improve their ability to resume doing the puzzle after multiple interruptions. This would be aided by the fact that the interrupting task was the same each time (Cades et al., 2011). Importantly, the results of the present and previous studies point to an asymptotic effect of multiple interruptions rather than a cumulative linear effect. Thus a single interruption can have a relatively large effect on performance time, with the effect leveling off with multiple interruptions.

Importantly, puzzle self-efficacy was significantly and substantially more predictive of puzzle completion time than was the interruption manipulation, as it accounted for four times more variance in performance than did the interruption manipulation. In practical terms, a machine assembler with low self-efficacy who was interrupted would take twice as long to perform tasks compared to an assembler with high self-efficacy, costing the employer $307 per week, and approximately $17,360 per year. Because self-efficacy can come from successful experience with a task, the results indicate that training to the point of high self-efficacy is even more important than minimizing interruptions. This is especially important because it is unlikely that interruptions can be eliminated or even reduced much in most workplaces. Future studies might investigate whether self-efficacy moderates the effect of interruptions on performance. Given the effect size for the ANOVA in the present data, the sample sizes required to have adequate power to detect moderation are very large (over 400; Fritz & MacKinnon, 2007) and those analyses could not be performed.

Puzzle self-efficacy correlated with word search performance as well as puzzle performance. Although the self-efficacy items were worded specifically for jigsaw puzzles, evidently the construct generalized to word search performance. Notably, according to Wikipedia, word searches are referred to as puzzles as well as games (Word Search, 2015). Further, puzzle and word search performance were correlated, indicating some overlap in the two domains. Interestingly, recent experience with puzzles was significantly correlated with puzzle performance, but not with self-efficacy. Although self-efficacy arises from experience with tasks, evidently it does not have to be recent experience.

Attention residue theory (Leroy, 2009) predicts that more secondary task rehearsal should result in slower puzzle completion. More primary task rehearsal should result in lower word search performance. Surprisingly, both primary and secondary task rehearsal correlated negatively with puzzle performance indicating that more of either type of rehearsal resulted in faster puzzle completion. An examination of the scatter plots showed that the slowest performers, those who scored 1 *SD* or more above the mean on completion time (34 mins or more, about 10% of participants) all indicated low primary and secondary task rehearsal (1 or 2 on a 5-point scale) which could account for the negative correlations, because the rest of participants were evenly dispersed throughout the distributions. Coupled with the near zero correlation between primary task rehearsal and word search performance, it appears that task rehearsal does not account for performance on either task, especially not for the slowest performers. Clearly self-efficacy is a much stronger predictor for both tasks. It would be useful to include self-efficacy in future theories involving multitasking.

The interruptions affected performance, however, perceptions did not reflect the level of disruption. Although uninterrupted participants disagreed more strongly that the word search distracted them from the puzzle, all group means fell into the disagree-neutral end of the scale. Participants also generally disagreed that they had resumption lags or were rehearsing the previous tasks. This finding is important because individuals may allow themselves to be interrupted, or to engage in task switching, if they don't realize the extent of the disruptiveness.

Performance on the word search did not vary across conditions. The word search was interrupted either once or four times, therefore the theoretical predictions of memory for goals theory should apply. It is difficult to explain the results based on attention theory constructs. Although perhaps participants in the multiple interruption condition experienced a practice effect and improved their ability to resume the puzzle as well as to return to the word search, or that they sped up their work with multiple interruptions, which has happened previously. However neither of those possibilities would explain how the single interruption was no different from the uninterrupted condition. It is also possible that the nature of the word search task played a role. The word search may have had a ceiling effect in that easy to find words were identified very quickly, and finding further words was increasingly difficult, so the allotted four4 minutes produced a ceiling effect. Or perhaps the word search task is easy to resume at the last step, and was not much different than starting from the beginning. The current measurement design did not score word search performance at each interruption, but such a procedure could answer the question in future studies. Because interruptions in work and life often involve tasks that are important to perform, future interruption studies should include measures of performance on interrupting tasks in order to further understand the mechanisms involved.

Limitations

Although the procedures incorporated findings from observational field studies in work environments regarding interruption length, spacing, and context the present study was a laboratory study. The results must be replicated in field settings before firm conclusions can be drawn regarding costs to employers.

Conclusions

The present study employed primary and secondary tasks that involved fundamental cognitive skills required in work and life. Although interruptions and multitasking have received a great deal of attention from researchers, individual characteristics such as working memory and self-efficacy have been underrepresented in the literature. The present study is the first to examine task self-efficacy along with interruptions in an experimental framework. The results indicate that task self-efficacy explains performance much more than do interruptions, and therefore should receive more attention in future studies and theory. Also, although interruptions do slow performance, participants did not have insight into the level of the effects. If people don't believe that interruptions have deleterious effects, then they are not likely to take steps to limit or avoid them. That may be particularly true in conditions of high self-efficacy. For example, 64% of Americans say they are "very good" or "excellent" drivers (PRNewswire, 2011). If individuals believe that they are good at driving, and they don't think that cell phone usage is deleterious to driving, then they may decide to continue using cell phones while driving.

Performance on secondary tasks under sequential multitasking conditions is underrepresented in the literature, and also requires further study. In work and in everyday life, a secondary task may be as, or more, important than a primary task. Although the present study did not find deleterious effects, it would be useful to explore a variety of tasks and conditions that may affect secondary task performance.

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