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Single And Multiple Interruptions Increase Task Performance Time, But Don't Affect Stress, Pressure or Flow

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Running head: SINGLE AND MULTIPLE INTERRUPTIONS AND TASK PERFORMANCE

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Abstract

We compared task performance time and psychological reactions for uninterrupted, single interrupted, and multiple interrupted conditions. For 110 undergraduates, those who were uninterrupted while completing a jigsaw puzzle were 26% faster than the single interruption, and 30% faster than the multiple interruption conditions. Single and multiple interruption conditions were not significantly different. Participants in the multiple interruption condition felt more stress than those in the uninterrupted condition, although stress levels were low in both conditions. Perceptions of time pressure and flow were not different across conditions. Performance on the interrupting task (a word search puzzle) was not significantly different across conditions. An interruption or multiple interruptions significantly and substantially slowed performance although participants were not psychologically bothered by being interrupted.

Keywords: interruptions, flow, worker efficiency

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The phenomena of interruptions, distractions, multitasking, and information overload have received increasing attention from the popular press, scientists, and even legislatures. For example, several best selling non-fiction books address time management in an era of almost constant distractions. Although there have been exceptions (Freedman, 2007) the popular press mainly reports negatively about interruptions (e.g., Begley, 2009; Friedman, 2006; Kirn, 2007; Tugend, 2008), maintaining that interruptions promote "continuous partial attention" and that it may be a matter of how detrimental interruptions are, not whether it is damaging or whether it can be beneficial. Cell phone use while operating vehicles (and trains) has become a hot button issue due to its impact on safety. More than 250 bills are pending in 42 states restricting cell phone use for calls or texting while driving a vehicle ("Driving While Distracted", 2009). Texting was linked to 25 deaths in a California train accident ("Crash", 2008). And one study estimated that cell phone distractions are responsible for 2,600 deaths and 330,000 injuries in the United States every year (Brit, 2005).

For some jobs and tasks, safety is clearly an important concern in the study of interruptions and distractions. However, for many jobs and tasks, where safety is not an issue, the concern lies in the effect of interruptions on other factors such as the quality, quantity, and accuracy of performance, the time to perform a task, or stress and pressure that may result from interruptions. In circumstances where the interruption involves performing another task, the quality of performance on the interrupting task may also be a concern. Interruptions may affect task performance in various ways. One hypothesis is that interrupting an ongoing task results in an attention residue, (Leroy, 2009) where the individual continues to think about the interrupting task when returning to the ongoing task, which creates a lag time in performance An interruption

might also create a lag time because it interrupts the flow of the task (Csikszentmihalyi, 1975), or it might be a side effect of increased stress or time pressure.

To view interruptions objectively it is important to acknowledge that interruptions may have negative, neutral, or positive effects on performance. Jett and George (2003) outlined both positive and negative consequences that could result from interrupting a task with an intrusion, which is an unexpected encounter initiated by another person, which can be face-to-face or electronic, that interrupts the flow and continuity of an individual's work and brings that work to a temporary halt. It could result in negative consequences such as time pressure due to less time to complete a task, stress, anxiety, or disruption of flow (Csikszentmihalyi, 1975), which may increase the time to do a task or increase errors. Jackson and Marsh (1996) found that flow correlated positively with performance. Jett and George also postulated potential positive consequences from an intrusion, including getting information that wouldn't be known otherwise.

Welford (1952) found that switching to a new task before the first one was finished (parallel multitasking) led to poorer performance than doing each task serially. More recently Trafton and Monk (2007) reviewed the applied literature on interruptions and concluded that the bulk of studies found that tasks that were interrupted took longer to complete than tasks that were not interrupted. That may be due to what they refer to as resumption lag time, the time it takes to resume the original task. Welford referred to this as a psychological refractory period. Although most studies found that interruptions had negative consequences some studies (Ratwani & Trafton, 2006; Speier, Valachich & Vessey, 1999; Speier, Vessey & Valachich, 2003) found that at least for a simple, boring, or repetitive task, participants worked faster after the interruption,

resulting in no net increase in time to complete the ongoing task. Therefore, interruptions may be positive, negative, or neutral for the ongoing task.

Factors such as type and length of interruptions have received a good deal of attention from researchers. Factors that have not received much attention include performance on the interrupting task, individual differences, and the frequency of interruptions. Most often, researchers have focused on performance of an ongoing task. However, in work and everyday life, it is common to be interrupted to perform another task that may require speed, or accuracy, or both, and the interrupting task may be as or more important than the ongoing task. Therefore it is important to study performance on an interrupting task as well as the ongoing task.

There are also several individual difference factors that are usually not included in studies, but which are important to account for when studying task performance, and the extent to which interruptions are disruptive. Bluedorn, Kaufman, & Lane, (1992) and Slocumbe and Bluedorn (1999) formalized the concept of polychronicity, which is the extent to which a person prefers to have multiple tasks to work on at once and to switch between tasks before completion. People high on polychronicity should be less affected by interruptions than people who are low on polychronicity. Need for achievement is another individual difference characteristic that could affect performance, as it reflects a person's general will to do well on all or most tasks undertaken. A person's prior experience or level of expertise with the tasks would also affect performance, and the extent to which interruptions are disruptive. Finally, it is important to study the frequency of interruptions and their effects. Interruptions vary not only in their type and duration, but in their frequency. Gonzalez & Mark (2004) found that technology workers were interrupted every three minutes, on average. Nurses averaged 2.6 interruptions per 25 minutes of administering drugs to patients, and spent an average of 11% of their time dealing with those

interruptions (Kreckler, Catchpole, Bottomley, Handa, & McCulloch, 2008). If there is a resumption lag time, whether it is due to attention residue, disruption of flow, or additional stress, then multiple interruptions would be expected to result in multiple lag times, and therefore increase the time it takes to complete a task.

The present study

Given the complexities of task performance, and of how and whether interruptions will disrupt performance, our understanding is still at a rudimentary level. Existing studies very widely in terms of which types of tasks were chosen for an ongoing task or an interrupting task. Because of this, Trafton and Monk (2007) called for researchers to examine and identify the type of task and type of interruption to be studied. To address Trafton and Monk's suggestion, the next several paragraphs describe the characteristics of tasks and interruptions that are relevant to the present study. As our ongoing or primary task, we chose to have participants complete a jigsaw puzzle. Notably, although jigsaw puzzles are considered a recreational activity, assembling a 100 piece puzzle requires a complex array of basic cognitive skills that are important requirements for many everyday tasks (driving, playing sports, map reading) as well as many jobs (baggage X-ray screening, manufacturing assembly, human-computer interaction, search and rescue, industrial inspection, crime scene analysis, triage at an accident scene, accident analysis). It is a visual and psychomotor task that requires planning and organizing, exhaustive visual search with serial processing of a free field, target identification, focused attention, visual comparison (compare pieces to complete picture), short and long-term working memory, decision making, and even a rudimentary form of hypothesis testing.

In terms of planning and organizing, a jigsaw puzzle has a clear task goal, which should encourage flow and motivation to complete it. Further, the process is unstructured, participants

are free to choose any assembly strategy and to organize or reorganize the materials in the search field in any way they deem appropriate. Visual search is involved in locating an appropriate puzzle piece when its position in the search field is unknown. Wickens & McCarley (2008) noted that visual search is one of our most common and important attentional skills. Theoretically, this kind of search task is referred to as free field, where the search field is haphazard (a pile of puzzle pieces), as opposed to well organized such as in a computer pull-down menu (Wickens & Holland, 2000). Serial search means individual target items (puzzle pieces) are processed one after another. An exhaustive search means search continues exhaustively through the field to locate all targets.

Target identification also involves aspects of visual perception and attention (Wickens & McCarley, 2008), and in terms of feature integration theory (FIT, Treisman & Gelade, 1980) puzzle assemblers need to attend to color, several aspects of shape, and parts of images. In FIT terms, puzzle pieces would be relatively complex and identifying them would require focused attention (as opposed to something that could be accomplished more automatically).

Puzzle assembly also requires short and long term working memory in order to recall features in the complete picture, recall shape, colors and parts of images on individual pieces, and to recall location of pieces that have been examined and not used. It requires decision making in terms of when to stop searching for a particular piece, or to adopt a different assembly strategy. Finally, it also requires a rudimentary form of hypothesis testing in that a participant hypothesizes that a particular piece will fit a particular space, tries the piece to see if it fits, and concludes whether it did or not.

We selected a word search as the interruption task. The word search required visual search, focused attention, as well as cognitive processing of letters and words. An advantage to

this type of task was that it could be scored (in terms of number of words found) so that we could measure performance on the interrupting task as well as the ongoing task. Further, we included a multiple interruption condition because although frequent interruptions are a common aspect of work (Gonzalez & Mark, 2004) and life, and multiple interruptions are often part of the procedures used in studies experimental comparisons of the frequency of interruptions are nonexistent in the literature.

Both tasks were chosen because they require cognitive skills that are important in both work and everyday life, and further, the experimental tasks had to be tasks that did not require specialized training, that participants would not have specialized expertise in, and could be accomplished in a reasonable amount of time. Further, we expected that both tasks would be fairly engaging and likely to induce flow because they had clear goals, immediate feedback about performance, participant skills were suited to the task and participants could concentrated on the tasks.

We predicted that participants in the uninterrupted condition would complete the 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 interrupting task with one or multiple interruptions, would report more attention residue, more stress and time pressure, more disrupted flow, and less satisfaction with their performance than when uninterrupted.

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

The main task was a 100 piece Hello Kitty jigsaw puzzle designed for ages 5 and over. Pretesting with five undergraduates indicated that the puzzle could be completed in between 15 and 25 minutes.

The interruption task was a one page word search puzzle that contained the names of all 50 states embedded in a 22 x 22 matrix of letters. It also listed the names of all 50 states in alphabetical order.

Participants also completed a questionnaire that assessed demographics, individual differences (such as experience with puzzles, need for achievement, and polychronicity), general responses to the experimental process, as well as attention residue and flow on a 5-point scale (1 = strongly disagree, or definitely false to 5 = strongly agree, or definitely true). Five items from Heckert et al. (1999) measured need for achievement (Cronbach's $\alpha = .91$). The items were: I am a hard worker, It is important to me to do the best job possible, I push myself to be "all that I can be", I try very hard to improve on my past performance when doing work, I try to perform my best when doing work.

The five items that measured polychronicity (Cronbach's $\alpha = .67$) were drawn from Slocumbe and Bluedorn (1999). They were: I like to juggle several activities at the same time, I believe people should try to do many things at once, I prefer to do one thing at a time, I would rather complete an entire project every day than complete several parts of several projects, and

When I work by myself, I usually work on one project at a time, the last three were reverse scored.

For attention residue, in addition to measuring performance on the two tasks, similar to Leroy's (2009) procedure, we also included four attitudinal items based on Leroy's description of the concept. One item measured attention residue in going from the first task to the second (I was thinking about the puzzle while I was doing the second task). Three additional items measured attention residue in going from the second task back to the first task (It was difficult to get back into the flow of the puzzle after doing the second task, I was thinking about the second task when I went back to doing the puzzle, After the second task was complete I quickly refocused on the puzzle). The items that measured flow were drawn from a variety of sources (e.g., Jackson & Marsh, 1996). They were: I was able to concentrate on each task while I was doing it, I felt like I was "in the zone" when doing the puzzle. Stress and time pressure were assessed with individual items: the entire process was stressful, I felt pressed for time in doing the puzzle.

Procedure

Participants were randomly assigned to one of three conditions: uninterrupted, a single interruption, and four interruptions. All participants were measured on their net time to complete the jigsaw puzzle (subtracting out any time for interruptions). 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. Participants completed the questionnaire after the experimental tasks were complete.

Participants in the uninterrupted condition completed the jigsaw puzzle without interruption and were then given four minutes to work on the word search. For the single interruption condition, the experimenter entered the room after approximately six minutes of work on the jigsaw puzzle, stopped timing on the puzzle, brought the participant to another table in the room, and asked him or her to work on the word search, then left. After four minutes, the experimenter reentered the room and asked the participant to stop working on the word search and to go back to work on the puzzle, and restarted timing for the puzzle. 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 with approximately three minutes in between, to total four minutes of interruptions. Actually, in what we call the single interruption condition, the researcher actually interrupted twice, once to interrupt the puzzle work to have the participant work on the word search, and again to interrupt the word search work to return to the puzzle. Extrapolating from that, there were a total eight interruptions in the multiple interruption condition. We will use the term single interruption because there was a single interruption of the puzzle, then a single interruption of the word search. Similarly, in the multiple interruption condition, there were four interruptions of the puzzle, and four interruptions of the word search. Researchers prominently displayed the stopwatch to the participants, and instructed them to complete the puzzle as quickly as possible.

Results

Because performance on tasks can be affected by individual differences in skill and motivation, we performed a series of tests to ensure that our randomization procedure had evenly dispersed participants across conditions in terms of those individual differences. The first two sections of Table 1 show the results of those tests. There were no significant differences in

number of puzzles completed in the last six months, in self estimated skill at doing puzzles, doing puzzles as a hobby, or in the extent to which they liked to do puzzles. Neither were there significant differences in overall need for achievement nor in polychronicity.

Performance on the ongoing task. Table 2 shows descriptive statistics and the results of the ANOVAs and t-tests. As hypothesized there were significant differences in the amount of time to complete the puzzle. A post hoc Scheffé test showed that those in the uninterrupted condition completed the puzzle significantly faster than either the single interruption or multiple interruption conditions, however there was not a significant time difference between the single and multiple conditions. These findings mirror those of previous research in two ways. First, uninterrupted participants were faster than interrupted, indicating that there was a resumption lag time. However, the lag time didn't accumulate linearly, in that there was a small but nonsignificant difference between one interruption and four interruptions, which parallels a handful of studies that found that participants speeded up after an interruption. (Ratwani & Trafton, 2006; Speier, Valachich & Vessey, 1999; Speier, Vessey & Valachich, 2003). Our finding adds another dimension to our knowledge because the previous studies involved simple, repetitive tasks, and the present tasks were complex and engaging.

Stress and time pressure. Participants in the uninterrupted condition found the process to be significantly less stressful than those in the four interruption condition. The one interruption condition was not significantly different from either of the other two conditions. Notably, the means were all below the midpoint of the scale, indicating that participants did not find the process to be particularly stressful. Further, there were no significant differences in time pressure across the three conditions.

Attention residue. We found mixed support for the idea that a resumption lag might be caused by attention residue. First, as the hypothesis would predict, we found that those in the uninterrupted condition, who had finished the jigsaw puzzle, dwelled less on the puzzle while doing the word search than either the one interruption or four interruptions conditions. However, there was no difference between the single and multiple interruption conditions. Second, we again found no significant difference between the single and multiple interruption conditions on whether they were thinking about the word search when they went back to the puzzle. Note that we did not include this item for the uninterrupted condition because they completed the puzzle before they did the word search and did not go back to the puzzle.

Performance on the interrupting task. Interestingly, there were no significant differences in performance on the word search, as measured by number of words found. We had hypothesized that four, one minute intervals with the word search would result in lower performance than one four minute interval whether that interval was as an interruption, or after finishing the puzzle, and that four interruptions would result in worse performance than one interruption. Evidently the interrupting task was impervious to being interrupted.

Flow. We found mixed support for the idea that a lag time might be caused by flow being disrupted. Comparing the two interrupted conditions in terms of flow, there was no significant difference in the extent to which they were "in the zone" when doing the puzzle. There was a significant difference in the extent to which they found it difficult to get back into the flow of the first task. Those who were interrupted once found it less difficult to get back into the flow than those who were interrupted four times. Note that because both means were between 2 (disagree) and 3 (neutral) neither condition felt particularly that their flow was disrupted. Both groups also reported that they were equally able to quickly refocus after the interruption.

Discussion

Both interrupted conditions took significantly longer than the uninterrupted condition to complete the puzzle. Further, the increase in time has some practical significance as well. The condition with one interruption took 5.3 minutes (26.5%) longer and the four interruptions condition took 6.0 minutes (30%) longer than the uninterrupted condition. And this 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 a task that had to be restarted from the beginning.

Surprisingly, there wasn't a significant difference between one and four interruptions. If attention residue is present, then there should be a substantial difference, but there wasn't. Trafton & Monk (2007) referred to a resumption lag, the extra time it takes to resume the first task and complete it after an interruption. According to Alton &Trafton's (2002) memory for goals theory, the disruptiveness of an interruption depends on its length (longer is more disruptive), the amount of rehearsal (regarding the first task) during the lag time between ending the first task and attending to the interrupting task, and the amount of rehearsal allowed by the interrupting task. Rehearsal during the lag time can include leaving environmental cues to aid restarting the task (e.g., mark the last sentence read). It is possible that participants left environmental cues that helped them resume the puzzle. For example, they might have left the piece they were working on in a staging area. Trafton & Monk's research indicated that leaving environmental cues would reduce the resumption lag time, and therefore the time to complete the ongoing task.

It is also possible that multiple interruptions resulted in a speed up in work on the jigsaw puzzle after the interruptions, and perhaps more interruptions resulted in more speedup, which

could make up for the resumption lag time, which is the time it takes to complete a task once it is resumed after an interruption. 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 faster than uninterrupted participants. In the present study, It is possible that the third and fourth interruption became anticipated and the participant could have sped up a coping mechanism for periodic interruptions.

Also, although participants in both interrupted conditions took considerably longer to complete their task, they were no different in terms of how the interruption affected them psychologically. There were no differences in their experience of stress, time pressure, attention residue, or flow. And the interruption, whether there was one or four, did not result in significant differences in performance on the interrupting task (the word search). Although the uninterrupted participants disagreed more strongly that the word search distracted them from the puzzle and that they were thinking about the puzzle while doing the word search, all three group means fell into the disagree to neutral end of the scale, which indicates that they didn't perceive the interruptions to be problematic, even though they were. Although participants found it more difficult to get back into the flow of the puzzle when interrupted multiple times, and they took longer to complete the puzzle, they didn't perform any worse on the interrupting task when they had to do it in four one-minute segments than in one four-minute segment.

This is contrary to our expectation that more frequent interruptions would negatively impact performance and attitudes. Interruptions substantially increased the time to complete the ongoing task, but did not result in any significant psychological differences. This indicates that participants might not have been aware of how much the interruptions were affecting their performance. We suspect that if participants were aware of how much the interruption would

affect time to complete the puzzle, it would bother them more, in terms of increased stress or time pressure. A lack of awareness of the impact of interruptions may lead to a vicious cycle, in that if people don't think interruptions are problematic, they won't take steps to avoid them.

Finally, it should be noted that tasks used for this experiment were chosen to closely approximate the length of tasks in a knowledge worker environment, based on studies such as Mark, Gonzalez and Harris (2005) and Speier, Valachich, and Vessey (1999). A sizable portion of the research on interruptions included primary and interrupting tasks that were performed on a computer, and were measured in seconds or milliseconds, where resumption lag might be a fraction of a second. The present study adds to knowledge because we found a similar impact on completion with an ongoing task that was complex, and that averaged 23 minutes to complete.

In conclusion, for this study both single and multiple interruptions significantly affected the time to perform the task, but the frequency of interruptions did not matter. This likely means that the time delay caused by returning to a primary task (resumption lag) is impacted by the total time away from that task rather than the frequency. And repeated interruptions did not appear to come with psychological effects.

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Table 1

Results of Randomization Checks

	Uninterrupted N = 25	Single interrupt N = 48	Multiple interrupts N = 36
	Mean (SD)	Mean (SD)	Mean (SD)
Number of puzzles last 6 mos.	.36 (.8)	.84 (2.2)	.55 (.6)
Skill at doing puzzles	3.3 (1.2)	3.1 (.9)	2.9 (1.0)
Like to do puzzles	3.6 (1.0)	3.3 (1.2)	3.3 (1.1)
Do puzzles as a hobby	1.5 (.7)	1.7 (1.1)	1.5 (.9)
Need for achievement	4.3 (.6)	4.4 (.6)	4.6 (.5)
Polychronicity	2.7 (.7)	2.8 (.7)	2.5 (.5)

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

Table 2

Experimental results – ANOVAs and t-tests

	Uninterrupted M (SD)	Single Interruption M (SD)	Multiple Interruption M (SD)	*F* (2, 108)	*t* (82)
Time to do Ongoing task (minutes)	20.1_a (5.4)	25.3_{ab} (9.2)	26.1_b (11.4)	3.4*	
Process stressful	1.6_a (.7)	2.0_{ab} (.9)	2.2_b (.9)	3.2*	
Time pressure on puzzle	2.8 (1.3)	3.3 (1.3)	3.3 (1.1)	1.6	
Performance on interrupting task (# words found)	9.2 (2.8)	9.0 (2.9)	9.6 (3.0)	.44	
Word search distracted from puzzle	2.0_a (1.2)	2.8_b (1.1)	3.1_b (1.2)	6.6**	
Thinking about puzzle while doing word search	1.75_a (1.1)	2.9_b (1.4)	3.1_b (1.4)	8.3**	
In the zone when doing puzzle	4.1 (1.1)	4.0 (.8)	3.9 (1.2)	0.2	
Thinking about word search when went back to puzzle		2.1 (1.1)	2.2 (1.3)		-0.28
Difficult to get back to flow		2.1 (1.0)	2.6 (1.2)		-2.3*
Quickly refocused after interruption		4.1 (1.1)	3.8 (1.5)		1.2

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