Helpful or Harmful? Examining the Effects of Interruptions on Task Performance

Raj M. Ratwani
George Mason University
Fairfax, Virginia

J. Gregory Trafton
Naval Research Laboratory
Washington, D.C.

Christopher Myers
Rensselaer Polytechnic Institute
Troy, New York

Most research on interruptions has shown that they can be disruptive by causing a longer time to complete the primary task and by causing more errors on the primary task. However, a limited amount of research has shown that interruptions can actually be beneficial to simple primary tasks, a benefit that has been explained by arousal. We sought to replicate the finding that simple tasks can benefit from interruptions and to examine the specific processes that are actually improving as a result of the interruptions. More specifically, reaction time data and eye movement data were collected to account for motor actions and perceptual processes. Results indicate that participants' immediate action following the interruption was disrupted. However, participants' other actions during the interruption trials were actually performed faster and with fewer errors as compared to the control. This speed-up is not attributed to faster motor responses, but actually to faster perceptual processing.

INTRODUCTION

Most studies examining the impact of interruptions on primary task performance showed that interruptions can be detrimental in accomplishing the primary task (Altmann & Trafton, 2004; Czerwinski, Cutrell, & Horovitz, 2000; Gillie & Broadbent, 1989; Monk, Boehm-Davis, & Trafton, 2002, 2004; Trafton, Altmann, Brock, & Mintz, 2003). Interruptions have increased the time required to accomplish the primary task, led to more errors, and elicited greater feelings of stress and anxiety (Adamcyzk & Bailey, 2004).

Although the majority of the interruptions literature has focused on the deleterious effects of interruptions, Speier and colleagues have shown that interruptions can be beneficial to performance on the primary task (Speier, Valacich, & Vessey, 1999; Speier, Vessey, & Valacich, 2003). Speier et al. (1999) showed that on simple decision making tasks interruptions resulted in a shorter total time to complete the primary task as compared to a condition with no interruptions; accuracy was equivalent in both conditions. This work suggests that interruptions cause arousal and stress levels to elevate and attention to narrow, resulting in faster performance on simpler tasks. On the other hand, when performing a complex task, the interruptions exceed the cognitive capacity of the decision maker. The increased arousal may cause relevant cues to be ignored resulting in a longer time to complete the primary task and an increased error rate. However, while performing a simple task, it is not clear what specific processes led to the faster task performance. Arousal could lead to a general speed-up in processing resulting from faster motor and perceptual processes, or it could lead to a speed-up in one specific cognitive process.

The first goal of this paper was to replicate the finding that interruptions improve performance on a simple task. If interruptions improve performance, participants should complete the primary task faster and with similar accuracy as compared to a condition with no interruptions. Second, we sought to perform a fine-grained analysis by using reaction time data and eye movement data to determine what specific processes are actually impacted.

EXPERIMENT

In the primary task, participants searched a column of numbers in a spreadsheet and transcribed only the odd numbers onto a separate list; participants received two interruptions in each interruptions trial. Eye movement data were collected as participants performed the task.

We examined reaction times to determine whether performance on the primary task improved during interruption trials as compared to a control condition with no interruptions. The resumption lag and inter-action interval were used for these analyses (Altmann & Trafton, 2004; Trafton et al., 2003). The resumption lag has been operationally defined as the time interval between the completion of the secondary (interrupting) task and the first action back on the primary task. It is essentially the time taken to resume the primary task after completing the interrupting task. The inter-action interval is the average time taken to perform a single action on the primary task. Accuracy was also examined to determine whether interruptions affected the number of errors made.

We also examined the motor and perceptual processes that occurred while performing the primary task in both the control and interruption conditions. The motor processes were measured by examining the time it took to enter each odd number. In order to determine if the perceptual processes were affected we examined the number of fixations and fixation durations.

Method

Participants. Eleven undergraduate students participated for course credit.

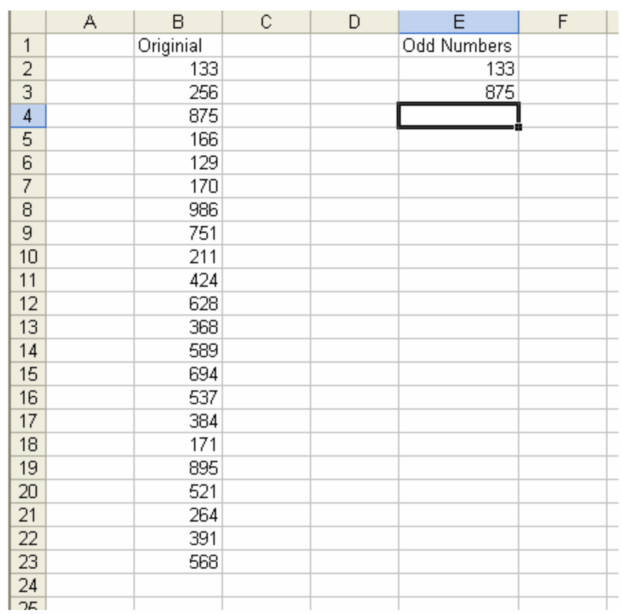
Materials. Twenty-two Microsoft© Excel spreadsheets were created, each sheet containing 22 three-digit numbers. The numbers were randomly generated with the constraint that at least half the numbers were odd. The distance between numbers was approximately 2.5° of visual angle. The numbers were listed in a single column (labeled "original") in each spreadsheet in a random order (see Figure 1).

Twenty-two addition problems were created, each containing five randomly generated digits ranging from 1-9. Eye track data were collected using the LC Technologies EyeGaze System operating at 60 Hz (16.7 samples/second).

Design. A within-subjects design was used. Half of the spreadsheets had no interruptions (control condition), and half of the spreadsheets had two interruptions each (interruption condition). Each spreadsheet served as a trial. During the interruption trials one interruption occurred during the first half of the trial (almost immediately) and one during the second half, thus each "interruption" sheet had two interruptions. Each spreadsheet was randomly assigned as a control or interruption trial; the trials were randomly presented to the participants.

Procedure. The primary task required participants to type the odd numbers from the original column in the spreadsheet into a column labeled "odd numbers." They began at the top of the original column in the first spreadsheet and typed the odd numbers into the designated column without leaving spaces between the cells (see Figure 1).They performed the same task on each spreadsheet until all the spreadsheets had been completed; the experiment was self-paced.

The interrupting task was an instant message (IM) containing an addition problem with 5 whole-number addends. The IM completely occluded the spreadsheet and required immediate attention. The participant attended to the IM immediately and mentally added the integers as quickly and accurately as possible. The participant typed the answer in the message window, sent the message, closed the IM window, and finally resumed the primary task. The interruption lasted approximately ten seconds and occurred only after an entire 3-digit number was entered into the odd numbers column, and never occurred while a number was being entered. One control and one interruption spreadsheet served as practice trials.



	A	B	C	D	E	F
1		Original			Odd Numbers	
2		133			133	
3		256			875	
4		875				
5		166				
6		129				
7		170				
8		986				
9		751				
10		211				
11		424				
12		628				
13		368				
14		589				
15		694				
16		537				
17		384				
18		171				
19		895				
20		521				
21		264				
22		391				
23		568				
24						

Figure 1. Primary search task, participants had to transcribe the odd numbers from the Original column to the Odd numbers column.

Measures. The reaction time (RT) data were analyzed by computing an inter-action interval for the control and interruption trials and the resumption lag for the interruption trials. The inter-action interval was the average time between entering numbers into the "odd numbers" column on the spreadsheet. The resumption lag was the average time from the end of the interrupting secondary task to the first action back on the primary task. The first action back on the primary task was always entering an odd number into the appropriate column. The resumption lag was calculated for the early and late interruptions.

The eye track data were analyzed using ProtoMatch software (Myers & Schoelles, 2005). ProtoMatch defines fixations as a minimum of 6 samples within a default 2°-of-visual-angle window resolution. Each cell in the "original column" and "odd numbers" column was defined as an area of interest for categorizing the location of fixations.

RESULTS AND DISCUSSION

RT and Accuracy. The inter-action interval from the control condition and the mean resumption lags for the early and late interruptions were examined to determine if the IM interruptions were disruptive. The ANOVA was significant, $F(2,20) = 51.5$, $p < .001$, $MSE = .57$. Tukey HSD post-hoc comparisons showed that the early interruption point resumption lag ($M = 4.3$ secs) and the late interruption point resumption lag ($M = 4.1$ secs) were significantly longer than the inter-action interval ($M = 1.4$ secs), $p < .01$ (see Figure 2). The early and late interruption point resumption lags were not significantly different from each other. This shows the first action back to the primary task after the interruption was significantly slower than the average time to complete a single action in the control condition. Participants took almost three times as long to resume the primary task after being interrupted. Next, performance in the rest of the trial was examined.

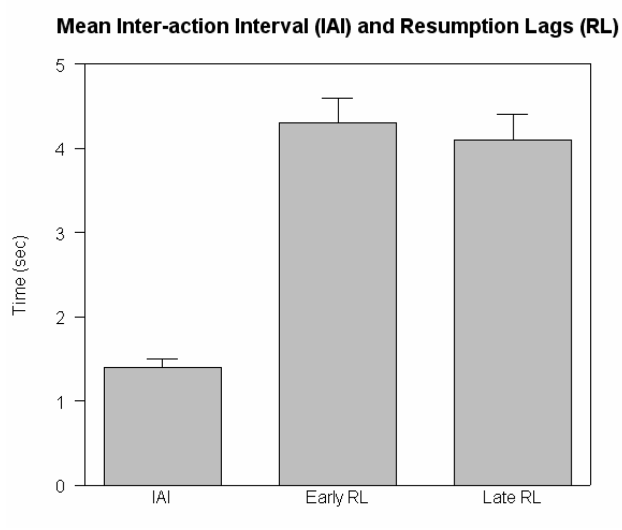


Figure 2. The inter-action interval and early and late resumption lags

The inter-action interval from the interruption conditions ($M = 1.2$ secs) was significantly faster than the inter-action interval from the control conditions ($M = 1.4$ secs), $F(1,10) = 17.9$, $p < .01$, $MSE = .01$. Thus, overall only the initial action back to the primary task was hindered by the interruption. Although there was this initial time cost, the inter-action intervals were actually faster during the interruption trials as compared to the control trials.

To examine accuracy on the primary task, two broad categories of errors were defined: task critical errors and duplicate errors. Completely skipping an odd number or typing in an even number was coded as a task critical error. Typing the same odd number twice was categorized as a duplicate. Participants made more task critical errors during the control conditions ($M = 4$) as compared to the interruption conditions ($M = 2$), $F(1,10) = 4.9$, $p = .05$, $MSE = 4.5$. There was no significant difference in the number of duplicate errors between conditions, $F(1,10) = .49$, $p = .5$, $MSE = 2.3$. Thus not only were participants' inter-action intervals faster during the interruption trials, they made fewer errors. These differences are illustrated in Table 1.

Measure	Control	Interruption
Inter-action Interval	1.4 sec	1.2** sec
Number of Errors	4	2*
Motor Response Time	1.6 sec	1.5 sec
Number of Fixations	1.4	1.4
Fixation Durations	459.7 msec	333.2** msec

* p = .05, ** p<.01

Table 1. Mean comparisons between the control and interruption trials

Motor Response Data. The motor response time during the control and interruption trials were compared to determine if it accounts for the faster inter-action intervals during the interruption trials. The average time it took to enter a number was compared for the control and interruption trials. The control ($M = 1.6$ sec) and the interruption ($M = 1.5$ sec) motor response times were not significantly different from each other, $F(1,10) = 1.6$, $p = .23$, $MSE = .02$. Thus, it was not the motor response times that contributed to the speed-up.

Eye Movement Data. The eye movement data were examined to determine if the shorter inter-action interval during the interruption trials was due to faster perceptual processing. We examined the number of fixations and the fixation durations during the inter-action interval for both conditions. There was no significant difference in the number of fixations for the interruption ($M = 1$ .40) and control (M =1.44) conditions, $F(1,10)$ =.12, p=.7, MSE =.06. There was, however, a significant difference in the fixation durations for the interruption (M =333.17) and control conditions (M =459.76), $F(1,10)$ =38.29, p<.001, MSE =2301.59.

The eye movement data demonstrate that while participants made approximately the same number of fixations during the inter-action interval for control and interruption conditions, participants made shorter fixations during the interruption trials. Thus, there was a perceptual speed-up, as displayed in Table 1.

CONCLUSION

Following an interruption, the first action back on the primary task was disrupted. However, the inter-action interval during the interruption trials was faster than the control trials, a speed-up that can be attributed to shorter fixation durations. In addition, participants made fewer task critical errors during the interruption conditions. Results demonstrate some benefit from the interruptions.

These results suggest that interruptions can be used to actually improve performance on certain tasks. This improvement is not attributed to faster motor responses, but improvements in perceptual processing. These results have implications for the current theories of interruptions since these theories do not account for any type of benefit there might be from interruptions.

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