Dealing with Interruptions can be Complex, but does Interruption Complexity Matter: A Mental Resources Approach to Quantifying Disruptions

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Dealing with Interruptions can be Complex, but does Interruption Complexity Matter: a Mental Resources Approach to Quantifying Disruptions

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Past work examining the effects of interruption complexity on primary task performance has yielded quite mixed results. Some research suggests that more complex interruptions lead to greater disruption of the primary task, while other studies have shown that interruption complexity does not directly influence the amount of primary task disruption. It is our hypothesis that interruption complexity, defined by the number of mental operators required to complete a task as opposed to an intuitive sense of difficulty, does affect primary task performance, such that interruptions requiring more mental operators (more complex) lead to greater disruption than do less complex interruptions. Participants performed a single primary task in conjunction with either a simple or complex interruption. The complex interruption required more mental operators to complete than the simple interruption. Our results showed that it took longer to resume the primary task following a complex interruption than it did following a simple interruption. These results suggest that more complex interruptions, as quantified by the number of mental operations required, do indeed lead to greater primary task disruption.

INTRODUCTION

It is safe to say that interruptions are a part of each of our lives on a daily basis. However, the effects of these events are less clear. One body of research has documented disruptive effects such as decrements in task completion time (Eyrolle & Cellier, 2000; Monk, 2004; Trafton, Altmann, Brock, & Mintz, 2003) and accuracy (Cutrell, Czerwinski, & Horvitz, 2001; Edwards & Gronlund, 1998). A few studies, though, have suggested that interruptions can actually aid performance in certain contexts (Ratwani, Andrews, McCurry, Trafton, & Peterson, 2007; Speier, Vessey, & Valacich, 2003; Ziljstra, Roe, Leonora, & Krediet, 1999). These findings suggest that specific aspects of the tasks being performed and the types of interruptions may play a major role in determining how disruptive an interruption will be (or whether it will be disruptive at all). One such aspect, which has been explored with conflicting results, is the complexity of the interruption.

Some studies have shown that increased complexity leads to slower resumption times (Hodgetts & Jones, 2005, 2006) and decreased primary task accuracy (Gillie & Broadbent, 1989). Increased resumption times were attributed to interference caused by the existence of additional goals. Decreased task accuracy was attributed to increased processing and memory loads in the more complex conditions.

However, other research found that more complex interruptions did not lead to a decrement in task performance. Increasing the complexity of interruptions increased time on task slightly, but not significantly (Ziljstra et al., 1999). Additionally, no performance decrement in terms of accuracy was noted. Eyrolle and Cellier (2000) found that highly complex interruptions (ones with more items to be processed) led to slightly higher error rates, but had little other effects on task performance. Lastly, Cades, Trafton, Boehm-Davis and Monk (2007) found that participants were slower at resuming a primary task when they were interrupted with either of two difficulty levels of an n-back working memory task (Lovett, Daily, & Reder, 2000) than they were when the interruption consisted of a simpler task (repeating a number aloud that was read to them by the computer). However, there were no resumption time differences between the two difficulty levels of the n-back task.

This result was explained using a combination of the Memory for Goals model (Altmann & Trafton, 2002) and an NGOMSL analysis (Kieras & Polson, 1985), The memory for goals model predicts that the ability to resume depends primarily on interruption length and the opportunity for rehearsal during the interruption. Specifically, the greater the number of mental operators a given task requires, the less opportunity there is for rehearsal during that task. In this specific experiment, the NGOMSL analysis revealed that, even though one of the n-back tasks seemed harder, both n-back tasks required a similar number of mental operators. Thus the opportunity to rehearse was similar in both n-back conditions. Given that both conditions had the same interruption length, both should (and did) have similar resumption times. The further prediction that the n-back tasks would lead to slower resumption times than the number repetition condition, which had the greatest opportunity to rehearse, was also supported (Cades et al., 2007).

Although all of the previous work cited attempted to manipulate interruption complexity, few went so far as to identify the cognitive mechanisms that made the various tasks more or less complex. What was clear from these results is that in order to truly and accurately manipulate complexity it was essential to first identify (and quantify) the mechanisms underlying complexity. Cades et al. (2007) suggested that tasks which differ in the number of mental operators should be used to explore how the complexity of an interrupting task affects people's ability to resume. This paper aims to help answer the question of whether a more complex (as measured by the number of mental operators) interruption will lead to greater decrements in the ability to resume the primary task over and above a simpler (fewer mental operators) interruption.

EXPERIMENT

In this experiment, participants were required to perform nine trials of a primary task with either a simple or a complex interrupting task. The simple interruption task required participants to decide which of two two-digit numbers was higher and respond by clicking on the button corresponding to that number. The complex interruption was made up of the simple interruption plus a few additional steps and was designed to specifically require more mental steps than the simple interruption. For this complex interruption, participants first had to choose the higher of two two-digit numbers (as in the simple interruption), then add the two digits of the higher number, determine whether this sum was odd or even, and finally respond by clicking on either the odd or even button.

METHOD

Participants

Twenty-four undergraduate students (23 women, 1 man) at George Mason University participated for course credit. The average age of the participants was 19. All participants were randomly assigned to either the simple or complex interruption condition.

Task and Materials

The primary task (see Figure 1) involved programming a simulated Video Cassette Recorder (VCR) (Gray, 2000) interface to record a future television show. The show information was presented to participants on a 3x5 index card and each trial ended once all of the information on the card was programmed into the VCR.

Both interrupting tasks consisted of a pair of two-digit numbers displayed on the screen below a set of written instructions. The numbers were randomly generated with the constraint that both numbers had the same tens digit (e.g., 25 and 27, 78

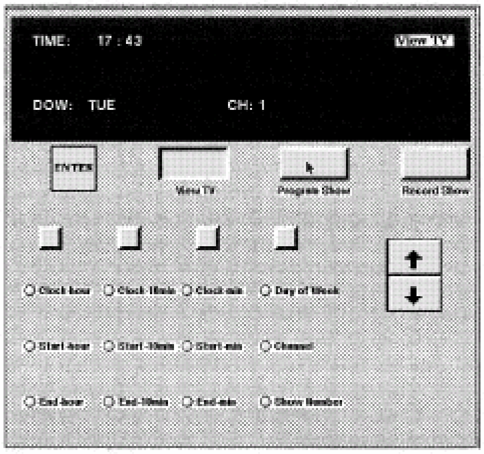

Figure 1: The VCR Interface

and 72, 33 and 31, etc.) This was done to ensure that all pairs of numbers required similar processing in order to make the initial high/low judgment required in both the simple and complex condition and to ensure that the number of mental steps, which was our primary manipulation of interest, did not vary within interruption trials. A new pair of numbers was displayed every 3.5 seconds during the interruption. Each interruption lasted for 35 seconds and participants were interrupted around 3 or 4 times per trial. Interruptions were triggered by a random number of clicks ranging from fifteen to twenty-two. This was done to prevent participants from guessing when they would occur. However, as some shows required more clicks to program than others the number of interruptions varied slightly between participants.

In line with predictions from the Memory for Goals model (Altmann & Trafton, 2002), it was hypothesized that both interruption conditions would disrupt peoples' ability to resume the primary task. The complex interruption required completion of the simple interruption plus additional steps, which meant that the complex interruption condition required more mental operations, and presumably allowed less opportunity for rehearsal. It was, therefore, also predicted that the complex interruption condition would be more disruptive to primary task resumption than the simple interruption condition.

Design and Procedure

This experiment used a two level (simple or complex interruptions) between-subjects design. Prior to the experimental trials, participants were trained on the VCR alone and the VCR with whichever interruption corresponded to the condition to which they were assigned. Participants then performed nine trials of the VCR task with interruptions, with each trial consisting of a different television show to program. The experiment lasted approximately one hour and participants experienced somewhere between thirty and forty 35-second interruptions across the experiment.

When interrupted, the VCR screen disappeared and the interruption screen with the instructions and numbers was presented for the duration of the interruption. After the 35 seconds, the interruption screen disappeared and participants were returned to the VCR task. This pattern continued until the completion of each trial, at which time the VCR program was reset.

Measures

Each mouse click was time-stamped and recorded for all participants. Inter-action intervals were calculated as the average time between clicks on the primary task. Disruption was quantified using a special inter-action interval called the resumption lag (Altmann & Trafton, 2002), which was the time between the end of the interruption and the first action, or mouse click, back on the primary task. Comparing this measure across experimental conditions has been shown to accurately assess the amount of disruption caused by a given interruption (Altmann & Trafton, 2007; Monk, Boehm-Davis, & Trafton, 2004; Ratwani et al., 2007).

RESULTS AND DISCUSSION

As a manipulation check, inter-action intervals were compared to resumption lags across condition (Figure 2). A repeated measures ANOVA confirmed, that interruptions were indeed disruptive, with resumptions lags (M = 3118.29, SE = 134.83) significantly longer than inter-action intervals (M = 875.81, SE = 29.04) collapsed across

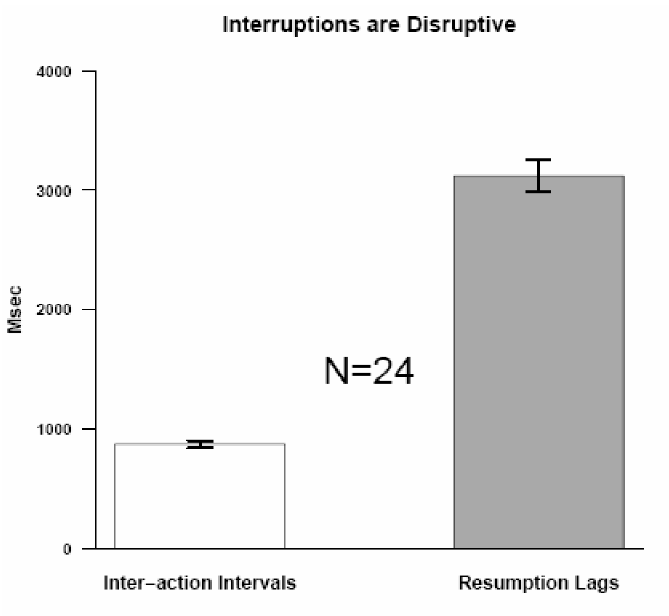

Figure 2: Average click times by type across conditions (Error bars are standard error of the mean)

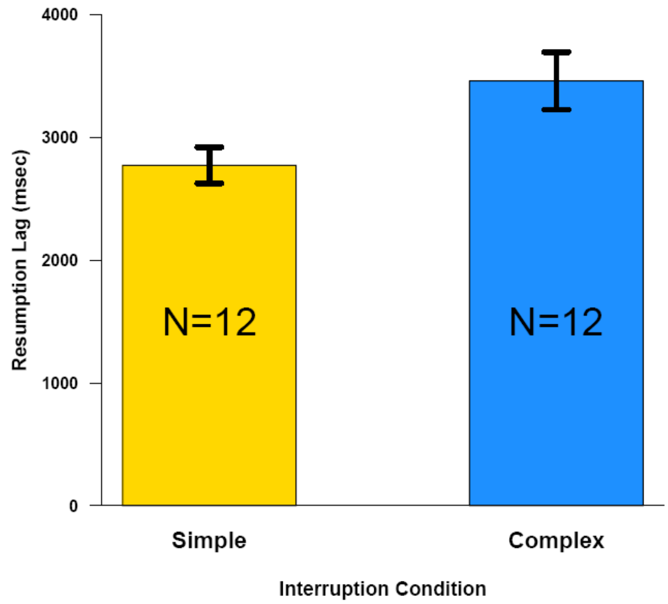

Figure 3: Resumption lags by interruption difficulty (Error bars are standard error of the mean)

condition ($F(1, 22) = 308.92$, $p < .001$, MSE = 195,339.98, $\eta^2 = .93$).

If the complexity of the interruption is an important aspect in determining that interruption's disruptiveness, then we would expect the simple interruption condition to lead to faster resumption times than the complex interruption, supporting earlier findings, which showed greater disruption following more complex interruptions (Cades et al., 2007; Gillie & Broadbent, 1989; Hodgetts & Jones, 2005, 2006). Alternatively, if interruption complexity turned out to be either unimportant or not central to the disruptive mechanism of interruptions, then we would not expect to see differences between the simple and complex interruption conditions (Eyrolle & Cellier, 2000; Ziljstra et al., 1999). A omnibus ANOVA revealed a main effect of interruption complexity. Resumption lags following a complex interruption (M = 3461.92, SE = 234.35) were significantly slower than resumption lags following a simple interruption (M = 2774.66, SE = 147.03) ($F(1, 22) = 6.17$, $p < .05$, MSE = 459217.27, $\eta^2 = .22$) (Figure 3).

These results support the Memory for Goals model by showing that increasing the number of mental operators during the interruption and reducing the opportunity for rehearsal leads to increases in the disruptiveness of the interruption.

GENERAL DISCUSSION

In both this experiment and Cades et al. (2007), greater interruption complexity led to greater primary task disruption, when complexity was evaluated in terms of number of mental operators. As previous research has shown, simply because a task seems more complex does not mean that it necessarily requires additional mental operators (Cades et al., 2007). In the case of findings (past, current, and future) which claim that interruption complexity does not influence disruptiveness, it will be important to examine those tasks to see if the more complex tasks actually require more mental resources or if they simply seem harder. Using more quantitative evaluation techniques will surely aid in our abilities to predict the disruptive effects of various types of interruptions.

Although these results offer strong support for the Memory for Goals model's predictions about interruption complexity, it is also interesting to note the relatively small effect size (Cohen, 1992). It suggests that, although the difference between the simple and complex conditions is most likely not due to chance, the actual magnitude of the effect is moderate at best. Given the conflicting nature of the previous research examining the relationship between the complexity of an interruption and its disruptiveness, it is not surprising that the effect size is relatively small.

These data show that while the complexity of the interruption is an important part in understanding its disruptiveness, and that more complex interruptions are more disruptive, this one aspect cannot fully explain what causes different interruptions to be more or less disruptive. Rather, this is just one aspect of many that play a role in people's abilities to perform tasks with interruptions.

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