REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*
January 26, 2007

2. REPORT TYPE
Final Report

3. DATES COVERED *(From - To)*
01 Feb 05 – 30 Sep 06

4. TITLE AND SUBTITLE
HSI and Cognitive Modeling

5a. CONTRACT NUMBER

5b. GRANT NUMBER
ONR #N00014-05-1-0438

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
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5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
George Mason University
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8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Office of Naval Research
One Liberty Center
875 North Randolph St, Suite 1425
Arlington, VA 22203-1995

10. SPONSOR/MONITOR'S ACRONYM(S)
ONR

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

This project involved two components: (a) data collection to understand the performance outcomes resulting from interruptions and (b) knowledge/skill enhancement for an ONR project officer. The data collection efforts included both naturalistic and laboratory observations of performance as a function of interruptions. The naturalistic study demonstrated the difficulties inherent in this type of research and provided the foundation for the development of a laboratory task on which data were collected, analyzed, and reported.

15. SUBJECT TERMS
Interruption, experiments, modeling

16. SECURITY CLASSIFICATION OF: a. REPORT	b. ABSTRACT	c. THIS PAGE	17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON / 19b. TELEPHONE NUMBER *(include area code)*
Unclassified	Unclassified	Unclassified	UU	6	Deborah A. Boehm-Davis / 703-993-1000

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39.18

HSI and Cognitive Modeling

Final Report

ONR Grant #: N00014-05-1-0438
Period of Performance: February 1, 2005 – September 30, 2006

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January 2007

HSI and Cognitive Modeling
Final Report

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Summary of Completed Project

Interruptions are an everyday occurrence, particularly in the workplace. Understanding how people recover from interruptions is critical to understanding how to improve job performance. This project involved two components: (a) data collection to understand the performance outcomes resulting from interruptions and (b) knowledge/skill enhancement for an ONR project officer. The data collection efforts included both naturalistic and laboratory observations of performance as a function of interruptions. In a pilot study, we attempted to collect naturalistic data on what types of interruptions occur in the workplace and the extent to which workers are able to return to the point of interruption upon resuming their original task (if, indeed, they return to their original task following the interruption). Part of the goal of this study was to examine the hierarchical structure of naturalistic tasks in order to study the effects of being interrupted at different levels of the hierarchy. That study demonstrated the difficulties inherent in naturalistic research. It proved difficult to identify which activities were performed in service of a specific overall task without significant input from the workers, which was difficult to obtain after the task had been completed. However, the study provided insights that were useful in developing a laboratory task on which data were collected, analyzed, and reported (see attached report).

For the second component of the project, an ONR program officer (Dr. Helen Gigley) came to GMU to enhance her knowledge of cognitive modeling by acquiring programming skills in developing and implementing cognitive process models. In her time with us, Dr. Gigley worked with Dr. Boehm-Davis to increase her working knowledge of areas of research within the domain of Human Systems Integration and to develop a working knowledge of building cognitive models in ACT-R. The goal was to develop a computational model to describe the performance data we were collecting on interrupted performance. However, we were unable to develop a working model of the data in the time available.

Reference

Cades, D., Trafton, J. G., & Boehm-Davis, D. A. (2006) Mitigating Disruptions: Can Resuming an Interrupted Task Be Trained? In *Proceedings of the Human Factors & Ergonomics Society Annual Meeting*, Santa Monica, CA: The Human Factors and Ergonomics Society.

Mitigating Disruptions: Can Resuming an Interrupted Task Be Trained?

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Research has shown that with practice people improve on most tasks. It has also been made clear that over time interruptions become less disruptive. It is unclear whether the reduction in interruption disruptiveness is due to a general practice effect or specific to the interruption/resumption process. In this experiment, participants performed three sessions of a task with one, two, or three of the sessions containing interruptions. We found that in addition to all participants showing primary task improvement, those with more exposure to interruptions also showed improvement in dealing with the interruptions. Specifically, participants with practice on only the primary task did not show improvement with the interruptions. These results suggest that the mitigations of the disruptions are directly related to people getting better at handling the interruptions.

INTRODUCTION

In the modern workplace, interruptions disrupt each one of us on a daily basis. We have email notifications, meeting reminders, instant messages, text messages, and countless other sources of disruption constantly demanding our attention. Many studies have shown that interruptions are disruptive to the performance of a primary task (Gillie & Broadbent, 1989; Hess & Detweiler, 1994; Miyata & Norman, 1986; Monk, 2004; Trafton, Altmann, & Brock, 2005; Trafton, Altmann, Brock, & Mintz, 2003). These interruptions are, for the most part, unavoidable and it is important to work towards understanding ways to mitigate their disruptive effects.

In previous studies, researchers have found that there is a strong learning component to interruptions. For example, Trafton et al. (2003) found that participants not only sped up on the primary task, but their time to resume following an interruption also decreased over three twenty minute sessions – they learned how to resume faster with practice. Additionally, the overall effectiveness of disruption-mitigation strategies seems to decrease with practice: Trafton et al. (2003, 2005) found that the effect of disruption mitigation strategies (e.g., rehearsal or environmental cues) was much greater in earlier sessions than in later sessions. Hess & Detweiler (1994) showed a decrease in primary task accuracy when participants were interrupted after having been trained on the primary task without interruptions as opposed to when they had been trained with interruptions.

These experiments show that people do get better at the interruption/resumption process with practice, though interruptions are still disruptive compared with non-interrupted performance. It is unclear from these experiments, however, where the locus of improvement is. It could be that as participants practice a task, they learn that task and their resumption ability is simply based on this primary task learning. Alternatively, it could be that people actually learn how to resume after being interrupted. In other words, it is their experience in dealing with interruptions and resumptions that reduce the overall disruptiveness of interruptions. Note that the difference between these two explanations has profound implications for training. If learning the primary task reduces the disruptiveness of interruptions, then training can focus on individual tasks. If, however, learning to resume is critical, then tasks must be trained in an environment where interruptions occur frequently so that learning to resume is integrated into the task learning. Different theoretical models of interruptions do not make strong predictions about which of these explanations is correct. There is a learning component in most theories of interruptions, but none of them predicts which process occurs after an interruption. The goal of this work was to first replicate the overall mitigations shown by Hess & Detweiler (1994) and Trafton et al. (2003) and to then tease apart and account for primary task improvements as opposed to improved performance on the act of resuming an interrupted task.

EXPERIMENT

To show differences between main task improvement and improvement on the resumption process, we designed an experiment in which participants had different amounts of practice being interrupted. In this experiment, participants were interrupted in one of three sessions (condition 3.1), in two of three sessions (condition 3.2), or in all three sessions (condition 3.3). In the one and two session interruption conditions, the non-interrupted trials always occurred before the interrupted trials.

It was predicted that if the mitigations were only based on primary task improvement, then the resumption times would decrease across sessions regardless of whether participants were interrupted in previous sessions; in other words, the resumption times would be equal for all three groups in session 3. Alternatively, if participants learned to resume, then the resumption time would only decrease across interrupted sessions and would be proportional to the number of interrupted sessions each participant had completed (i.e., more interrupted sessions leading to faster resumption times) rather than the total number of sessions each had done. In other words, the resumption times in the final session would be shortest for the three session interruption condition, followed by the two session interruption condition, and finally the one session interruption condition.

METHOD

Participants

Fifty-seven undergraduates from George Mason University participated for class credit. All were randomly assigned to one of three conditions.

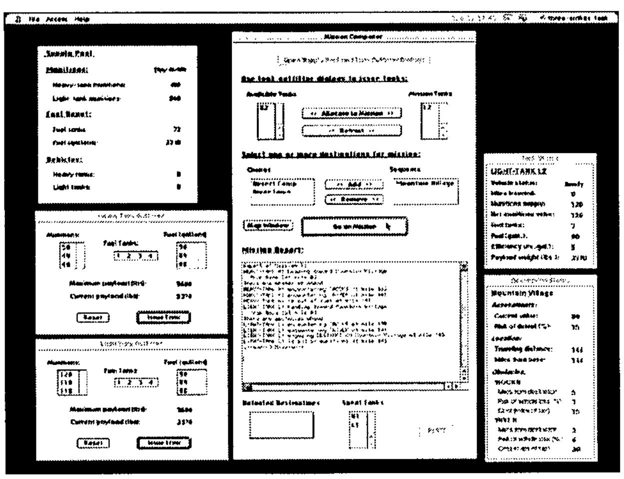

Figure 1: The Tank Task used in the experiment. The upper left window lists available resources. The two windows on the bottom left allow the user to outfit heavy (middle) and light (lower) tanks. The two windows on the right show the stats for a selected tank (middle) or city (lower). The large window in the center provides information about cities, missions, and mission outcomes.

Task and materials

The primary task (Figure 1) was a complex desktop computer based resource-management and strategy task (Brock & Trafton, 1999). Participants were responsible for managing a set of tanks (heavy and light) and their associated munitions, fuel, and fuel tanks in order to destroy three destinations. The interface consisted of a number of windows that allowed the operator to equip the tanks and subsequently send them on missions. Status updates were given upon each user action to allow the operator to track the success or failure of the overall mission. The secondary task (Figure 2) was a tactical assessment task (Ballas, Kieras, Meyer, & Brock, 1999). In this task, objects moved from the top to the bottom of the screen and had to be coded hostile or neutral depending on their color and a set of rules regarding the speeds and directionality of the different objects. These two tasks were displayed sequentially and were never on the screen at the same time.

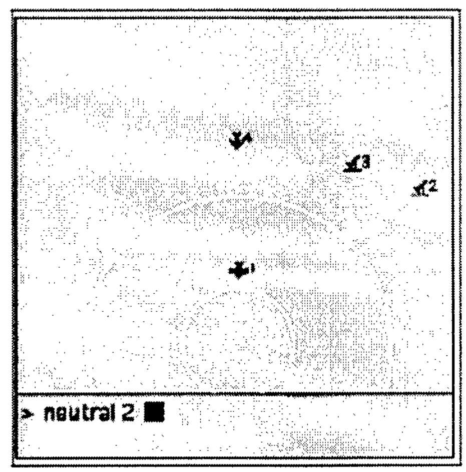

Figure 2: The Radar Task used in the experiment. Participants had to identify whether each vehicle shown was neutral or hostile according to color and a set of rules.

Design and Procedure

Participants were trained on the primary and secondary tasks individually and were shown one interruption. There was one within-participants factor (total number of sessions) and one between-participants factor (number of interrupted sessions). Each session lasted approximately 20 minutes and the program shut down automatically at the end of each session.

All non-interruption sessions consisted of the participants performing only the primary task. During an interruption session, participants were interrupted with the secondary task twelve times. Each interruption lasted approximately 30 seconds. All interruptions occurred directly after a mouse click. Conditions were named as "number of total sessions. number of interrupted sessions." For example the one interruption condition was 3.1 as participants did 3 total sessions with only the last one being interrupted. Participants in condition 3.2 had the last two sessions interrupted, and participants in condition 3.3 had all three sessions interrupted (Figure 3).

Number of Interrupted Sessions	Session 1	Session 2	Session 3
3.1	O	O	X
3.2	O	X	X
3.3	X	X	X

X = Interruption, O = No Interruption

Figure 3: Experimental design (number of interrupted sessions x session order).

Measures

Each mouse-click and keystroke was recorded for all participants. In both interrupted and non-interrupted sessions, the inter-action interval was measured by taking the time difference between actions, defined by mouse-clicks, on the primary task.

A special type of inter-action interval called the resumption lag was measured for each of the twelve interruptions in the interruption sessions. This metric has been shown to reliably quantify the disruptive effects of interruptions (Monk, 2004; Trafton et al., 2003, 2005). It is defined as the time it takes to resume the primary task following the cessation of the interruption (Altmann & Trafton, 2004), measured in this task as the time between when the tank task is redisplayed following an interruption and the first click on the tank task.

RESULTS AND DISCUSSION

Outliers greater than three standard deviations from the mean were removed from the resumption lag data. As expected, the mean inter-action intervals decreased linearly

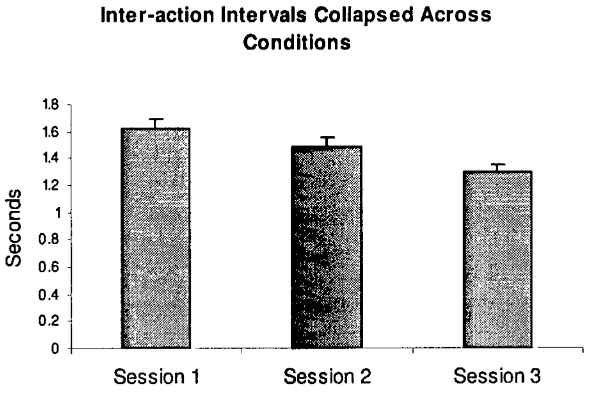

Figure 4: Graph of Inter-action Intervals (sec) collapsed across conditions by session. Error bars are standard error of the mean.

across conditions from session 1 to session 3, $F(1,59) = 32.37$, MSE = 0.096, $p < 0.001$ (Figure 4). This confirmed the overall practice effect on the primary task as shown previously (Trafton & Trickett, 2001; Trafton et al., 2003). As Figure 5 suggests, experience with interruptions (condition 3.3) led to a decrease in resumption times across sessions ($M_{Session1} = 5.20$, $M_{Session2} = 4.21$, $M_{Session3} = 4.24$), $F(1, 18) = 8.58$, MSE = 1.50, $p < 0.05$ These results support our claim that in addition to primary task training, participants are also improving on handling the interruption.

Improvement in dealing with interruptions was also shown by the significant downward linear trend found across conditions in session three ($M_{3.1} = 5.49$, $M_{3.2} = 4.53$, $M_{3.3} = 4.24$), $F(2, 54) = 3.74$, MSE = 2.15, $p < 0.05$. Overall, these findings imply that the disruptiveness of interruptions can be mitigated through training and practice, so long as the actual interruption and resumption process is included.

The decreasing inter-action intervals across sessions confirms the main task practice effect (Trafton et al., 2003), which we expected to see. In addition to improved performance on the main task, practicing with interruptions was important as the resumption lags decreased across conditions from one session to the next when the first of these two sessions was interrupted. Along with the significant downward linear trend in condition 3.3, resumption lags also decreased significantly from session 2 to session 3 in condition 3.2, $t(235) = 2.02$, $p < 0.05$.

From these data it is still not clear whether these improvements are due to the overall practice of the task or specifically due to improvement on the interruption. A more interesting trend to notice is that across all conditions, the first time someone was interrupted (the three tallest bars in Figure 4) the corresponding resumption lags were not statistically different, $F(2, 36) = 0.97$, MSE = 1.39, $p = 0.39$. If this were not the case, and the only aspect being trained was primary task performance, then we would expect that all the

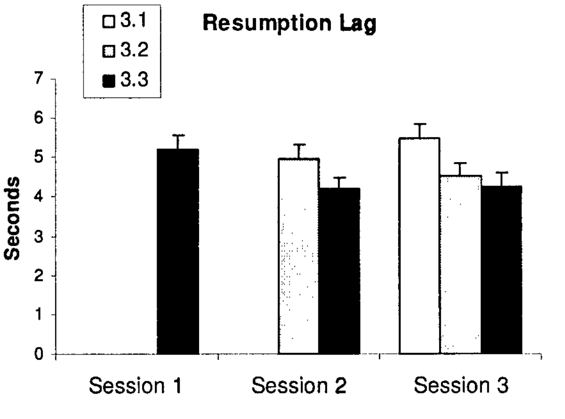

Figure 5: Graph of resumption lags (sec) across condition and session. Error bars are standard error of the mean.

resumption lags for all three conditions in session 3 would be equivalent. Instead our data suggest that the decreasing resumption lags seen in the multiple interruption conditions (3.2 and 3.3) are due to participants' learning how to better deal with the interruption.

It is interesting that most of the training effect on the interruption occurs in the first twenty-minute session. Although there is a large (and reliable) decrease in resumption lags between the first and second sessions in condition 3.3, there is no additional benefit to the resumption process after the second interrupted session. It would seem that either there is some baseline level of disruptiveness that cannot be trained away or the training effect plateaus after one session. Additional sessions would be needed to test this theory.

Both Trafton et al. (2003) and Hess and Detweiler (1994) suggested that performing an interrupted task over time would lead to a mitigation of the disruptive effects of that interruption. However, neither of those studies was able to determine what aspects of the task-interruption-resumption process were being trained. Our data clearly show that in addition to getting better at the primary task, participants were actually learning how to deal with the task resumption process. The implications of this work suggest that one way to help mitigate the disruptive effects of unavoidable interruptions is simply to practice dealing with them.

Acknowledgments

This work was supported in part by grant number N00014-05-1-0438 and grant number 55-8122-06 from the Office of Naval Research. We thank Patrick McKnight, Chris Monk, Peter Squire, and Raj Ratwani for comments and guidance throughout this project.

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