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SHORT COMMUNICATION

A comparison of human versus virtual interruptions

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Although a wealth of research has examined the effects of virtual interruptions, human-initiated interruptions are common in many work settings. An experiment compared performance on a primary data-entry task during human-initiated (human) versus computer-initiated (virtual) interruptions. Participants completed blocks of trials that featured either an interruption from a computer or an interruption from a human experimenter. The timing of the onset of the interruptions was also varied across trials. Human interruptions resulted in much shorter interruption lags. No significant differences were observed for the number of correct responses on the primary task for human versus virtual interruptions, but interruptions that occurred later in the task sequence resulted in fewer mistakes. The social aspect of human interruptions may have attenuated interruption lags in that condition, and it is possible that virtual interruptions may permit people greater temporal flexibility in managing their engagement with interruptions.

Practitioner Summary: An experiment compared human- and computer-initiated interruptions of a verbal data-entry task. Human-initiated interruptions resulted in much shorter interruption lags. Virtual interruptions may permit people greater temporal flexibility in managing their engagement with interruptions.

Keywords: interruptions; interruption lag; resumption lag; human–computer interaction; multitasking

1. Introduction

Interruptions are common in work settings and often are detrimental to the successful completion of an interrupted task (Trafton and Monk 2007; Latorella 1999; Cellier and Eyrolle 1992; Squire and Parasuraman 2010). Several factors affect the extent to which performance of an interrupted task is disrupted. Research has shown the importance of *interruption lag* – the time that elapses between the onset of an interrupting task and engagement with the interruption. People have negotiated interruptions more effectively when they are allowed time to reach a strategic stopping point in the primary task before engaging the interrupting task (Altmann and Trafton 2002; Trafton et al. 2003). As such, longer interruption lags decrease disruption and *resumption lag* – the delay in resuming a task after attending to the interruption.

Although researchers have examined the deleterious effects of computer-initiated (virtual) interruptions such as alerts, notifications, and instant messages (Hodgetts and Jones 2007), face-to-face interruptions were the most common interruptions reported by nurses (Berg et al. 2013; Biron, Loiselle, and Lavoie-Tremblay 2009). Human-initiated (human) interruptions are also common in offices, and engaging these interruptions involves social norms (Nardi and Whittaker 2002; O'Conaill and Frohlich 1995) that may make it more difficult to strategically delay engagement with an interruption source and to intentionally integrate the interruption into the task sequence (see Latorella 1999). To our knowledge, however, previous research has not explored differences between human and virtual interruptions, though taxonomic descriptions of interruptions (McFarlane and Latorella 2002) have considered the source of interruptions as a theoretically important variable.

This experiment compared the effects of human and virtual interruptions on a data-entry task. We expected that human interruptions would be more disruptive (i.e. show more error and longer resumption lags) than virtual interruptions. We expected that the mechanism of disruption would be a shorter interruption lag in the human interruption condition. We expected that participants would be more comfortable with delaying engagement with virtual interruptions. Interruptions also were initiated at different points in the primary task. We expected that early interruptions would be most disruptive to performance of the primary task, because they occurred during a portion of the task with high memory demands (Miyata and Norman 1986).

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2. Method

2.1. Participants

Participants ($N = 25$, 17 females, M age $= 19.73$, $SD = 0.92$ years) were recruited from undergraduate psychology courses and were compensated with course credit.

2.2. Procedure and stimuli

The first independent variable in the experiment was the interruption source. Participants completed one block each of human and virtual interruption trials in a within-subjects design. Blocks featured one practice trial and nine test trials. The order of presentation of blocks was counterbalanced. For the primary task, participants first heard a word list. Eighteen five-word lists were created using the *Paivio et al. Word List Generator* (Friendly 1996). Words had two syllables, five to nine letters, and a Kucera–Francis frequency of at least 50, which is specified as the third quartile of frequency in the Friendly database. Representative word examples included ‘water’, ‘circle’, ‘product’, ‘hotel’ and ‘student’. Text-to-speech conversions (www.ispeech.org) were used to produce audio of word lists. Participants then advanced to a different screen and typed the words into text boxes in alphabetical order (see Figure 1, Panels A and B).

For the interruption task, 19 one-syllable, five-letter words were used, and unique codes (five random letters and numbers) were associated with words. Human and virtual interruptions were designed to be equivalent. For human interruptions, the experimenter (i.e. the second author, a student researcher) stood out of view behind a partition and watched participants’ task progress on a second monitor. To interrupt, the experimenter appeared from behind the partition and said, ‘Hi’. The experimenter waited for the participant to make eye contact, then asked the participant to provide the word associated with a code, e.g. ‘Please provide the code for X14W2.’ Participants were not instructed or required to maintain eye contact while the experimenter spoke. For virtual interruptions, an audio alert (the Google chat alert) coincided with the appearance of a button labelled ‘Code Response Required; Click to Listen’ (see Figure 1, Panel C). Upon clicking the button, participants heard the same code requests verbatim in a text-to-speech message. In both conditions, participants could continue working on the primary task as they listened.

For the secondary task, participants clicked on a button labelled ‘View Codes’ to see codes and their corresponding words (Figure 1, Panel D). The ‘View Codes’ button was available at all times during performance of the primary task. The dependent variable interruption lag was the time from the onset of the interruption (‘Hi’ in the human condition or the alert

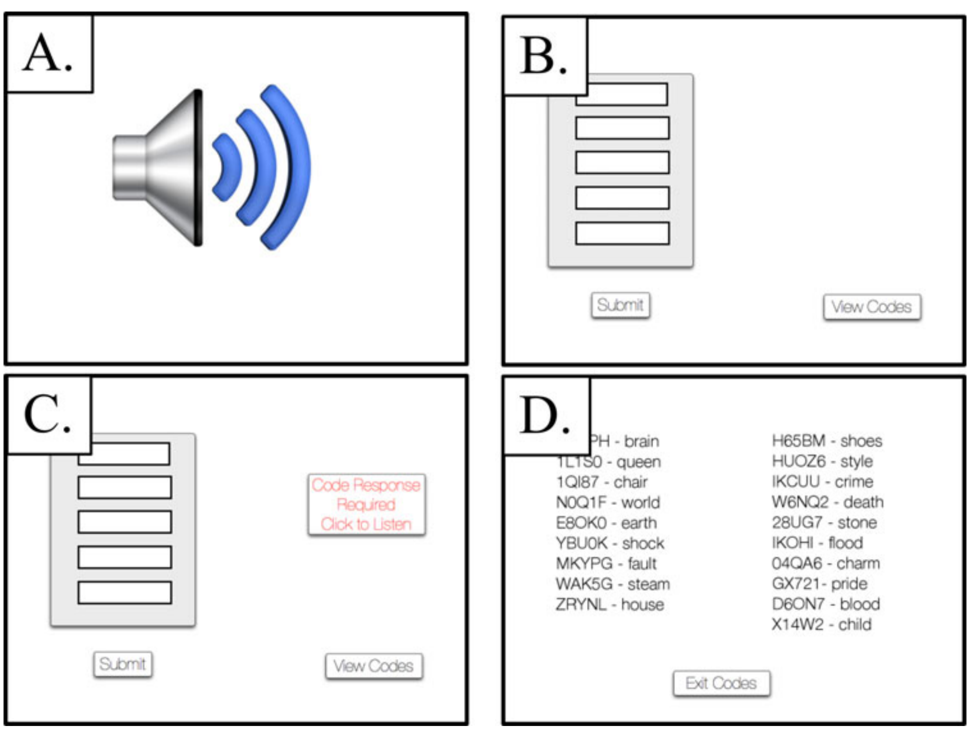

Figure 1. Screen shots of the task sequence. Panels A and B show the primary task. Panel C shows a virtual interruption. Panel D shows the secondary (interrupting) task screen.

in the virtual condition) until the participant clicked 'View Codes'. Participants looked up the word, announced the word aloud and clicked 'Exit Codes' to resume the primary task (Figure 1, Panel B). The dependent variable resumption lag was the time between the 'Exit Codes' click and the onset of a keypress to resume typing or a click on the 'Submit' button. Trials concluded when the participant clicked 'Submit'. Responses to the primary task were correct if a word was typed in its correct alphabetical position; scores ranged from 0 to 5 per trial. The timing-dependent variables were manually scored from video of the experiment recorded using ScreenFlick 2 software.

The second independent variable in the experiment was the interruption timing. Across trials, participants were interrupted at three points during primary task performance: (1) immediately as the data-entry screen appeared (early); (2) immediately upon beginning to type in the first box (middle) or (3) immediately upon beginning to type in the third box (late). Every trial was interrupted, and interruptions at each point in time were repeated for three trials within a block in a random order.

3. Results

One participant was removed from all analyses due to experimenter errors during human interruptions. Data from 12 trials (across 8 participants) were excluded for the same reason. Data from four trials were excluded, because participants did not follow instructions. Scores greater than 3 *SD*s above their group cell means for interruption lag and resumption lag were excluded for 13 trials (across 10 participants). Data were analysed with 2 (interruption source) × 3 (interruption timing) repeated measures ANOVAs on each of three dependent variables: (1) number of correct primary task responses; (2) interruption lag and (3) resumption lag. Greenhouse–Geisser corrections were used for violations of sphericity, and post hoc follow-up comparisons used Fisher's protected *t*-test.

There was no difference in the number of correct responses (out of five possible) for human versus virtual interruptions, $F(1,24) = 1.09$, $p = 0.31$ (see Figure 2). The effect of interruption timing was significant, $F(2,48) = 20.26$, $p < 0.001$, $\eta_p^2 = 0.46$. Participants performed better when the interruption occurred at the late point in the primary task ($M = 3.12$ correct responses, $SE = 0.23$) as compared to the middle ($M = 2.23$ correct responses, $SE = 0.18$) and early ($M = 1.99$ correct responses, $SE = 0.18$) points, $ps < 0.001$, respectively, and the middle and early interruptions were not significantly different, $p = 0.18$. The interaction was not significant, $F(2,48) = 0.33$, $p = 0.72$.

There was a significant difference in the interruption lag (in seconds) for human ($M = 3.35$ s, $SE = 0.21$) versus virtual ($M = 6.69$ s, $SE = 0.38$) interruptions, $F(1,24) = 96.17$, $p < 0.001$, $\eta_p^2 = 0.80$ (see Figure 3).[1] The effect of interruption timing was not significant, $F(1.24,29.76) = 0.90$, $p = 0.37$, nor was the interaction of the independent variables, $F(1.14,27.37) = 2.73$, $p = 0.11$.

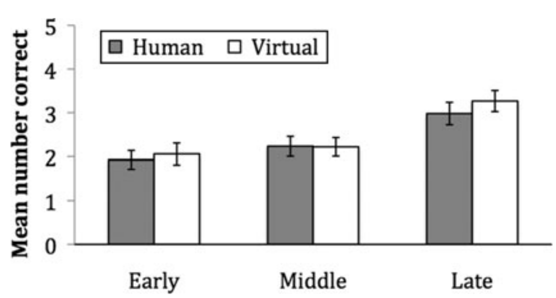

Figure 2. Mean number of correct responses. Error bars represent standard error.

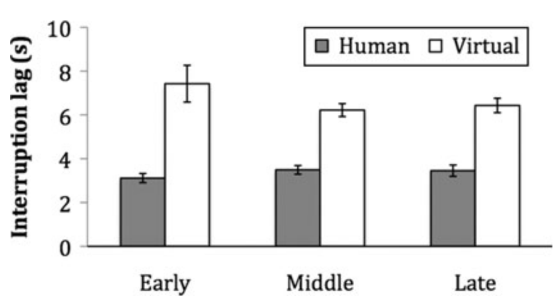

Figure 3. Mean interruption lags. Error bars represent standard error.

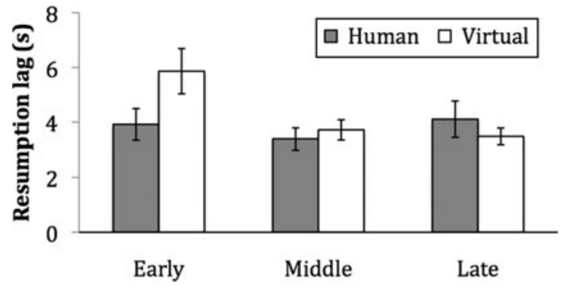

Figure 4. Mean resumption lags. Error bars represent standard error.

There was no difference in resumption lag (in seconds) for human versus virtual interruptions, $F(1,24) = 1.47$, $p = 0.24$ (see Figure 4). The effect of interruption timing was significant, $F(1.61,38.69) = 4.17$, $p = 0.03$, $\eta_p^2 = 0.15$. Participants were faster to resume when the interruption occurred at the late ($M = 3.79$ s, $SE = 0.42$) or middle ($M = 3.55$ s, $SE = 0.27$) as compared to the early ($M = 4.89$ s, $SE = 0.59$) point in the primary task, $ps = 0.03$, respectively, and the difference between the late and middle points was not significant, $p = 0.53$. The interaction was also significant, $F(2,48) = 4.68$, $p = 0.01$, $\eta_p^2 = 0.16$. Simple effects analyses showed the interaction was driven by a difference for human ($M = 3.92$ s, $SE = 0.58$) as compared to virtual ($M = 5.86$ s, $SE = 0.83$) interruptions for early interruptions, $p = 0.03$. Human and virtual interruptions were not different for middle, $p = 0.56$, or late interruptions, $p = 0.31$.

4. Discussion

The large difference in interruption lags suggested that, with virtual interruptions, participants strategically postponed engaging in the secondary task. With human interruptions, the perceived social expectations associated with the interruption (Nardi and Whittaker 2002) likely prompted more immediate engagement with the interruption. Although our task combinations did not show differences in accuracy for human versus virtual interruptions, research has suggested that shorter interruption lags result in greater disruption. Further research is needed to determine whether other primary and interruption task combinations will result in performance differences for human as compared to virtual interruptions.

Our data also showed longer resumption lags for virtual interruptions that occurred in the early part of the task. Research has shown that longer resumption lags are inversely related to the probability of making a mistake (Brumby et al. 2013). To maintain the same level of accuracy, participants may have needed more time to resume the task with a virtual interruption that occurred early in the primary task sequence, which was assumed to be particularly demanding on memory. Interruptions that occurred in the early or middle part of the primary task sequence were more disruptive to accurate performance of the primary task for both human and virtual interruptions. We interpret this to be consistent with the notion that demands on memory decreased as the task progressed, because participants offloaded the number of to-be-remembered items as they typed responses.

More research is needed to explore further the differences between human and virtual task interruptions. The social or power status of the human interrupter may affect how people manage in-person interruptions. In practical applications, human versus virtual interruptions may occur for different reasons, and people may use different strategies to deal with in-person versus virtual interruptions. Nardi and Whittaker (2002) discussed the benefits of face-to-face employee contact, but it is possible that virtual interruptions will offer people more flexibility and success in managing the timing of their engagement with interruptions for some tasks. Future research may show that in office settings for example, a virtual interruption may be preferable to an in-person interruption for work tasks that require longer interruption lags to facilitate intentional integration (see Latorella 1999) of the interruption into the task scheme. The same may be true of other settings, such as nursing, where the majority of interruptions are in-person interactions with other humans (Berg et al. 2013; Biron, Loiselle, and Lavoie-Tremblay 2009).

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No potential conflict of interest was reported by the authors.

Note

1. A reviewer suggested the possibility that the human interruption condition, through demands due to the procedure, may have resulted in a qualitatively different type of interruption (characterised by preemptive as opposed to intentional integration, see Latorella 1999) that required participants to cease the primary task to obtain the interruption task code. We re-examined our data by sub-dividing the interruption lag into two separate epochs for a finer-grained exploratory analysis. The epochs were: (A) the time between the onset of the interruption and the onset of obtaining the information required to engage the secondary task; and (B) the time between the onset of obtaining the information and the onset of the mouse click on the 'View Codes' button. These data were examined with a 2 (interruption type) $\times$ 2 (epoch A versus epoch B) repeated measures ANOVA, which showed a very large main effect of human versus virtual interruptions, $F(1,24) = 78.43$, $p < 0.001$, and a smaller main effect of epoch, $F(1,24) = 9.11$, $p = 0.006$. Preemptive integration of the human interruption would predict an interaction such that epoch B would show faster responses as compared to epoch A, but only for the human interruptions. Crucially, this interaction was not significant, $F(1,24) = 1.24$, $p = 0.28$, which reflected that the underlying qualitative form of the interruption types was not different. Instead, human interruptions resulted in faster responses for both epochs across the entirety of the interruption lag, and epoch B took longer than epoch A for both types of interruptions.

References

Altmann, Erik M., and J. Gregory Trafton. 2002. "Memory for Goals: An Activation-Based Model." *Cognitive Science* 26 (1): 39–83.

Berg, Lena M., Ann-Sofie Källberg, Katarina E. Göransson, Jan Östergren, Jan Florin, and Anna Ehrenberg. 2013. "Interruptions in Emergency Department Work: An Observational and Interview Study." *BMJ Quality & Safety* 22 (8): 656–663. doi:10.1136/bmjqs-2013-001967.

Biron, Alain D., Carmen G. Loiselle, and Mélanie Lavoie-Tremblay. 2009. "Work Interruptions and Their Contribution to Medication Administration Errors: An Evidence Review." *Worldviews on Evidence-Based Nursing* 6 (2): 70–86.

Brumby, Duncan P., Anna L. Cox, Jonathan Back, and Sandy J. J. Gould. 2013. "Recovering from an Interruption: Investigating Speed–Accuracy Trade-Offs in Task Resumption Behavior." *Journal of Experimental Psychology: Applied* 19 (2): 95.

Cellier, Jean-Marie, and Helene Eyrolle. 1992. "Interference Between Switched Tasks." *Ergonomics* 35 (1): 25–36.

Friendly, M. 1996. *Paivio et al. Word List Generator*, Online Application. http://www.datavis.ca/online/paivio/

Hodgetts, H. M., and D. M. Jones. 2007. "Reminders, Alerts, and Pop-Ups: The Cost of Computer-Initiated Interruptions." In *Human–Computer Interaction: Interaction Design and Usability*, edited by J. Jacko, 818–826. New York: Springer.

Latorella, Kara A. 1999. *Investigating Interruptions: Implications for Flightdeck Performance*. Vol. 99, no. 209707. National Aeronautics and Space Administration, Langley Research Center. http://www.cs.odu.edu/~mln/ltrs-pdfs/NASA-99-tm209707.pdf

McFarlane, Daniel C., and Kara A. Latorella. 2002. "The Scope and Importance of Human Interruption in Human–Computer Interaction Design." *Human–Computer Interaction* 17 (1): 1–61.

Miyata, Y., and D. A. Norman. 1986. "Psychological Issues in Support of Multiple Activities." In *User-Centered System Design: New Perspectives on Human–Computer Interaction*, edited by D. A. Norman, 265–284. Mahwah, NJ: Lawrence Erlbaum Associates.

Nardi, Bonnie A., and Steve Whittaker. 2002. "The Place of Face-to-Face Communication in Distributed Work." In *Distributed Work*, edited by P. Hinds and S. Kiesler, 83–110. Cambridge, MA: MIT Press.

O'Conaill, Brid, and David Frohlich. 1995. "Timespace in the Workplace: Dealing with Interruptions." In *Conference Companion on Human Factors in Computing Systems*, 262–263. http://dl.acm.org/citation.cfm?id=223665 ACM.

Squire, P. N., and R. Parasuraman. 2010. "Effects of Automation and Task Load on Task Switching During Human Supervision of Multiple Semi-Autonomous Robots in a Dynamic Environment." *Ergonomics* 53 (8): 951–961. doi:10.1080/00140139.2010.489969.

Trafton, J. Gregory, Erik M. Altmann, Derek P. Brock, and Farilee E. Mintz. 2003. "Preparing to Resume an Interrupted Task: Effects of Prospective Goal Encoding and Retrospective Rehearsal." *International Journal of Human–Computer Studies* 58 (5): 583–603.

Trafton, J. Gregory, and Christopher A. Monk. 2007. "Task Interruptions." *Reviews of Human Factors and Ergonomics* 3 (1): 111–126.