On the Nature of Interruptions in Complex Dynamic Tasks

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The formal study of interruption can improve workplace safety by providing insights into the cognitive processes underlying interrupted task performance (Boehm-Davis & Remington, 2009). Experimental studies examining the disruptive effects of interruptions have typically used basic laboratory paradigms (Trafton & Monk, 2007) and account for disruptive effects using prospective memory models (McDaniel, Einstein, Graham, & Rall, 2004) or activation-based models (Altmann & Trafton, 2002). However, the effects of interruptions in more complex dynamic tasks, such as air traffic control (ATC), may be different because they require operators to perform multiple task goals in a continuously evolving task environment.

The current study examined the impact of two kinds of interruption on performance in simulated ATC. Participants ($n = 60$) were required to accept/handoff aircraft entering/exiting their sector and to prevent aircraft pairs from conflicting (violating minimum separation standards). There were three within-subjects conditions: no-interruption (baseline control), a blank interruption (blank screen for 27s), and an *n*-back interruption (visual 2-back task, for 27s). Each ATC trial included two delayed-execute PM tasks: a conflict-resolution PM-task and a handoff PM-task. Both tasks were encoded before the interruption occurred.

The conflict-resolution PM-task required participants to resolve a deferred conflict immediately after the interruption ended. Time taken to resolve this conflict was taken as resumption time. We predicted resumption time would increase for both interruption conditions due to the need to reorientate to the evolved visual ATC scene. We also predicted the *n*-back interruption would further increase resumption time due to blocking rehearsal. Interruptions significantly increased resumption time. However, in contrast to previous research using basic tasks (Monk, Trafton, & Boehm-Davis, 2008) resumption time was not greater in the demanding *n*-back interruption relative to the blank interruption.

The handoff PM-task required participants to handoff an aircraft using a non-routine keystroke at 63s (on average) after the interruption. To be clear, the aircraft flashed for hand-off and the participant needed to remember to press the alternative handoff key instead of the routine handoff key. Prior research has examined PM in simulated ATC (Loft, 2014), and we extended it by examining how interruptions would impact PM. Based on findings in basic delayed-execute studies, we predicted interruptions would increase handoff PM-task errors. The average error rate on the handoff PM-task was 31%, but this did not differ between the conditions.

Two important findings emerged from this study. Firstly, we did not find rehearsal to be an important factor in interruption recovery in simulated ATC. This indicates that orientating to an evolved visual scene may be the primary driver behind resumption time costs in this dynamic task. Secondly, we replicated the PM errors reported in previous simulated ATC experiments, but found that PM performance was robust to interruptions. Whilst the use of a student sample with limited training limits the generalizability of the present study, we recommend psychological models of interruption be applied cautiously, particularly in safety-critical environments. Human factors practice and research will benefit from further examining the nature of interruptions in complex task environments.

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