Title
Different Cognitive Mechanisms Account for Different Types of Procedural Steps

Journal
Proceedings of the Annual Meeting of the Cognitive Science Society, 31(31)

ISSN
1069-7977

Authors
Ament, Maartje
Blandford, Ann
Cox, Anna

Publication Date
2009

Peer reviewed

Different Cognitive Mechanisms Account for Different Types of Procedural Steps

Maartje G. A. Ament (M.Ament@ucl.ac.uk)

Ann Blandford (A.Blandford@ucl.ac.uk)

Anna L. Cox (Anna.Cox@ucl.ac.uk)
UCL Interaction Centre
MPEB 8th Floor
University College London
Gower Street
London, WC1E 6BT

Abstract

Device-specific errors occur on steps that do not directly contribute to the main goal; examples are the post-completion error and device-initialisation error. Device-specific steps are more likely to be forgotten than their task-specific counterparts. We hypothesise that this is caused by a lower cognitive salience on device-specific steps, resulting in lower associated activation levels. In addition, associative links between device-specific steps may not be as strong as those between task-specific steps. The first experiment explores the differences in performance and eye movements between device- and task-specific steps. The second experiment looks more closely at the origin of procedural cues for the different types of steps. It was found that eye-movements and performance differ between the types of steps, indicating that different cognitive processes are at work. No differences were found in where cues come from, so an alternative explanation is discussed.

Keywords: human error, post-completion error; device-specific error; eyetracking; cognitive salience; cueing.

Introduction

Post-completion errors occur when the last step in a task is forgotten, because the main goal has already been achieved. A similar error has been observed at the beginning of a task, before the main goal is initialised. An example is forgetting to touch in with your Oyster card on the London Underground. These errors share the property of not directly contributing to the main goal, and are therefore called device-specific errors (as opposed to task-specific ones).

Based on task-structure, three types of device-specific steps can be identified. First, there are those at the beginning of a procedure or sub-task, which form so-called initialisation steps. Second, there are those that form a 'clean-up' step after a task or sub-task has been completed. These are referred to as post-completion steps. And third, there are those device-specific steps that are functionally independent from their neighbours, and are therefore termed independent device-specific steps.

Previous studies have found relatively high error rates on post-completion steps across a number of different tasks (Byrne & Bovair, 1997; Back, Cheng, Dann, Curzon, & Blandford, 2006). It is expected that errors on other device-specific steps are also more common than their task-specific counterparts. A study by Li, Blandford, Cairns, and Young (2008) supports this prediction, showing a relatively high error rate on sub-task initialisation steps.

Altmann and Trafton (2002) developed the Activation-based Goal Memory (AGM) model. This model suggests that goals in memory have activation levels associated with them. The goal with the highest activation level is executed. Goals may gain activation by an increased sampling rate, and lose it through interference and decay over time. The priming constraint requires that suspended goals are primed before they can become active again, by means of a retrieval cue. This retrieval cue can be internal, such as associative links between successive steps in a procedural task, or external, such as a visually salient item in the interface.

Our hypothesis is that the mechanism for these increased error rates lies in cognitive salience. Because device-specific steps do not form a natural part of the task, but are instead required by the device, they are thought to have lower cognitive salience than task-specific steps. This leads to the prediction that associative links between device-specific steps are weaker than those for task-specific steps. This would explain the observed higher error rates on the former.

Device-specific and task-specific steps rely on different kinds of knowledge: device knowledge and task knowledge respectively (Cox & Young, 2000; Li et al., 2008). This may indicate that they also rely on different cognitive processes. Two experiments are presented here that study the cognitive processes underlying the various types of steps.

The first experiment provides a general exploration of the different device-specific steps, and their underlying cognitive mechanisms. A novel task that includes a variety of device-specific and task-specific steps is introduced.

The second experiment looks at retrieval cues in more detail, focusing on the difference between device-specific and task-specific steps. It is hypothesised that internal cues are more important for task-specific steps, and external cues are more important for device-specific steps.

Experiment 1

The first experiment aimed to explore the difference between device-specific and task-specific steps, using a variety of measures such as error rates and eye movements.

Method

Participants Twelve undergraduate students took part in the experiment, all were paid £6 for their time.

Stimuli A new task called the spy game was developed for this experiment. It required participants to follow a procedure to fly a plane to a certain destination, and deliver a secret message. Figure 1 shows a screen shot of the interface.

The spy game involves a number of different device-specific steps. There were 4 initialisation steps, such as switching on the cockpit and switching on the radio. There were 5 post-completion steps, including switching the engines back into forward thrust and switching off the radio. Also, there were 2 independent steps, releasing the brakes and retracting the landing gear.

Figure 1: The spy game.

Design All participants completed the same task. Steps were varied in a within-participants design, so each participant completed a variety of different steps: 11 device-specific steps (as outlined above), and 17 task-specific steps.

The dependent measures are error rate and completion time. Errors are counted systematically and are defined as any action that deviates from the required action at a certain step. To ensure only inappropriate actions are counted and not each individual inappropriate click, only one error was counted on each step.

In addition, eye-movement data was collected. First, the three classical eye movement measures, average fixation duration, number of fixations and total fixation duration, were recorded. Second, the order in which steps are focused on was also recorded.

Procedure The experiment started with an on-screen information sheet that explained the cover story and the steps necessary to complete the task. Participants were then walked through the task step by step: an instruction was shown superimposed on the task interface, until the corresponding step was completed accordingly. Any errors made during the training were pointed out immediately using the default Windows XP error sound, and proceeding was not possible until the error was corrected. Participants practiced until they completed two trials without making any errors. The main task then started, on which 11 trials had to be completed. The total duration of the experiment was approximately 50 minutes.

Results

Error Data Data from 12 participants was recorded, but one had to be excluded because of a faulty data recording. A total of 28 errors could be made on a single trial. Each participant completed 11 trials, and data from 11 participants was analysed, giving a total opportunity for errors of 28 x 11 x 11 = 3388. Across all participants, a total of 106 were made, giving an overall error rate of 3.1%.

Error rates for device-specific steps were higher than for task-specific steps, 5.3% and 1.8% respectively. A paired samples t-test showed that this difference is significant, $t = 2.953, p < 0.05$. Looking at device-specific errors in more detail, the error rate on initialisation steps is 5.6%, on post-completion it is 4.3% and on independent steps the error rate is 7.0%. These differences were not significant, as shown by a repeated-measures ANOVA, $F(2,22) = 0.682, p = 0.516$.

Eye-movement Data One eye-movement recording had to be removed from analysis due to faulty calibration. The analysis of the eye-tracking data focuses on the eye-movements just prior to a step: for each step, the data from the moment the previous step is clicked on until the next meaningful mouse click was isolated.

The classical measures (number of fixations, average fixation duration and total fixation duration) were compared for task- and device-specific steps on trials when an error was or was not made. Table 1 shows a summary. The step types in straight font represent all correct cases. The associated cases when an error was made are displayed in italics. When an error was made, there are no significant differences between task- and device-specific steps, for all three eye tracking measurements (number of fixations: $F = 1.886, p = 0.174$, average fixation duration: $F = 1.023, p = 0.315$, total fixation duration: $F = 2.640, p = 0.109$). When an error was *not* made, on the other hand, the measures do show significant differences between task- and device-specific steps. The number of fixations is significantly greater on device-specific steps, $F = 80.776, p < 0.001$. The average fixation duration is significantly shorter on device-specific steps, $F = 47.197, p < 0.001$. The total fixation duration is significantly longer on device-specific steps, $F = 60.820, p < 0.001$.

Looking at the different types of device-specific steps in more detail, an ANOVA test shows that there were differences between the three categories as well. The average fixation duration is significantly lower on initialisation than on post-completion and independent device-specific steps (as shown by Tukey's HSD post-hoc test), $F = 23.840, p < 0.001$. No

Table 1: Summary of eye tracking data for device-specific and task-specific steps.

Type of step	Number of fixations	Average fixation duration	Total fixation duration
Task-specific	3.32 (3.62)	692 (403)	1736 (1316)
error	*8.71 (7.27)*	*621 (294)*	*4302 (2348)*
Device-specific (total)	4.82 (4.58)	584 (342)	2197 (1598)
error	*6.71 (4.99)*	*712 (393)*	*3523 (1680)*
Initialisation	4.96 (4.78)	488 (260)	2051 (1616)
error	*6.41 (3.73)*	*529 (239)*	*2768 (987)*
Post-completion	4.92 (4.20)	634 (370)	2442 (1587)
error	*5.17 (4.15)*	*879 (377)*	*3423 (1516)*
Independent	4.25 (5.03)	657 (372)	1872 (1498)
error	*9.07 (6.56)*	*721 (481)*	*4570 (2070)*

differences are shown for the number of fixations, $F = 1.625, p = 0.197$. The total fixation duration is significantly longer on post-completion device-specific steps (as shown by Tukey's HSD post-hoc test): $F = 10.475, p < 0.001$.

Fixation Order A pilot study had revealed an interesting pattern in fixation order on some device-specific steps. Before the correct step was focused on, participants sometimes first looked at the *next* step. The occurrence of this pattern was counted for each of the different categories of steps. For task-specific steps, the pattern was observed in 5.6% of cases. For initialisation device-specific steps, this was 28%, for post-completion steps it was 14% and for independent device-specific steps the pattern was observed in 16% of cases[1]. A one-way repeated measures ANOVA shows a significant difference between the different types of steps, $F(2,40) = 3.712, p < 0.05$. Post-hoc tests revealed that only the initialisation step was significantly higher than the others.

Discussion

The first experiment aimed to gain a deeper understanding of performance and the patterns in eye movements associated with errors and error free performance for task-specific and device-specific steps.

Error Rates The overall error rate falls below the level at which they would be called systematic (5%). As expected, there is a significant difference between device-specific and task-specific error rates: more errors are made on the former. This provides further support for the distinction between device- and task-specific steps. According to Cox and Young (2000) and Li et al. (2008), they rely on different types of knowledge: device-knowledge and task-knowledge, respectively. Moreover, their underlying procedural representations may be different, in this case leading to a lower cognitive salience on device-specific steps.

[1]It should be noted that this was almost exclusively caused by one step. On the other step in this category, the percentage was close to 0.

Eye-movement Data The traditional measures of average fixation duration, number of fixations, and total fixation time were studied. They showed that, when an error was made, there are no significant differences between task and device specific steps, for all three eye movement measurements. When an error was not made, on the other hand, the measures do show significant differences between task- and device-specific steps. On the correct execution of device-specific steps, the average fixation duration was shorter and the number of fixations was higher. Moreover, the total fixation duration was longer than for task-specific steps.

This difference may indicate that different cognitive mechanisms are at work for the different types of steps. A greater number of fixations and shorter fixation durations may indicate that searching behaviour is taking place. Engaging in searching behaviour may mean that participants are having more trouble retrieving device-specific steps from memory. They may rely on cues from the environment, or might prefer to get information from the interface rather than doing effortful memory retrieval. This is in line with the hypothesis that device-specific steps have lower cognitive salience, and thus need stronger environmental cues to reach the appropriate activation level.

Fixation Order The eye movement data showed an interesting pattern: when a device-specific step was correctly executed, eye gaze was sometimes first directed at the next step, before returning to the correct step. This pattern was found on approximately a quarter of the initialisation steps, and on a sixth of post-completion and independent device-specific steps. On task-specific steps, this pattern was only occasionally seen.

An explanation for this observed pattern is that task-specific steps may be more cognitively salient than device-specific steps, so their activation value will be higher and they are more likely to be activated. Cox and Young (2000) suggest that task-specific steps are integral to the task sequence, whereas device-specific steps are dictated by the device. Therefore, procedural links are more likely to exist in the former. The activation may naturally flow to the next, salient task-specific step, instead of to the correct, but less salient device-specific step, because the underlying procedural representation favours task-specific steps. If there is a functional link between the device-specific step and the next task-specific step, for instance when the device-specific step enables the execution of the task-specific step in the interface, the task-specific step may provide a cue for the device-specific step. If this cue is not strong enough, or if the activation of the task-specific step is too high, an error is likely to be made.

As such, this eye-movement pattern is expected only on initialisation steps, because only on these is the device-specific step followed by a task-specific one. This is not the case on post-completion and independent steps, on which procedural links take a different form. Indeed, at 28%, the eye movement pattern was observed many more times on initialisation steps than on any other step.

Experiment 2

The first study showed an interesting difference in the eye movement patterns for device-specific and task-specific steps. Fixations were shorter and more numerous just before device-specific steps. Error rates on these steps were also higher, indicating that different cognitive mechanisms may be at work.

Li et al. (2008) suggested that procedural links may be less strong for certain device-specific steps. The first experiment is in line with this. It is hypothesised that for task-specific steps, cues relatively often originate internally, whereas on device-specific steps, they are not always readily available. In this case the environment, such as the interface, must be relied on. The idea behind this is that device-specific steps have lower cognitive salience and are less strongly anchored in the user's task model, and thus additional support is necessary for these steps to reach the appropriate activation level. Therefore, any disruption of the interface should affect device-specific steps more severely than task-specific steps. Effects are likely to be seen in error rates and in the time it takes for a step to be done: they are both expected to be higher on device-specific steps.

Method

The origin of cues can be studied by manipulating their availability and looking at the effects of this on the time it takes to complete a step and on error rates. If a potential cue is made less available, and the completion time and error rates are affected, this is an indication that the cue was important.

Design The availability of procedural cues is difficult to manipulate experimentally. Internal cues are very difficult to influence in a controlled manner, so instead this study focuses on external cues only. It was thought that the most important part of an external cue comes from the actual visual representation of the step, such as a button, text input field or other interface item. Removing this visual representation will then also reduce the cueing capability of the step.

The same spy task as in the previous study was used, with an adjustment to allow the manipulation of cues. Some of the interface items, such as a button or an input field, were temporarily hidden from the screen to stop them from providing a cue. The removal of the element did not mean that the step could not be carried out: the underlying area on the interface was still functional, so clicking on it completed the step in the same manner that clicking on the actual interface element did.

The hidden items were changed on each step during the procedure. They were chosen semi-randomly: in approximately 50% of the cases it was the next correct step, and in the other 50% it was a random other step. This ensured that the hidden step was not always the correct one, which would have allowed participants to simply look for the empty area to help them do the task.

To stop the disappearance of a step from grabbing visual attention and thereby inadvertently cueing the next step, the interface element was always hidden a step early. As a result, the hiding of a step had to last for two consecutive steps: the current, relevant step and the step directly preceding it. Thus, two steps were hidden at all times, and on each next step only one of them was changed.

All participants completed the same task. Steps were varied in a within-participants design, so each participant completed a variety of different steps (see experiment 1). There were two independent variables: the type of step (initialisation, post-completion or independent device-specific, or task-specific) and whether or not its interface element was hidden. The dependent variables were error rate, time to complete a step, average fixation duration, number of fixations, total fixation duration and the order in which steps are fixated on.

Procedure The procedure was identical to that of the first experiment.

Participants Twelve participants were recruited amongst undergraduate students; all were paid £5 for their time. Only participants who had not taken part in the previous study were allowed to take part.

Results

Data from 12 participants was recorded. Each participant did 11 trials, although some did a few more or less as a result of a bug in the program[2]. A total of 28 errors could be made on a single trial, and the total opportunity for errors was 3961.

Error Rates Across all participants, a total of 121 errors were made, giving an overall error rate of 3.1%. Error rates for device-specific steps were higher than for task-specific ones, 6.3% (SD = 4.7%) and 1.1% (SD = 1.3%) respectively. A paired samples t-test showed that this difference is significant, $t(11) = 3.815, p < 0.005$. Looking at device-specific steps in more detail, the error rate on initialisation steps is

[2] The bug caused the program to crash at random points, after which it was restarted. However, the number of trials already completed could not be determined precisely, hence some participants did a few more or less.

7.0% (SD = 6.3%), on post-completion steps it is 7.6% (SD = 9.5%) and on independent ones it is 2.8% (SD = 2.9%).

Error rates on hidden steps were higher than on visible steps, 4.0% (SD = 2.7%) and 2.5% (SD = 2.0%) respectively. A paired-samples t-test showed this difference to be significant, $t(11) = 3.000, p < 0.05$.

However, no significant interaction was found between the two conditions, as shown by a 2-way repeated measures ANOVA. Since the assumption of sphericity was violated, the Greenhouse-Geisser correction was applied: $F(3,33) = 0.516, p = 0.587$.

Completion Time The mean time to complete one step was 2372.8ms for device-specific steps (SD = 800.7), and 2554.3ms for task-specific steps (SD = 500.4). A 2-way repeated measures ANOVA showed that this small difference was not significant, $F(1,10) = 1.148, p = 0.309$.

When looking at device-specific steps in more detail, the data show a significant difference between initialisation and post-completion steps only (with the former being higher, $F(3,30) = 3.247, p = 0.036$).

There was no significant difference between hidden (M = 2362.4ms, SD = 613.4) and visible (M = 2564.7ms, SD = 714.9) steps, $F(1,10) = 2.720, p = 0.130$. Also, an interaction between the two conditions was not present, $F(1,10) = 0.057; p = 0.815$.

Eye Movements Eye movements of only 11 of the 12 participants were recorded as a result of faulty hardware. The analysis of the eye-tracking data focuses on the eye-movement patterns just prior to a step. For each step, the data from the moment the previous step is clicked on until the next meaningful mouse click was isolated.

The number of fixations per step was higher for device-specific steps (M = 5.38, SD = 1.80) than for task-specific steps (M = 4.14, SD = 1.16). A 2-way repeated measures ANOVA showed that this difference was significant, $F(1,10) = 24.509, p < 0.001$. Looking more closely at the three different categories of device-specific steps, there were no differences between them. The number of fixations per step averaged at M = 4.59 (SD = 1.38) for the hidden condition, and M = 4.93 (SD = 1.86) for the visible condition. This small difference was not significant, $F(1,10) = 1.974, p = 0.190$. No interaction between the type of step (device-specific or task-specific) and visibility of the step (hidden or not) was found, $F(1,10) = 2.670, p = 0.133$.

The average fixation duration was greater for task-specific steps (M = 711.5ms, SD = 104.8) than for device-specific steps (M = 586.3ms, SD = 96.0). This difference was shown to be significant, $F(1,10) = 33.905, p < 0.001$. A closer look at the individual categories shows that the average fixation duration is shortest for initialisation steps.There was no significant difference in the average fixation duration between hidden (M = 657.4ms, SD = 115.5) and visible conditions (M = 640.4ms, SD = 122.2), $F(1,10) = 1.539, p = 0.243$. There was also no interaction between the type of step and its visibility, $F(1,10) = 0.172, p = 0.687$.

The total fixation duration was larger on device-specific steps (M = 2502.2ms, SD = 552.0) than on task-specific steps (M = 2157.4ms, SD = 449.9). This difference was found to be significant, $F(1,10) = 16.138, p = 0.002$. A closer look at the categories shows that the total fixation duration is longest for initialisation and post-completion steps, whereas those for independent and task-specific steps are shortest. There was no significant difference between hidden steps (M = 2324.1ms, SD = 460.3) and visible steps (M = 2335.4ms, SD = 597.9), $F(1,10) = 0.017; p = 0.900$. There was also no significant interaction effect between the two conditions, $F(1,10) = 1.638, p = 0.229$.

The first experiment showed an interesting effect in fixation order: the order in which steps are fixated on does not always match up with the order in which steps have to be executed. Similar patterns were found on the second experiment. On device-specific steps, participants looked at the next step before looking at the current step in 21.1% of cases. For task-specific steps, this was 9.7%. When looking at the categories in more detail, it becomes apparent that the pattern occurred most often on initialisation steps (in 30% of cases), and less often on the others (16% on both post-completion and independent steps). A 1-way repeated measures ANOVA reveals a significant difference between the conditions ($F(4,50) = 11.147, p < 0.001$); a post-hoc test showed that only the initialisation step differed significantly from the others.

Discussion

The second experiment looked at the origin of procedural cues. It was hypothesised that for device-specific steps, these cues come relatively often from the environment, and for task-specific steps, they more often originate internally. From this follows the prediction that making cues less available by hiding them should affect device-specific steps more than task-specific steps.

Error Rates As expected, the results show that more errors are made on device-specific steps. This confirms the findings of the first experiment. It is thought to be due to device-specific steps having lower cognitive salience, and thus they are more at risk of losing their activation before being executed.

The error rates on hidden steps were shown to be higher than on visible steps. This shows that the manipulation worked, and that it was effective in disrupting cues. This was essential, because if there was no difference at all it would have been likely that the manipulation did not have an effect, compromising the findings of the experiment.

However, the lack of interaction between the type of step (device-specific or task-specific) and the visibility (hidden or not hidden) on error rates means that the disruption of cues did not differentially affect performance on device- and task-specific steps. This is against expectations, because it does not support the idea that cues come from the environment more often for device-specific than for task-specific steps.

Several explanations for this can be found. First, of course, is that the hypothesis is false, and that there is indeed no difference in where cues come from on device- and task-specific steps. However, considering the relatively small number of participants, caution has to be taken not to dismiss the hypothesis in error. Also, the error rates were rather small, which may have led to a floor effect. It is therefore possible that an interaction between the two conditions is simply too small to pick up.

Second, it is possible that the experimental manipulation did not work as expected. It is likely that factors other than visibility play a role in the cueing process, such as location or relation to other interface items. Manipulating only one of these may result in the experiment only tapping part of the cueing process. Nevertheless, the experimental manipulation did have an effect, as demonstrated by the difference in error rates between hidden and visible steps. Thus, while this study successfully manipulated external cues, they may be more complex than it has accounted for.

Third, a potential confounding factor is that the hidden step may have been used as a predictor for the correct next step. In 50% of cases, the hidden step is indeed the correct step; in the other 50% it is a random other step. Therefore, although half of the time the prediction will be wrong, the other half of the time the hidden step will correctly predict the next step. So while it may be more effective and efficient to retrieve the next correct step from memory, there may still be a benefit to using the hidden area as a predictor.

Eye Movements The three classical eye movement measures, average fixation duration, number of fixations and total fixation duration, were investigated. On device-specific steps, the average fixation duration was shorter, the number of fixations was larger and the total fixation duration was longer than on task-specific steps. This is exactly as expected, and in line with previous results. It supports the idea that information from the interface is used differently on different types of steps. Moreover, many short fixations can be an indicator of searching behaviour taking place, or of environmental cues being taken from the interface.

No such differences in eye movements were observed between visible and hidden steps.

The previous two studies showed an interesting effect in fixation order: the order in which steps are fixated on does not always match up with the order in which steps have to be carried out. This is especially the case for initialisation device-specific steps, on which people first look at the next step, before returning to the correct step. The same pattern was observed in the current results on a quarter of cases, for initialisation steps. This finding once again suggests that cueing is a more complex process than previously thought.

General Discussion

The current studies have shown that a distinction between device-specific and task-specific steps is a useful one: errors occur more often on the former than on the latter. Previous studies have also made similar distinctions (i.e. Cox & Young, 2000), but have not studied the implications of this on human error.

Moreover, the experiments presented here show that the distinction makes sense from a cognitive point of view. Eye movement patterns for the different types of steps differ. This is an indication that different cognitive processes are at work. What exactly the nature of these processes is, remains to be studied in the future.

The second experiment attempted to determine where cues originate, for device-specific and task-specific steps. The hypothesis was that for device-specific steps, the predominant source of cues is the environment, whereas for task-specific steps, cues more often originate internally. However, this hypothesis could not be confirmed. Although it could also not be dismissed with certainty, alternative explanations must be sought. Perhaps the difference lies more in whether cues are used at all. Li et al. (2008) argue that certain device-specific steps may not rely on cueing as much. Instead, their execution relies more on a deliberate and less automatic mechanism.

In any case, the two experiments have made it clear that cueing is a complex process. Other possible mechanisms need to be explored, such as cues from the location or from the relation to other items in the interface. Future experiments can manipulate these, and find out what the effects are on task performance and eye movements. In this manner, the nature and origin of cues can be explored in more detail.

Acknowledgments

This work is supported by an EPSRC DTA studentship.

References

Altmann, E. M., & Trafton, J. G. (2002). Memory for goals: An activation-based model. *Cognitive Science*, *26*, 39-83.

Back, J., Cheng, W. L., Dann, R., Curzon, P., & Blandford, A. (2006). Does being motivated to avoid procedural errors influence their systematicity? In *Proceedings of hci 2006* (Vol. 1, p. 2-9).

Byrne, M. D., & Bovair, S. (1997). A working memory model of a common procedural error. *Cognitive Science*, *21*(1), 31-61.

Cox, A. L., & Young, R. M. (2000). Device-oriented and task-oriented exploratory learning of interactive devices. In N. Taatgen & J. Aasman (Eds.), *Proceedings of the third international conference on cognitive modelling* (p. 70-77). Veenendaal,The Netherlands: Universal Press.

Li, S. Y.-W., Blandford, A., Cairns, P., & Young, R. M. (2008). The effect of interruptions on postcompletion and other procedural errors: An account based on the activation-based goal memory model. *Journal of Experimental Psychology: Applied*, *14*(4), 314-328.