Learning with Interruptions: Representing Past Computer Activity for Recall of Learned Procedures

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ABSTRACT

The digitization of knowledge work has led to an increase in computer-related interruptions. Recovering from interruptions can get harder over time as knowledge about the suspended activity fades from memory. Prior research suggests that digital reinstatement systems should not only be concerned reminding users with previous content but also of their intentions and goals. In this study, we investigate different reviewing methods for computer-based, procedural learning tasks on Photoshop by comparing different types of content through both video and images. Our research suggests that viewing video the original course content made for the best review method for these types of learning task.

INTRODUCTION

We live in a day where people use, share, and organize information in a myriad of ways. These activities increasingly involve computers [1]. Computers have a positive effect on people's work activities and are becoming more and more prevalent in our everyday lives. Computers are not only convenient but can increase productivity. However, sometimes computers can be frustrating to use. Most of the time working with computers is spent with multiple applications, where *typically*, each application only partially supports the task in which is trying to be accomplish.

Adam is working on his computer for a research paper that is due for his online class. Adam has a Word Document open on the left side of the screen as he refers to a PDF open on the right. He has multiple books open for easy reference. Adam also plans to add in a relevant example that he learned from a previous class.

Not only do we have digital resources that help finish work, but physical tools, such as papers and books, and mental resources, such as thoughts and memories. People work in a distributed workspace.

As we continue to transition into a more digital workspace we enter into a space of increasingly fragmented work practices. Computers provide a steady stream of interruption - through utilities like emails and alerts - and in most cases these interruption can seem annoying and affect productivity. However, some interruptions are necessary in the course of conducting daily tasks. While interruptions provide timely information, they degrade cognitive context by redirecting attention and overwriting working memory, making it difficult to resume complex activities later. As most work is not completed in one sitting, daily tasks aren't the only instances subject to interruptions. Long term projects that require multiple re-visits over days or weeks duration also suffer similar cognitive consequences. There is a time and cognitive cost every time work undergoes a short interruption or a long-term break.

Adam is almost done with his research paper. He is getting tired and decides to call it a night. He shuts his laptop and goes to bed. Two days later Adam comes back to his paper, opens up his Word Document and PDF on his computer and pulls out his books, sits down and asks himself, "Okay where was I?"

Work centers around activities driven by motivations and goals that may span multiple documents and applications [3,4,5]. Thus systems that restore work context must be concerned not only with restoring computing resources, but also with helping users remember their motivations and goals. This paper begins to address the question of how to minimize the impact of interruptions and breaks to reestablish mental context of interrupted activities.

Focus

With this question in mind, we started to explore different reviewing methods of previous work activity in computer-mediated tasks, specifically for online learners. Online learning is a form of distant education where the majority of resources needed to accomplish the required tasks take place within one's computer. Online learning has an increasing population of users for both massive open online classrooms (MOOCs) and short tutorial videos. Both

MOOCs and tutorials exemplify a computer task where one must start and restart similar activities over an extended period of time.

This paper looks specifically at people reviewing previously learned procedures from short video tutorials. When a person needs a video tutorial to learn something such as how to convert a JPEG file to PNG or learn the basics of a new application like Photoshop - In what ways can a system re-present information more efficiently once its already been learned? What are some discounted ways in which the information can be represented in order to transition the learned content from working memory to being encoded in long-term memory? – so the procedure can actually be learned. By eliminating progressively less 'useful' content in a reviewing tools, students can not only save time in reviewing but unconsciously work toward actually learning the content by shifting away from a reliance on digital tools as they gain long term procedural knowledge. Overall, we seek to discover what review methods best assist students in getting back in a 'learning state of mind' not only by reminding them of previous content but also of their intentions, in this case, an intention to learn a procedural task. Again, systems that aim to restore work context must not restore computing resources, but must also help users remember their motivations and goals.

METHODS

In this experiment we had participants come into the lab where they learned three different procedural learning tasks on Adobe Photoshop. Forty-eight hours later the participants came back into the lab to perform the previously learned tasks while having access to limiting reviewing methods. The two days interruption simulates a typical classroom-learning break between course lectures.

This research works toward understanding the advantages and disadvantages of both presentation content and presentation system within review tools. Presentation content refers to the type of information that review system contains. In our research we are interested in exploring original course content and personal work history. Original Course content refers to only having access to the tutorial as it was originally presented during the learning process. Personal work history refers to the entire screen activity during the learning process. Personal work history captures both original course content and all other learning activity as it appeared on the screen during the learning process. Presentation system refers to how the content is presented during the review portion of the study. Content was either provided in the form of static images or a video. With these two variables (content and system) we have clean 4 way comparison [Figure 1] that will be the basis of our analysis.

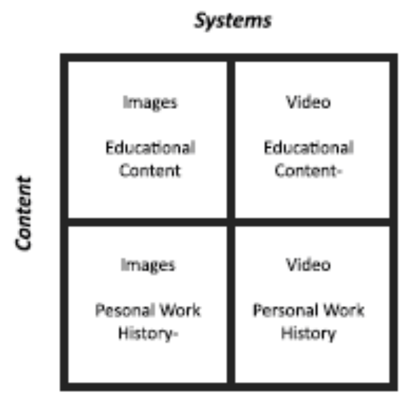

Figure 1: Study conditions

Hypothesis

We are interested in understanding the affordances that different review methods can provide. Is it enough to just see the educational content as it was originally presented during the first learning phase? Or is it more beneficial for the participant to see their entire work history? Not only seeing what they were learning but also how. We hypothesized the following:

H1: Personal work history will serve as better review content and will aid for faster execution of task.

Again, in this study we also take the opportunity to explore different review systems by manipulating the way in which it was presented. Not only are we interested in the type of content that best suits this type of learning, but also the style in which the content is presented to the user, in this study's case, images and video. When people are looking at images they have to think harder about what all is going on. Memories not only of what they were doing but also how. By mentally piecing images together, more types of memories are likely to be retrieved then passively re-watching a video. We hypothesized the following:

H2: Static images will serve as a better review system and will aid for fast execution of the task.

STUDY 1

Participants

UC San Diego undergraduate students (n=12, mean age = 21, 10 women) participated in exchange for partial course credit. All participants were be brought into the Human Computer Interaction Lab at UC San Diego and had basic computer knowledge with little to no experience in Adobe Photoshop.

Procedure

Questionnaire: All participants took a survey to insure participants had the required skills to take part in the experiment. The survey consisted of questions that measured previous experience with the following systems:

computer mediated design, common open-source editing tools, Photoshop and other Adobe applications. All surveys were evaluated by the researcher and were approved or denied for participation in the study. If the participant qualified as a novice user they then proceeded to further testing. All initial recruited participants qualified as novice users.

'Learning' Day: Participants were asked come into UC San Diego's Human Computer Interaction Lab to watch three procedural learning videos, tutorials, to learn tasks on Adobe Photoshop CC. Participants learned each task on an iMac. The three video tutorials taught the following tasking: 1) make a purple airplane 2) rounding the edges of a photograph 3) circle frame around a photo. The researchers created three equal-level tutorials in order to prevent any priming effects during the experiment. All videos had a total of 9 different steps. Video time averaged about two minutes each and all video durations were within 10 seconds of each other. Therefore, all participants learned all 27 different procedural steps over the course of the experiment with order properly counterbalanced. Tutorial viewing order was based off a Latin Square [Figure 2] experimental design in order to balance viewing order of the three tutorials.

	View/Review 1st	View/Review 2nd	View/Review 3rd
Subject 1,4,7,10	1 (purple airplane)	2 (rounded edges)	3 (framed circle)
Subject 2,5,8,11	2 (rounded edges)	3 (framed circle)	1 (purple airplane)
Subject 3,6,9,12	3 (framed circle)	1 (purple airplane)	2 (rounded edges)

Figure 2: Latin Square

Participants were asked to learn each tutorial individually. Tutorials were simultaneously viewed while the participant practiced the task on Photoshop. Photoshop and the tutorial (played via YouTube) were the only applications opened during the course of the study. Participants were encouraged to learn the material by being informed that they would have to come back to the task and perform either the same task or a variation in 48 hours. The participants had an unlimited amount of time to watch and learn each tutorial. The average time to learn each tutorial ranged from 5-10 minutes. Once the participant felt competent in performing the task without help of the tutorial, they were asked to close all applications before starting on the next video. Participants were not able to revisit any previously learned material once they verbally declared it learned. This procedure was repeated twice more with the different tutorial content. At the end of the learning phase participants were able to perform 3 different tasks without any help or instruction.

48 Hours: 48 hours later, the participants were required to come back into the lab in order to finish the study and receive full course credit.

'Test' Day: After the 48 hours, participants came back to the lab where they were presented with different review methods for each learned videos. Review methods consisted of the three following systems: 1) No Review 2) Static images taken from major steps from the tutorial 3) Re-watch tutorial video. Review images and video only contained educational content as it was originally presented in the learning phase. Participants had 2 minutes to review regardless of the system. The participant had the option to end the reviewing session sooner if he or she felt they were ready to complete the task. After the review session was complete, participants were asked to put the review tool away and then perform the reviewed task. At no point could participants could not go back and access the review tool. After the participant successfully completed, or declared they could not complete the task, he or she moved on to the next task. This process was repeated with varying review methods for each of the 3 tutorials. Participants were counterbalanced in that all participants began a task with no review, participants 1-6 would review images for their second task and watch a video to review for the third task. Participants 7-12 watched a video for their second task before reviewing images for the third task. Task execution was on the same rotation as it was presented to them on 'learning' day. [Figure 2] All of the participant's computer activity was screen recorded with audio to facilitate for later analysis.

STUDY 2

Undergraduate students (n =12, mean age = 20.5, 8 women), who had not participated in the first experiment, participated in exchange for partial course credit.

Participants

UC San Diego undergraduate students (n=12, mean age = 21, 10 women) participated in exchange for partial course credit. All participants were be brought into the Human Computer Interaction Lab at UC San Diego and had basic computer knowledge with little to no experience in Adobe Photoshop.

Procedure

Questionnaire: The questionnaire portion of the study was identical to Study 1.

'Learning' Day: To the participant, the learning portion of the study was identical to Study 1. The only difference was the researcher captured a full screen recording during the participant's entire learning process.

48 Hours: Over the 48-hour break static images and videos were taken out of the previously recorded ‘learning day’. Static images were taken chronologically as the participant made each *correct* step. Every time a participant made a correct step an image was captured, even if the step was repeated. For example, some participants would go back and repeat multiple correct steps before continuing on to the next step, resulting in more images. Therefore, the total number of images varied per participant as some procedures were learned differently. Videos start times were determined by the computer mouse's first motion when beginning a new task and stopped when the participant successfully completed the task or explicitly said he or she gave up.

‘Test’ Day: Testing day was procedurally identical as it was performed in Study 1. The difference was found in the presentation *content*. Participants now reviewed their own *personal work history*. Again, participants were on the same viewing rotation as described in Study 1.

ANALYSIS

Screen recordings from the ‘Test Day’ session were analyzed in ChronoViz. ChronoViz is a tool to aid the analysis of time-coded data. From the ‘test day’ session recordings, we recorded the following 5 events (in seconds): 1) how long it took to complete the task when no review was provided, 2/3) how long the participant took to review when viewing images or video, 4/5) time it took to complete task when images and video were given as a review system. Each participant had to complete the task in order for the task to qualify as successful completion. The steps taken to complete the task did not have match to the tutorial. Additionally, points were marked in ChronoViz when participants became stuck on a step that prevented them from completing the task. These points also identified the type of step that was mistaken, such as failure to identify correct icon, failure to find option in menu bar, and forgotten intentions. However, these findings showed too variable and unreliable to be considered for analysis.

RESULTS

Total Completion

Figure 3 presents the total number of participants who were successfully able to complete a given task. Results from Study 1 containing original course content (represented in blue) are as follows: 5/12 participants were successful when no review was presented, 11/12 participants were successful when review content was presented in the form on static images, and 11/12 participants were successful when they had access to re-watch the original course video. Results from Study 2 containing personal work history (represented in red) are as follows: 3/12 participants when having no review, 6/12 participants were successful reviewing their history as images, and 9/12 participants were successful when they watched a recorded video of themselves learning the task. Overall, participants were more likely to complete the task when some form of review was presented regardless of content or system.

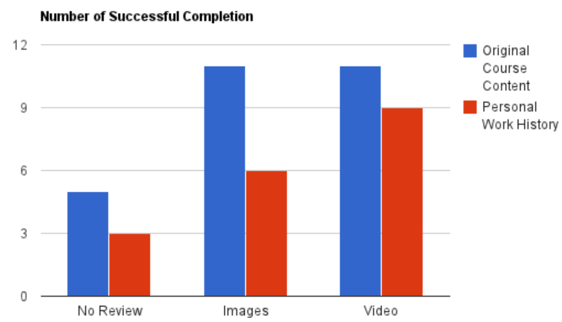

Figure 3: Number of successful task completions

Systems: When comparing between systems (images and video) we see that in total (including studies 1 and 2): 71% of people were success when having images as a review system compared to videos that resulted in an overall 83% success rate. Inferences that come from visual inspection of the graph lead us to believe that video might serve as a better reviewing system for this particular type of procedural task.

Content: When comparing reviewing content between conditions, our findings show that original course content served as a better review tool. Participants in Study 1 were 92% (22/24) successful when viewing course content, regardless of presentation method (images or video). This is in comparison to study 2 which totaled 63% (15/24) success rate in overall completion of tasks. These results suggest 1) some review is better than no review when performing a once learned procedural task 2) System - there is not a significant difference between reviewing system in regards to total number of completions within tasks and 3) Content - original course content serves as better review content.

Figure 4a-d: Visualizes relation between overall completion time (x-axis) and the time participants choose to spend reviewing (y-axis). Completion times were taken only from successful task completion instances.

Completion Time

Completion times were taken only from successful task completion instances. When reviewing the total time participants were more likely to use the full 2 minutes when using video than when they were reviewing images - presentation content did not affect review times.

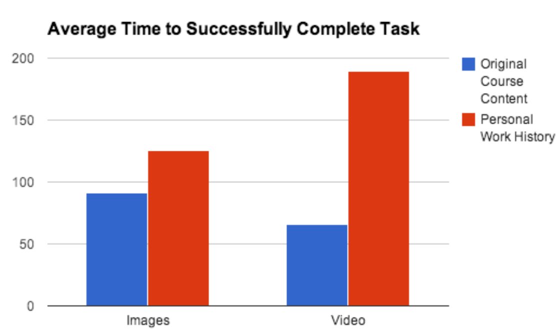

Figure 6: Average time to successfully complete the given task

System: Figure 6 displays time for successful completion with static images of original course content averaged is 90.87 seconds. Time for successful completion with video of original course content averaged is 65.48 seconds. Time for successful completion with static images of personal work history averaged 125.4 seconds. Time for successful completion with video of personal work history averaged 189.5 sec. In total when participants viewed images, regardless of content, it took participants an average of 103 sec to complete the task. When video was used as the reviewing system participants averaged 121 seconds for completion. Although Figures 5c and 5d indicate that viewing images result in faster completion time, Figures 5a and 5b suggest that there were more successful completion times for the video conditions therefore are subject to have more outlying results to work with. Visually, there are significant clusters in the video conditions as compared to a more dispersed plot as found in the image Figures 5a and 5d.

Content: Time for completing tasks when reviewing original course content regardless of review system averaged 78 seconds. The time for completing tasks when reviewing their personal work history, regardless of review, system averaged 163 seconds. On average people were twice as fast to complete tasks when given the original content. However from figures 5b and 5d we can visually inspect that personal work history conditions show some significant outliers. Therefore, when people were presented with original course content, participants had a greater chance of being not only being more successful but finishing is a shorter amount of time.

In summary the current analysis suggest 1) Participants are more consistent to use the full 2 minutes to review when reviewing with a video and that participants are more variable in review times when looking at static images 2) Systems - Although images had a lower total success rate, images had an overall faster completion time and 3) Content - original course content was completed in faster completion times. In conclusion, video of the original course content serves as the strongest review tool for this studies procedural tasks.

DISCUSSION

“Representing Past Computer Activity for Recall of Learned Procedures” has been an exploratory study within a larger effort in the HCI Lab at UC San Diego. From our research we have found many factors within our experimental design that could be adjusted to lead us into further understanding of the notion as to ‘what makes a good review system for an online learner’. One factor of the study that could reveal different results include different types of tasks reviewed, such as writing a research paper or a computer scientist learning a new coding language. These types of tasks are richer in personal context and reviewing one’s personal work history and could show more significance than a procedural learning-based task. Another manipulation factor would involve the participant being stopped midway through learning procedure. Simulating an actual task interruption where the participant doesn’t necessarily ‘re-do’ what they previously learned but have to continue from a unique point in time in which they stopped during the learning process.

One alteration for our experimental design that came out of our experience with the study and participants commentary during the ‘testing’ day would be to change the amount of time allowed for review. Perhaps the biggest component that prevented participants from being more successful in the personal work history condition came from the limited review time that was allowed during each study. Again, two minutes were allowed to review each system within each condition. Two minutes may have been a more ideal time for the first study when the original tutorial duration lasted 2 minutes, in comparison to the second study, where participants spent about 7-10 minutes actually learning the procedure. Therefore, when participants reviewed their personal work history, 2 minutes was not enough time for the participant to filter out all the important information they needed in order to complete the task. Subject 2B explicitly stated, “I didn’t have enough time to review the video” after her two minutes expired while reviewing the video of her personal work history.

Another interesting factor to consider for this particular experimental design would be to change the type of images selected for both conditions. Instead of limiting the images to only correct steps, it might be more beneficial for the participant to see static images every 3-5 seconds or so. That way, in the personal work history condition, participants are able to see the mistakes they made that eventually lead them to making the correct step. As researchers, we see a lot of learning between correct steps then just doing the correct step itself.

In conclusion, our studies shows trends that suggest video of original course content serves as the best type of review method for procedural learning tasks. This study’s particular type of learning task remains a nice, self-contained, common type of task that people frequently use and revisit often. Our study begins to build some basic knowledge and understanding of the different uses and potentials for different types of reviewing methods.

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