Does the Use of Tablets Lead to More Information Being Recorded and Better Recall in Short-Term Memory Tasks?

Hailey Arreola(✉), Andrea Nicole Flores, Amber Latham, Hanna MacNew, and Kim-Phuong L. Vu

Department of Psychology, California State University, Long Beach, USA
haileyarreolal@gmail.com,
{andrea.flores03,amber.latham,
hanna.macnew}@student.csulb.edu, kim.vu@csulb.edu

Abstract. Cognitive offloading is the process of recording information onto an external source (i.e., a piece of paper) to reduce short-term memory demands. People engage in cognitive offloading to be able to recall more information accurately [1]. The capacity for short-term memory is typically 7+/−2 items [2], but the number of items that can be accurately remembered decreases as the complexity of the information increases. As a result, people are more likely to engage in cognitive offloading when the memory task is difficult. Most cognitive offloading studies have used paper as the External Medium [1, 3]. People, however, may not have a pen and paper readily available to record information. Due to the increase of mobile technology, though, people are more likely to carry around mobile devices such as smartphones and tablets. Mobile devices can be used as a convenient medium to offload information. The present study examined if use of mobile technology would increase participants' offloading behaviors and recall accuracy compared to using paper for recording information. Results indicated that although all tablet features were available (e.g., swiping, voice recording), participants engaged in less cognitive offloading when using tablets compared to paper, and this resulted in lower recall performance for the tablet condition. Implications of these findings are discussed.

Keywords: Cognitive offloading · Mobile technology · Human performance

1 Introduction

1.1 Background and Motivation

The creation of mobile technology within recent decades has provided users with the option of offloading, or recording, information onto their devices rather than having to remember the information using their short-term or long-term memory. For example, users can set reminders or alarms on their smartphones or tablets to aid their memory for performing a task in the future. The Pew Research Center [4] indicates that approximately 53% of Americans own a tablet and 77% own a smartphone. These percentages are typically higher for younger adults, aged 18–34, [4, 5]. This widespread ownership

S. Yamamoto and H. Mori (Eds.): HCII 2019, LNCS 11569, pp. 292–302, 2019.
https://doi.org/10.1007/978-3-030-22660-2_20

of mobile technology provides a tool that has the potential to increase human performance capabilities across a large segment of the population.

For example, a person's usage and reliance on technology can alter their behavior by influencing decisions to extend their memory into the physical world to reduce workload. College students can take pictures of PowerPoint slides with their smartphones while their professor displays the slides during class to minimize the physical and mental demands of taking notes while listening to the professor. The capturing of the information on the smartphone can also increase the accuracy of the notes that students take by preserving the source (i.e., picture of what was presented) and not just relying on the students' memory of what was shown on the slide. There can be drawbacks, however, associated with the use of technology in educational settings.

Mueller and Oppenheimer [6] examined students' note taking behaviors when using a laptop versus paper. They found that when a laptop was used for taking notes, students were more likely to take verbatim notes. Taking verbatim notes could be beneficial because it captures the information in the exact manner that it was presented, which is helpful for acquiring factual knowledge. Verbatim notes, however, can be detrimental for long term memory learning as it results in shallow processing of the information that was being presented, which leads to poorer memory of that information [7]. Mueller and Oppenheimer [6] also found that students who used a laptop for taking notes performed worse than students who used paper to take notes on a subsequent assessment for comprehension questions. Thus, Mueller and Oppenheimer concluded that use of a laptop for note-taking could negatively affect students' performance on educational assessments.

Although, use of a laptop for note-taking might not benefit delayed recall of information, Bui, Myerson, and Hale [8] found that using a computer to take verbatim notes (i.e., transcribe the lecture) was beneficial to performance when recall was tested immediately. However, Mangen, Anda, Oxborough, and Bronnick [9] found that when participants recorded words that were orally presented to them, they had better recall of the words when the words were hand-written on paper compared to when it was typed using either a conventional or virtual keyboard. Therefore, findings are mixed about whether the use of laptops and tablets for note-taking leads to better immediate recall of the recorded information. It should be noted, that in the three studies mentioned above [6, 8, 9], memory for the information was tested without the participants having access to the recorded information. For cognitive offloading tasks, though, the information is being recorded with the intent of referencing it during the recall test. Thus, use of laptops and tablets for recording information on cognitive offloading tasks can lead to information being recorded more efficiently and in verbatim, which can increase recall accuracy on both short- and long-term prospective memory tasks.

The present study uses short-term memory tasks, which require recall of information immediately, after the information was presented. People are able to retain an average of 7+/−2 items in their working short-term memory [2]. Because of this capacity limitation for short-term memory, it can be difficult for people to hold a lot of information in their mind. As a result, accuracy on short-term memory tests decreases rapidly as the number of items increase beyond 9 items. Moreover, the short-term memory span, or items that can be accurately recalled, decreases as the information becomes more complex (e.g., word length increases) [10]. Thus, the use of mobile

technology might be beneficial in improving performance on short-term memory tasks by allowing people to use a convenient medium to record information. For example, if people are looking for the location of a new restaurant, they must remember the address of the location long enough to input it on Google Maps or another navigation aide. Being able to record, or offload, this information with their mobile device would allow people to simply transfer the address to the navigation aide without taxing their working memory capacity.

Previous studies of cognitive offloading behavior have used paper as the medium for participants to write down information [3]. Risko and Gilbert found that one factor that influences participants' decision to offload information is the amount of effort that is required to record the information. Since people do not typically carry around a pen/pencil and paper with them, but are often carrying some sort of mobile device, the ease in which information can be recorded using mobile technology can potentially influence cognitive offloading behaviors. Thus, the present study examines whether the medium to record information (paper or mobile device) results in different cognitive offloading behaviors and performance on short-term memory tasks.

2 Experiment 1

Participants were asked to recall pairs of words that were associated with academic studies. Participants were given the opportunity to record the word pairs as the items were presented using either pen/paper or a tablet device in the first test portion. The number of word pairs that participants were asked to recall varied in Set Sizes of 2, 4, or 6. In the second test portion, participants were asked to perform the same memory task without the option of recording information to obtain baseline measures of their working memory capacity and determine whether cognitive offloading increases the participants' performance.

2.1 Methods

Participants. Twenty-three students from California State University, Long Beach (CSULB) participated in this study. Students were recruited using the Introductory Psychology subject pool. The data from one participant was not recorded due to a program failure. Thus, the analyses were conducted using the data from 22 participants (Females: 17, Males: 5; Mean Age: 18.91; Range: 18–28 years). Participants were compensated by receiving experimental credit towards their course requirement. Informed consent was obtained from all participants, and the protocol used in this study was approved by the institutional review board (IRB) at CSULB.

Design. This experiment employed 2 (External Medium for Offloading: Paper or Tablet) × 3 (Set Size: 2, 4, and 6) mixed design. The between-subjects variable was External Medium and the within-subjects variable was Set Size. Within this larger design, the data was examined by practice condition (i.e., practice or experimental trials) and offloading condition (i.e., Choice or No Choice conditions).

Apparatus. The experiment was programmed using SuperLab 5.0 software and run on computers with Windows 10 as the operating system. The computers were Dell desktops with 24-in. monitors. Participants were seated 60 cm away from the computer and monitor. For the tablet condition, a Samsung Galaxy Tab (S2) and Apple iPad (1st Generation iPad Pro) were available for the participants to record the information as it was being presented. For the paper condition, a pen and an 8.5 × 11 piece of paper was made available to participants to record information. For both conditions, all recall responses for each trial were typed responses made on a standard QWERTY keyboard.

Stimuli. The stimuli were pairs of words that associated an academic subject with a task that students typically need to remember to do during the semester. The academic subjects were abbreviated to 3–4 letters (Math = MATH, English = ENG, History = HIST, Psychology = PSY, Biology = BIO) to make the length comparable. Similarly, the tasks that needed to be completed in the subject areas were also shortened to 4–5 letters (Paper Assignment = PAPER, Reading Assignment = READ, QUIZ, Group Work = GROUP, Exam = EXAM). Each stimulus was presented for 1 s. The words were presented in the center of the screen using Arial font at a font size of 36 points. All letters were capitalized to standardize the presentation of the stimuli. The stimuli were presented as word pairs (i.e., ENG PAPER) in Set Sizes (number of word pairs to recall) of 2, 4, and 6.

Procedure. Participants were randomly assigned to be in the Tablet or Paper condition (External Medium). In the tablet condition, participants choose between two brands of tablets (Apple or Android) before beginning the practice condition. For the Paper condition, participants were given a pen and piece of paper. When recording information, participants in the tablet condition had the freedom to use any of the capabilities provided by the tablet such as voice recording or typing. After reading the instructions for the memory task, participants began a practice condition.

The practice condition consisted of 10 trials that allowed participants to familiarize themselves with the task. Participants could record information onto their assigned External Medium while the stimuli were being presented. The order of trials in the practice condition was fixed, with two replicates at the Set Sizes of 2, 4, 6, 4, and 2. Figure 1 shows an example of a single trial with a Set Size of 2: participants were first shown a screen that indicated the Set Size for the trial, followed by the word pairs, and then a screen with "????," which was the cue to recall the items. To recall the items, the participants inputted the first letter of each subject and task needed to be recalled (e.g., PQ for PSY QUIZ, BP for BIO PAPER). The use of first letters of the word pair for recall was implemented to avoid inaccurate responses caused by typos. Participants were able to reference their recorded information on the External Medium during the recall phase and when typing the responses. For accuracy, the case (upper vs. lower) did not matter. After each trial, participants were given feedback about their accuracy.

After the practice condition, participants began the Choice experimental condition where they still had the option to offload information onto their assigned External Medium during the stimulus presentation. Participants were presented with 18 trials, with 3 repetitions of Set Sizes of 2, 4, and 6, presented in random order, in each of two blocks. Next, participants completed the No Choice experimental condition, where no offloading was permitted in order to establish baseline memory capacity and to

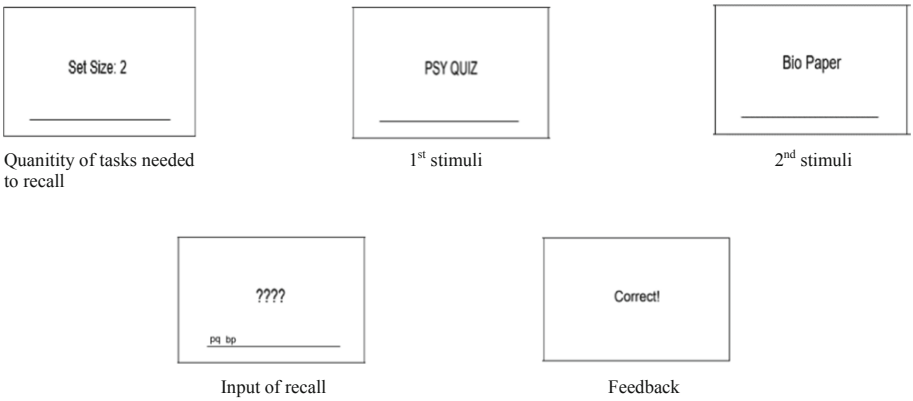

Fig. 1. Illustration of a single trial. Participants began the trial with the screen showing the Set Size (i.e., number of items to be remembered). Then, participants were shown the items and asked to recall the items when the screen displayed "????." After inputting their answers, participants were given feedback on their accuracy.

determine whether the offloading improved memory performance. Otherwise, the No Choice condition was similar to the Choice condition. After completing the No Choice condition, participants filled out two forms: a demographics questionnaire and a personality survey. The personality survey was administered for exploratory purposes and its findings will not be discussed in the present paper.

An experimenter was present in the room with each participant. The experimenter wrote down whether the participant recorded the information on the External Medium for each trial in the Practice and Choice conditions. The experimenter also ensured that participants did not record information in the No Choice condition.

2.2 Results

Practice Condition. Separate 2 (External Medium: Paper or Tablet) × 3 (Set Size: 2, 4, and 6) analyses of variance (ANOVAs) were performed on the mean proportion of offloaded trials (i.e., proportion of trials where participants recorded information) and mean accuracy (proportion of correctly recalled items). See Tables 1 and 2 for means.

For proportion of offloaded trials, there was a significant main effect of Set Size, $F(2, 40) = 29.21$, $MSE = .064$, $p < .001$, where proportion of offloaded trials increase as Set Size increases ($Ms = .22$, .55, and .80, for Set Size of 2, 4, and 6, respectively). No other effects were significant.

For accuracy, the main effect of Set Size was significant, $F(2, 40) = 9.19$, $MSE = .069$, $p = .001$. Accuracy was highest at Set Size of 2 ($M = .82$) and it decreased at Set Sizes of 4 and 6 ($Ms = .50$ and .56, respectively). No other effects were significant.

Experimental Choice Condition. Similar to the practice condition, separate, 2 (External Medium: Paper or Tablet) × 3 (Set Size: 2, 4, and 6) ANOVAs were conducted on mean proportion of offloaded trials and accuracy. See Tables 3 and 4 for means.

For proportion of offloaded trials, the main effect of Set Size was significant, $F(2, 40) = 33.04$, $MSE = .46$, $p < .001$. Similar to what was found in the practice condition, as Set Size increased, the portion of trials in which participants recorded information increased ($Ms = .29$, .72, and .91, for Set Size of 2, 4, and 6, respectively). The main effect of External Medium approached significance, $F(1, 20) = 3.93$, $MSE = .18$, $p = .061$, where participants showed a tendency to record more information when using paper ($M = .74$) than the tablet ($M = .54$). The interaction between Set Size and External Medium was not significant.

For accuracy, the main effect of Set Size was significant, $F(1, 40) = 9.32$, $MSE = .02$, $p < .001$. Accuracy was lower at Set Size of 4 ($M = .71$) than at Set Sizes of 2 ($M = .89$) and 6 ($M = .85$). The main effect of External Medium approached significance, $F(1, 20) = 3.42$, $MSE = .09$, $p = .079$, where participants showed a tendency to be more accurate when using paper ($M = .88$) than the tablet ($M = .75$). The interaction between Set Size and External Medium was not significant.

Experimental No Choice Condition. Participants in the No Choice condition did not have the option of recording information, but their accuracy was examined using a 2 (External Medium Group: Paper or Tablet) × 3 (Set Size: 2, 4, and 6) ANOVA. See Table 5 for means.

There was a significant main effect for Set Size, $F(2, 40) = 240.40$, $MSE = .016$, $p < .001$, where participants' accuracy decreased as Set Size increased ($Ms = .82$, .23, and .02, for Set Size of 2, 4, and 6, respectively). This main effect was qualified by a two-way interaction of Set Size and External Medium Group, $F(2, 40) = 4.07$, $MSE = .02$, $p = .025$, see Fig. 2. Test of simple effects were conducted at each Set Size. At Set Size of 2, participants assigned to the paper group ($M = .89$) were more accurate than those assigned to the tablet group ($M = .74$), $F(1, 20) = 8.07$, $MSE = .016$, $p = .01$. For Set Sizes of 4 and 6, the differences were not significant, $F < 1.0.7$

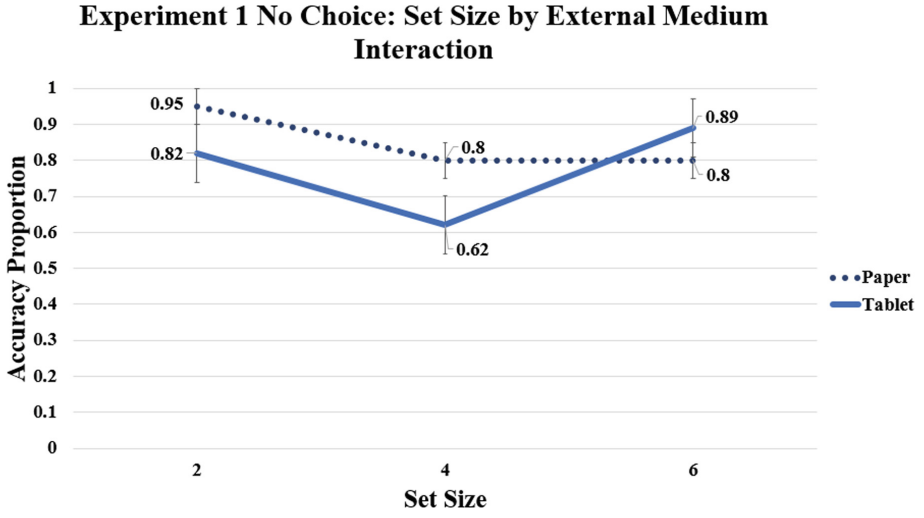

Fig. 2. An interaction between Set Size and External Medium occurring at Set Size 6.

Table 1. Proportion of trials offloaded in the practice condition by set size

Set Size		2		4		6		8	
		M	SE	M	SE	M	SE	M	SE
Exp. 1	Paper	.31	.04	.57	.03	.73	.03	-	-
	Tablet	.11	.02	.52	.03	.86	.03	-	-
Exp. 2	Paper	-	-	.75	.03	.95	.02	1.0	0
	Tablet	-	-	.39	.03	.68	.03	.91	.03

Note. Exp. = Experiment, M = Mean, SE = Standard Error

Table 2. Proportion of correct responses in the practice condition by set size

Set Size		2		4		6		8	
		M	SE	M	SE	M	SE	M	SE
Exp. 1	Paper	.82	.02	.61	.04	.61	.03	-	-
	Tablet	.82	.02	.38	.02	.50	.03	-	-
Exp. 2	Paper	-	-	.68	.02	.55	.03	.73	.04
	Tablet	-	-	.50	.03	.64	.03	.68	.04

Note. Exp. = Experiment, M = Mean, SE = Standard Error

Table 3. Proportion of trials offloaded in the experimental choice condition by set size

Set Size		2		4		6		8	
		M	SE	M	SE	M	SE	M	SE
Exp. 1	Paper	.41	.05	.85	.02	.97	.01	-	-
	Tablet	.17	.03	.59	.04	.85	.04	-	-
Exp. 2	Paper	-	-	.91	.02	.98	.01	.98	.01
	Tablet	-	-	.70	.04	.91	.03	.91	.03

Note. Exp. = Experiment, M = Mean, SE = Standard Error

Table 4. Proportion of correct responses in the experimental choice condition by set size

Set Size		2		4		6		8	
		M	SE	M	SE	M	SE	M	SE
Exp. 1	Paper	.95	.01	.80	.02	.89	.02	-	-
	Tablet	.82	.01	.62	.03	.80	.03	-	-
Exp. 2	Paper	-	-	.92	.01	.92	.01	.89	.01
	Tablet	-	-	.76	.02	.77	.03	.68	.03

Note. Exp. = Experiment, M = Mean, SE = Standard Error

Table 5. Proportion of correct responses in experimental no choice condition by set size

Set Size		2		4		6		8	
		M	SE	M	SE	M	SE	M	SE
Exp. 1	Paper	.89	.01	.20	.02	.03	.01	-	-
	Tablet	.74	.01	.26	.02	.02	.01	-	-
Exp. 2	Paper	-	-	.17	.02	.00	.00	.00	.00
	Tablet	-	-	.23	.02	.02	.01	.00	.00

Note. Exp. = Experiment, M = Mean, SE = Standard Error

2.3 Discussion

Participants engaged in cognitive offloading to maintain accuracy on the short-term memory tasks used in the present study. When the Set Size was 2, participants only recorded information during the stimulus presentation for 29% of the trials. At Set Size 4, however, offloading behavior increased to 72% of trials. At the Set Size of 6, participants recorded the stimuli on 91% of the trials. Comparing performance on the Choice versus No Choice condition, the cognitive offloading behavior resulted in increases in accuracy of 7%, 48%, and 83% at Set Sizes of 2, 4, and 6, respectively. The increase in accuracy for the different Set Sizes match the participants' cognitive offloading behavior: as cognitive offloading behaviors increased, accuracy increased. Because participants recorded the most information when the Set Size was 6, the largest benefit in performance was evident at this Set Size.

Participants tended to offload more when the External Medium was paper rather than a tablet, but this difference was not significant. Participants also showed a tendency to be more accurate in the paper condition than in the tablet condition. In the No Choice condition, participants in the paper condition had significantly higher accuracy than those in the tablet condition only when the Set Size was 2. Thus, the results of Experiment 1 only showed trends for a preference and slight benefit of paper as an offloading medium over the tablet. It is possible that the Set Sizes used in the Experiment 1, being 2, 4, and 6-word pairs, were not high enough to motivate users to use the tablet features for recording information. Therefore, we increased the Set Size by one level in Experiment 2 to examine whether making the task more difficult would motivate users to change their offloading behaviors.

3 Experiment 2

Experiment 2 was similar to Experiment 1, except that the memory task was made more difficult by using Set Sizes of 4, 6, and 8-word pairs.

3.1 Methods

A total of twenty two students were recruited from the same subject pool as in Experiment 1 (Females: 17; Males: 5; Mean Age: 18.36 years; Range: 18–22 years).

The apparatus, stimuli, and procedures used in Experiment 2 were identical to those used in Experiment 1, with the only difference being that three Set Sizes used were 4, 6, and 8, instead of 2, 4, and 6.

3.2 Results

The data from Experiment 2, were analyzed in the same manner as in Experiment 1.

Practice Condition. Similar to Experiment 1, separate 2 (External Medium: Paper or Tablet) × 3 (Set Size: 4, 6, and 8) ANOVAs were performed on the mean proportion of offloaded trials and accuracy, see Tables 1 and 2 for means.

For proportion of offloaded trials, the main effect of Set Size was significant, $F(2, 40) = 22.93$, $MSE = .04$, $p < .001$, where proportion of offloaded trials increased as Set Size increased ($Ms = .57$, .82, and .96, for Set Size of 2, 4, and 6, respectively). The main effect of External Medium was also significant, $F(1, 20) = 8.27$, $MSE = .12$, $p = .009$, where participants in the paper group ($M = .90$) offloaded more information than participants in the tablet group ($M = .66$). The interaction between Set Size and the External Medium approached significance, $F(2, 40) = 2.88$, $MSE = .04$, $p = .068$, see Fig. 3. For all Set Sizes, participants in the paper condition offloaded more information than participants in the tablet condition, with the difference being largest at Set Size of 4 ($MD = .36$), intermediate at Set Size of 6 ($MD = .27$), and smallest at Set Size of 8 ($MD = .09$).

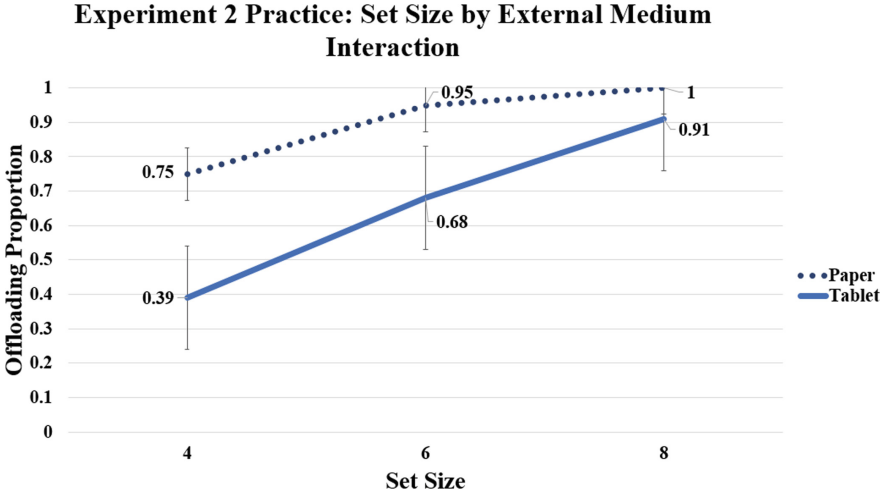

Fig. 3. For accuracy, there were no significant main effects or interactions.

Experimental Choice Condition. For the choice trials, mean proportion of trials offloaded and accuracy were analyzed using separate 2 (External Medium: Paper or Tablet) × 3 (Set Size: 4, 6, and 8) × 2 (Block: First and Second) ANOVAs, see Tables 3 and 4 for means.

For proportion of offloaded trials, the main effect of Set Size was significant, $F(2, 40) = 5.77$, $MSE = .03$, $p = .006$, where participants offloaded more trials when the Set Size was 6 and 8 ($Ms = .95$) than when it was 4 ($M = .80$). No other effects were significant.

For accuracy, only the main effect of External Medium, $F(1, 20) = 6.52$, $p = .019$, was significant. Participants were more accurate when offloading on paper ($M = .91$) than on a tablet ($M = .74$).

No Choice Experimental Trials. Accuracy scores were submitted to a 2 (External Medium Group: Paper or Tablet) × 3 (Set Size: 4, 6, and 8) ANOVA. There was a significant main effect of Set Size, $F(2, 40) = 27.13$, $MSE = .01$, $p < .001$, where accuracy decreased as Set Size increased, $Ms = .20$, .01, and .00, for Set Size of 4, 6, and 8, respectively). No other effects were significant.

3.3 Discussion

Increasing the Set Size by one level in Experiment 2 lead participants to record information on about 26% more trials compared to Experiment 1. Consequently, increasing Set Size motivated users to engage in more cognitive offloading. Additionally, participants in the present experiment were 76% more accurate in the Choice condition than in the No Choice condition. Thus, participants were using cognitive offloading as a strategy to improve their performance.

In the practice condition, participants assigned to the paper condition offloaded more information than participants assigned to the tablet condition, especially for the smaller Set Sizes. In the Choice experimental condition, participants were also more accurate when using paper to record information compared to using a tablet. Thus, similar to Experiment 1, participants preferred to use paper as the External Medium for offloading information, even though the tablet offers more features (e.g., voice recording) that could be used to effectively and efficiently record information. This may be attributed to the concept of "paper persistence," where individuals continue to use paper instead of technology due to paper's efficiency and ease of use, as well as a lack of knowledge or experience with the technology provided to them [11].

4 Conclusion

Overall, participants engaged in more cognitive offloading as task difficulty increased, which led to higher recall accuracy for more difficult trials in both Experiments 1 and 2. Thus, participants are able to effectively change their cognitive offloading behavior to adapt to task demands: offload information when the amount of items that need to be recalled exceeds short-term memory capacity. Participants also tended to engage in more cognitive offloading when assigned to the paper group compared to the tablet group. This preference for paper may be a result of its familiarity to users and quicker speed in recording information.

5 Limitations and Future Directions

This study consisted of several limitations. First, the level of knowledge and experience participants had with the tablet used during the experiment was not measured. It may be the case that the participants sampled do not use tablets for taking notes or setting reminders, which means that this aspect of the technology was novel to them. As a result, the participants were not able to take advantage of all the features of the tablet that could have led to more efficient recording of information and more accurate recall. Second, the sample size was small in both experiments, which resulted in low power for detecting group differences. Finally, the sample consisted of Introductory Psychology students, which limits the generalization of the research findings to other groups. Future studies should consider examining the use of the participants' personal mobile devices to increase familiarity of the device. In addition, larger sample sizes and more diverse user groups should be included in the sample.

Acknowledgements. We thank the students of the Center for Usability in Design and Accessibility for assistance with conducting this study. The CSULB McNair Scholar Program supported Hailey in this study.

References

1. Risko, E.F., Dunn, T.L.: Storing information in-the-world: metacognition and cognitive offloading in a short–term memory task. Conscious. Cogn. **36**(C), 61–74 (2015)
2. Miller, G., Kintsch, W.: The magical number seven, plus or minus two: some limits on our capacity for processing information. Psychol. Rev. **101**(2), 343–352 (1994)
3. Risko, E.F., Gilbert, S.J.: Cognitive offloading. Trends Cogn. Sci. **20**(9), 676–688 (2016)
4. Pew Research Center: Mobile Fact Sheet (2018). http://www.pewinternet.org/fact-sheet/mobile/. Accessed 25 January 2019
5. Smith, A., Fox, S.: U.S. Smartphone Use in 2015. Pew Research Center, Pew Internet & Technology Project site, 1 April 2015. http://www.pewinternet.org/2015/04/01/us-smartphone-use-in-2015/
6. Mueller, P., Oppenheimer, D.: The pen is mightier than the keyboard: advantages of longhand over laptop note taking. Psychol. Sci. **25**(6), 1159–1168 (2014)
7. Craik, F.M.I., Lockhart, R.S.: Levels of processing: a framework for memory research. J. Verbal Learn. Verbal Behav. **11**(6), 671–684 (1972)
8. Bui, D.C., Myerson, J., Hale, S.: Note-taking with computers: exploring alternative strategies for improved recall. J. Educ. Psychol. **105**(2), 299–309 (2013)
9. Mangen, A., Anda, L.G., Oxborough, G.H., Bronnick, K.: Handwriting versus keyboard writing: effect on word recall. J. Writ. Res. **7**(2), 227–247 (2015)
10. Baddeley, A.D., Thomson, N., Buchanan, M.: Word length and the structure of short-term memory. J. Verbal Learn. Verbal Behav. **14**(6), 575–589 (1975)
11. Saleem, J., Russ, A., Neddo, A., Blades, P., Doebbeling, B., Foresman, B.: Paper persistence, workarounds, and communication breakdowns in computerized consultation management. Int. J. Med. Inform. **80**(7), 466–479 (2011)