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The Effect of Note Taking Media and Preference on the Cognitive Processes Involved in Learning

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Abstract

This study seeks to evaluate how student information retention and comprehension can be influenced by their preferred note taking medium. One-hundred and nine college students watched lectures and took notes with an assigned medium: longhand or computer. Prior to watching the lectures, participants self-reported their preferred note taking medium. These lectures were pre-recorded and featured PowerPoint presentations containing information relating to the lecture. After the lectures, students were able to review their notes briefly before they engaged in activities unrelated to the lecture. They then took two tests based on the lecture material and completed a questionnaire further inquiring about their note taking tendencies. Tests contained two types of questions: conceptual and specific. A main effect of question type was found, with both computer and longhand note takers performing better on specific questions. Further, computer-preferred note takers who were forced to take notes by hand performed worst overall on the tests. Regardless of preference and question type, computer and longhand users performed equally well overall, and the interaction of medium and question type on test performance was not significant. For transcription tendencies, computer note takers generated more words and more 3-word verbatim sequences than longhand note takers. For note taking tendencies, the use of computer notes somewhat positively correlated with the use of no notes. The results of this study help to further understand how students' preferred note taking medium can influence performance on subsequent tests.

Keywords: Note taking, educational technology, medium preference, retention

The Effect of Note Taking Media and Preference on the Cognitive Processes Involved in Learning

Information technology has enabled humans to find information faster and more efficiently than ever before. Predictably, this has found its way into the classroom environment. Implementation of technology in the classroom is a rapidly growing trend across competitive educational societies. These technologies, however, have their advantages and their limits.

Current studies have focused on understanding how retention is affected by note taking strategies and media, as well as how classroom technologies influence retention. There are advantages and disadvantages of integrating technology into note taking and learning mechanisms. Advantages include students reporting increased organization and better communication, whereas disadvantages include distractions and shallower processing. The advancements, however, do not necessarily lead to increased performance. Oftentimes, they are distractors that inhibit attention, and thus can be detrimental to the educational process (Aagaard, 2015). Evaluating the method or strategy that an individual utilizes to take notes is seen as critical to the success of note taking.

A study by Kiewra et al. (1991), sought to investigate the functions of note taking methods as well as techniques. They identified three different functions in the note taking process: encoding (involves taking notes but not reviewing them), encoding plus storage (taking notes and reviewing them), and external storage (reviewing a peer's notes). In measures of recall, encoding plus storage was the superior method for recall performance. Additionally, those who used encoding plus storage and external storage note taking functions performed better on a performance test than the encoding group. These findings suggest that having a dedicated study period to review notes (even if you are using a peer's notes) will lead to higher performance than just taking notes without studying. Most importantly, taking notes in conjunction with having a review period is the most effective retention strategy.

Additionally, in the Kiewra et al. (1991) study, three note taking techniques were explored. These techniques were conventional note taking, linear note taking (listing topics in an outline and taking notes in the spaces between these topics), and matrix note taking (writing notes in organized tables). The matrix and linear methods were then compared to the conventional note taking process. The Kiewra et al. (1991) investigation revealed that these more structured formats allowed for the generation of significantly more ideas than the conventional note taking process. Furthermore, using the matrix technique resulted in greater recall than the other note taking techniques. Overall, this research reinforces the popular notion that note-taking in conjunction with dedicated studying is the superior way to perform well on tests. Further success can be achieved by taking notes in the linear or matrix format that involves a more structured approach, and straying away from the conventional method.

Di Vesta and Gray (1972) concluded that a student's activities during lecture can directly influence test results. In this study, students listened to a five-minute lecture, engaged in a five-minute interval period, and followed this with a three-minute testing period. Students who engaged in note taking during the lecture period performed better than those who did not take notes. Interestingly, they found that regardless of whether or not the student took notes, engaging in a rehearsal exercise during the interval period resulted in better test performance in the testing period. However, not all students used the interval period to rehearse what they had just learned. Those who took notes but did not use the interval period to rehearse material scored worse on the test than note takers who used the period to review. Lastly, the researchers also concluded that when a student engaged in note taking, rehearsal of material, and testing, they were able to recall more key ideas than students who engaged only in some or none of these activities (De Vesta & Gray, 1972).

The results of Di Vesta and Gray's (1972) study reveal advantageous strategies in the learning environment. Students who engage with the material frequently will perform better on tests and are able to retain more information overall. This evidence is supported by the findings of the Fisher and Harris (1973) study, which found that note takers retained more information than non-note takers when a review period is provided.

Quality of generated notes can also influence retention. In the Fisher and Harris (1973) study, researchers measured the quality of notes as the number of concepts that were presented in the lecture that the students recorded in their notes. Those who took notes of high quality performed better on free recall tests than did those who took notes of lesser quality. Additionally, those who did not take notes during lecture, but were able to review the lecture's high-quality notes, performed better on a traditional quiz than those with lower-quality notes. This finding suggests that the quality of the notes that are being taken is a critical contributor to the retention of information. This finding is further supported by Slotte and Lonka (1999). This study revealed that participants who took higher-quality notes – that is, those who elected to summarize lecture content in their own words, had higher test scores than those who took notes verbatim. Given studies by Fisher and Harris (1973) and Slotte and Lonka (1999), the importance of note quality is apparent. Doing more to interact with the lecture material, rather than simply transcribing notes verbatim, promotes increased retention and leads to better test performance.

In a recent study, Mueller and Oppenheimer (2014) looked to measure how retention, test performance, and information processing are influenced by the note taking medium. These researchers were able to identify several important conclusions regarding the advantages of longhand note taking and the disadvantages of computer note taking. In their first experiment, participants took notes during a lecture either using the traditional method (pen and paper) or on a provided computer. Test results revealed that longhand note takers performed better on conceptual-based test questions, despite transcribing significantly fewer words in their notes. They concluded that longhand note takers tended to undergo deeper processing when taking notes so, despite having written fewer words on the page, they successfully remembered more of what they had heard during the lecture. In their second experiment, Mueller and Oppenheimer (2014) warned laptop note takers about their media's detrimental habit of transcribing notes. Even when they were given this recommendation, laptop note takers still wrote significantly more words than longhand note takers. They were also outperformed by longhand note takers on conceptual-based quiz questions, replicating results from the first experiment. It is important to note that in both experiments, there was no significant difference in test performance on factual-based questions between longhand and computer note takers.

Additionally, in a study by Bui, Myerson, and Hale (2013), researchers explored the relationship between working memory abilities and note taking strategies. Much as in Mueller and Oppenheimer's (2014) study, these researchers were aware of computer note takers' tendency to transcribe the words said in a lecture rather than taking the time to carefully understand the information and process it. Researchers gave two groups of computer note takers different instructions. The first group was told to transcribe as many words as possible while the second group was told to try to take organized, consolidated notes. On a test given immediately after the lecture, those who tried to transcribe the lecture performed better. When two groups of longhand note takers were given the same instruction, both groups performed equally well and did not have significant differences in what was transcribed despite the varying instruction (probably due to physical limitations). However, when the test was not given immediately after transcription, those who took organized notes (either computer or longhand) performed better than those who transcribed notes. Interestingly, the opposite interaction occurred when participants were able to study their notes prior to taking the delayed test (Bui et al., 2013).

Both Bui et al. (2013) and Mueller and Oppenheimer (2014) conclude that simple transcription will hinder performance on a delayed test, as this note taking method leads to shallower processing and decreased retention. However, these studies produce conflicting results. Note takers in Mueller and Oppenheimer's study who transcribed notes performed *worse* than those who did not transcribe. In contrast, note takers in Bui et al.'s study who transcribed notes performed *better* than those who did not transcribe. These conflicting results may be due to the fact that Bui et al. provided slightly different instructions to one note taking group than Mueller and Oppenheimer did. This discrepancy demands further investigation into the effects on performance of transcribing lecture information.

After considering the significant evidence supporting the superiority of taking organized notes by hand as a way to retain lecture information, Kay and Lauricella (2011) sought to identify the reasons why many students insist on using laptops to take notes in lectures. In this experiment, students completed surveys involving laptop use, behaviors, and attitudes. Interestingly, researchers found that over 70% of students thought that laptops were important with respect to their academic success. In regard to note taking, students reported that note taking on a laptop occupied 50 to 100% of their time. Students additionally reported that note taking was the largest benefit of having a computer in the classroom, and that having a laptop in class enabled the accessing of online resources and lecture slides. This finding sparked great discussion considering the results from the Mueller and Oppenheimer (2014) and the Bui et al. (2013) studies. It is clear that taking longhand notes is superior for retention, but many students assume that despite the drawbacks that laptop use may hold, there are more academic benefits than costs (Kay & Lauricella, 2011).

The present study seeks to further analyze the factors involving information retention based on preference. While much of the literature examines performance based on note taking medium, strategies, and test intervals, no known studies have considered note taking preference of the subject. The present study seeks to consider the following questions: Does the individual's preference for note taking medium have the potential to override the retention benefits of longhand note taking? and due to the conflicting data involving review periods, will the implementation of a dedicated review period in the present study nullify the immediate retention benefits for the longhand note taking method? In addition to these questions, the present study also seeks to investigate how the participants' preferred medium for note taking will influence performance. If individuals with a habit of taking notes using a certain medium are forced to take notes using the opposite medium, will their performance suffer? This question has yet to be investigated, especially when considering the many advantages possessed by longhand note takers as discussed above.

Method

Participants. A total of 109 college students, age 18 and older, both men and women, were recruited through the University of Colorado undergraduate subject pool. Participants were enrolled in an introductory psychology course and participated for partial course credit. Four participants were excluded for (2) falling asleep, (1) being a non-native English speaker, and (1) showing signs of cognitive impairment. Thus, the main analyses were conducted on 105 participants.

Ethics, consent, and permissions. The use of human subjects was approved by the University of Colorado Institutional Review Board, Protocol Number 16-0053.

Design. A 2 x 2 x 2 mixed factorial design was used in the study. There were two between-subjects variables: note taking medium used in experiment (long hand, computer) and preference for note taking medium used in experiment (preferred, non-preferred). During the learning phase, subjects heard two lectures and took notes in a manner based on the assigned condition. There was one within-subject variable: the type of the questions on the tests (factual, conceptual). The posttest, which took place after a delay filled with interpolated tasks, consisted of two question types (factual, conceptual) in multiple-choice format. The dependent variable was the proportion correct on the test. The assignment of subjects to the various conditions was made by the experimenter based on the subject's note taking preference.

Materials. Two separate lectures were used from the Massachusetts Institute of

Technology (MIT) OpenCourseWare (OCW) database from the Introduction to Psychology course (Lecture A and Lecture B), taught by Professor John Gabrieli (2011). OCW material consists of MIT course content on various topics. Lecture A, which was on the topic of cognitive dissonance, was approximately 10 min long. Lecture B, whose topic was frontal lobe function, was approximately 18 min long. To check for preexisting knowledge of the material, a pretest, organized by Lalchandani (2016), was given to 80 undergraduate students, coming from the same subject pool as the current study. Results of this test determined that the amount of preexisting knowledge was at an acceptably low level (32.86%), $t(79) = 6.352$, $p < .001$. Both lectures were selected because they did not draw on information from previous lectures, meaning that prior knowledge was not required to learn the material, and because they fit the desired time criteria. The format of both lectures was an instructor's voice accompanied by PowerPoint presentation slides. The PowerPoints were presented to the participants via a digital projector with an onboard speaker system. The projector allowed participants to see the corresponding lecture slides from Professor Gabrieli's lecture, projected onto a screen at the front of the classroom. Transcripts generated of the lecturer's voice was used to assess verbatim note taking. The total lecture time was approximately 30 min, which is consistent with the Mueller and Oppenheimer (2014) study.

All participants were provided with either an Apple iMac computer running Microsoft Word (computer condition) or traditional pen and notebook paper (longhand condition) to take notes on the lectures. Once subjects provided their consent to participate, they were asked to answer the following question: "Please indicate your preferred note taking method: Longhand (or) Computer". Once students had indicated their preference, they were assigned to a note taking condition by the experimenter. Some participants were assigned their preferred note taking method (computer preferred, longhand preferred), but others were assigned to their non-preferred method (computer non-preferred, longhand non-preferred).

Upon the completion of both lectures, participants were given five min to review their notes, as was consistent with the Di Vesta and Gray (1972) study. After the review period, the notes were taken from the participants. The following 30 min consisted of the students completing various distractor tasks, during which their notes were unavailable to them.

Following the review and distractor periods, participants completed two tests (Tests A and B), which were written by Lakshmi Lalchandani (2016). The tests were reflective of the lecture material, and consisted of 12 questions each. Of the 24 questions, 12 were factually-driven questions, and the other 12 were conceptually-driven, adhering to guidelines from Butler (2010). These question types were equally distributed in each of the tests. The order in which the two tests were administered was fully counterbalanced within each between-subjects condition. The tests utilized a multiple-choice format with four answers to choose from. An example of a conceptual question is:

A person with lesions in the prefrontal cortex may have difficulty with mental flexibility and what?

a. Functional Fixedness
b. Ambiguity Error
c. Mental Filtering
d. Perseverative errors

An example of a factual question is:

What psychological aspect can be measured using sweat gland response?

a. Utilization behaviors

b. Psychopathy
c. Emotional reactivity
d. Lateral hypothalamic function

This question format which features varying question types served as an assessment tool to determine differences in the type of information stored as a result of the particular note-taking medium. Each test contained material from both lectures and were administered with pen and paper.

Of the 109 original participants, the final 44 were administered short-response questionnaires about their note taking tendencies. Different from the first dichotomous medium question, this questionnaire asked students to indicate how frequently they employed various note taking media. In short, the questions asked how frequently the participants took longhand notes, computer notes, and no notes in lecture.

Procedure. Participants completed the experiment in groups of 1-6. The classrooms in which the study took place were equipped with desks, iMac computers, and digital projectors. Each student sat at a desk with a computer, but the computer use was determined by the assigned condition. Those who were assigned to the computer condition simply took notes in Microsoft Word on the computer in front of them. Those assigned to take notes by hand were provided with a notebook and pen. Each desk had adequate space so those in the longhand conditions had ample room to take notes. All participants were instructed to take notes on the lecture material just as they would in a typical lecture environment, where they are expected to learn the material.

The lectures were projected onto a white projector screen that allowed for clear viewing of the PowerPoint slides. The slides displayed the corresponding material from the lecture. The lecture's audio was played through the projector's onboard sound system.

The sound was played at an adequate volume, with the researcher confirming that all participants could hear the sound loudly and clearly.

After both lectures had been played, participants were given a five min review period to study their notes. Following this period, the notes were collected and replaced with two distractor tasks: a series of computational math problems and geography crossword. This distractor period lasted approximately 30 min. Participants were instructed to work on one task first, and, halfway through the period (approximately 15 min) were told to switch to the other task. Following this 35 min interval, students were administered two multiple choice tests. Tests were distributed one at a time, and participants had to finish the first test and return it to the researcher before receiving the second. The tests were in the traditional pen and paper format, and the students did not have access to their notes or the lecture material. The order that the tests were administered was completely counterbalanced within each between-subjects condition. Following the completion of both tests, students were provided with a more specific questionnaire regarding their note taking preferences and tendencies. In a free-response format, students were asked to indicate, by percentage, how frequently they engaged in longhand note taking, computer note taking, and no note taking in their classes. This was the final activity in the experiment. The PowerPoint presentation viewing, study period, distractor period, testing period, and questionnaire period all occurred in the same room.

The number of correct responses on the tests was analyzed to measure performance, comprehension, and retention. Longhand notes were manually transcribed and compared with computer notes. The total number of words written was recorded and the amount of verbatim sequences copied from the lecturer were calculated using a program by Lalchandani (2016). These notes were analyzed to calculate the number of verbatim overlap sequences with the transcript from the lecturer. The amount of verbatim overlap was assessed as the number of identical 3-word sequences that note takers generated from lecture. Notes were also compared to the participants' reported preference. Questionnaire data were also analyzed for reported note taking tendencies. These measures served as dependent variables for content analysis.

Results

Regarding test performance, score, assigned medium, and preference were considered. For note analysis, words generated, 3-word verbatim sequences, assigned medium, and preference were considered. Posttest questionnaire data was also analyzed.

Test performance. Test performance was determined by the proportion of correct responses. A 2 x 2 x 2 mixed factorial analysis of variance (ANOVA) revealed several notable results. The interaction of medium and preference was marginally significant $F(1, 101) = 3.081$, $MSE = 0.026$, $p = .0822$. As seen in Figure 1, considering both note taking preference and actual medium used, those in the unpreferred longhand condition performed worse overall on the test. This finding specifically addresses the study's main hypothesis, which sought to explore if using an unpreferred medium for note taking would influence performance. As found previously, there was also a significant main effect of question type, $F(1, 101) = 24.385$, $MSE = 0.009$, $p < .0001$, with better performance on specific (.772) than conceptual (.692) questions.

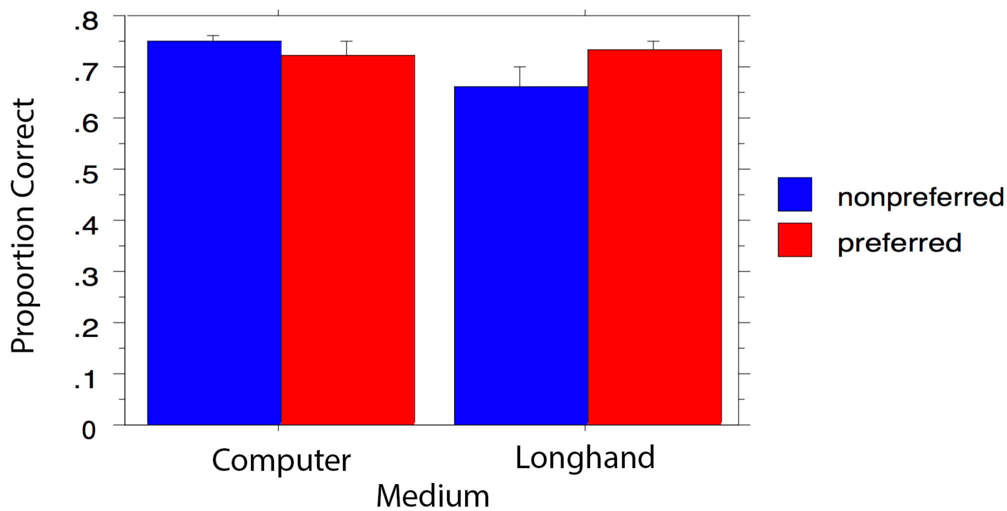

Figure 1. Computer-preferred note takers who were forced to take notes by hand performed marginally worst during testing.

Comparing these results to earlier work by Mueller and Oppenheimer (2014), the current study revealed no significant interaction of medium and question type, $F(1, 10)1 < 1$. The test advantage for conceptual questions with the longhand medium previously found by Mueller and Oppenheimer was not observed here. Additionally, regardless of preference, computer (.744) and longhand (.720) users performed equally well overall. The main effect of medium was not significant, $F(1, 101) = 1.749$, $MSE = 0.026$, $p = .1889$. There was also no overall difference in performance depending on whether note takers used the the preferred (.731) or unpreferred (.733) medium; the main effect of medium preference was not significant, $F(1, 101) < 1$.

Note analysis. As seen in Figure 2, computer note-takers generated more words than their longhand counterparts. The word count was determined by adding the amount of generated words together from both lectures. Here, a 2 x 2 factorial ANOVA was conducted that revealed a significant main effect of medium, $F(1, 101) = 27.303$, $MSE =$

12825.868, $p < .0001$. Neither the main effect of preference nor the interaction of preference and medium was significant, $F(1, 101) < 1$ in each case.

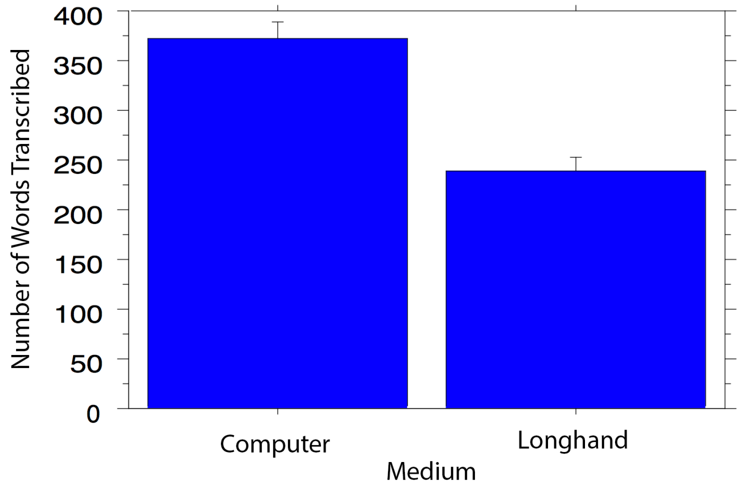

Figure 2. Those who used the computer to take notes generated significantly more words on average than their longhand equivalents.

The amount of verbatim overlap was analyzed by comparing the participants' generated notes against a transcript of the spoken words by the lecturer. Notes generated on the computer were compared to the transcript straight away, while notes that were generated by hand were re-transcribed after the experiment by the experimenter. The texts of all participants' notes were compared to the lecturer's transcript using a computer program that flagged sequence matches of 3-words. As predicted, those who took notes on the computer, regardless of preference, produced significantly more verbatim 3-word sequences than longhand note takers. The main effect of medium was significant, $F(1, 101) = 24.402$, $MSE = 451.987$, $p < .0001$. This result is shown in Figure 3.

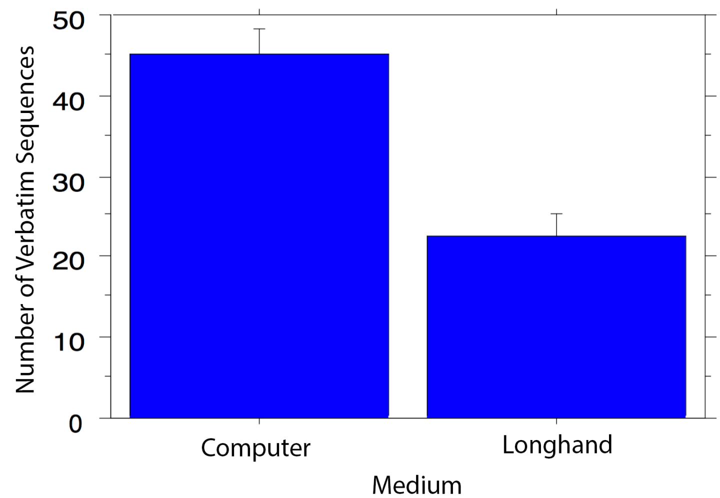

Figure 3. Computer note takers produced significantly more verbatim 3-word sequences than longhand note takers.

In terms of preference, those who took notes on the computer and preferred that medium did not generate significantly more verbatim 3-word sequences than the un-preferred group. Neither the main effect of preference, F (1, 101) = 1.289, MSE = 451.987, p = .2589, nor the interaction of preference and medium, F(1, 101) = 2.148, MSE = 451.987, p = .1459, was significant.

Medium usage questionnaires. Due to lacking representation for computer preferred note takers in this study, questionnaires were administered to participants (n = 44) about halfway through the experiment's duration. The goal of this survey was to determine the motivations behind participants' reported preference and the frequency which they used other media than their indicated preference. Correlational coefficients revealed that the use of computer notes somewhat positively (but not significantly) correlated with the use of no notes $r(42) = .149$, $p > .10$, whereas the use of longhand notes was somewhat negatively correlated with the use of no notes $r(42) = -.157$, $p > .10$. Thus, the <u>more</u> subjects reported using the computer the more they also reported taking no notes, whereas the less subjects reported using longhand the more they reported taking no notes. Additionally, those who initially indicated computer as their preference, later responded on the questionnaire that they use this medium 60% of the time they take notes on average. Those who indicated that they prefer longhand responded that they indeed use this medium 91% of the time that they take notes.

Discussion

Contrary to findings by Mueller and Oppenheimer (2014), there was no difference in test performance between longhand and computer note takers. Although there was a difference in performance based on question type, with better performance on the factual than on the conceptual questions, longhand and computer note takers performed equally well on both conceptual and factual questions. Despite flaws in sample sizes for computer preferred and longhand non-preferred groups, one might infer that the implementation of the study period assisted in having equal performance across the two medium groups. This boost in performance is supported by earlier studies (Di Vesta & Gray, 1972; Fisher & Harris, 1973) that have implemented a study period prior to testing. There was a marginally significant interaction of medium and preference, showing worst performance for the longhand medium when it was not preferred. However, it is unclear if this pattern would remain in a delayed test.

The significant results of generation support Mueller & Oppenheimer's (2014) findings that computer note takers generate more notes than longhand note takers. Interestingly, the present study revealed that regardless of preference, computer note takers generated more words. This more specific measure reveals that even if a student prefers a particular medium for taking notes, the medium that they are forced to use will indicate the amount of notes that they take. Even those who prefer taking notes on the computer write significantly fewer words when they take notes by hand. The same result holds true when analyzing verbatim 3-word sequences. Regardless of preference, computer note takers produce significantly more verbatim sequences than longhand note takers do. Any habits associated with preference seem to be nullified, and participants' note taking tendencies align with the medium of which they are assigned.

These tendencies raise questions about the functions of encoding and processing. Although it can be argued that longhand note takers write less because of physical limitations, they may also write fewer words because they engage in deeper processing and encoding functions. However, as mentioned above, these advantages may be nullified on an immediate test when a review period is provided. Again, it would be ideal to incorporate a delayed test to assess the encoding and processing advantages traditionally possessed by longhand note takers (Mueller & Oppenheimer, 2014), and how these advantages could be influenced by note taking preferences.

Based on the data in Figure 4, although not significant (p = .1459), an interesting interaction might be developing involving the amount of 3-word verbatim sequences in the computer condition. Specifically, it appears as that preference increases the difference in verbatim overlap between the computer and longhand conditions. Given that the computer preferred note taking condition was small in number (n = 10), there is reason to believe that this effect may grow with a larger sample. An investigation that seeks to identify how the number of 3-word verbatim sequences varies between computer preferred and non-preferred may prove interesting.

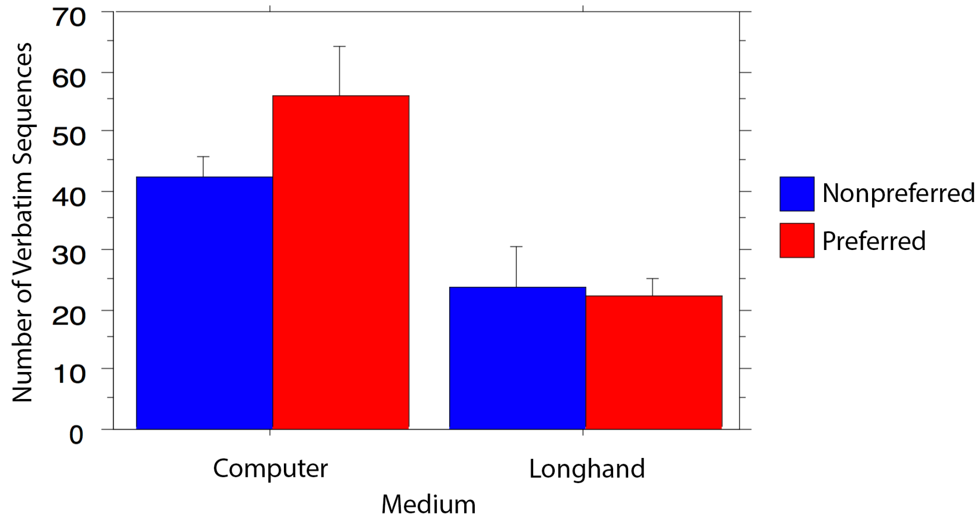

Figure 4. While not statistically significant, an interesting interaction has the possibility to occur involving the amount of verbatim 3-word sequences generated by computer preferred and non-preferred participants.

Correlational analyses revealed that participants who declared the computer as their medium used also reported that they were more likely to not take notes in class than their longhand counterparts. This finding perhaps supports the literature about multitasking and distractions associated with laptop use in the classroom. Studies by Fried (2008) and Kraushaar and Novak (2010) both concluded that laptops serve as distractions to the user and promoted multitasking. These behaviors lead to lower course averages. Because these participants prefer to use their computer in the classroom, perhaps they are more prone to engaging in non-note taking behaviors, resulting in more reports of taking no notes than their longhand equivalents.

In conclusion, the current study includes thought-provoking findings that are admittedly limited by disproportionate group sizes. The study period in this experiment might have nullified any differences in performance on a posttest. It is unclear if the retention and comprehension advantages of longhand note takers are present in a delayed test when preference is considered. All participants performed worse on conceptual than on factual questions, despite differences in their note taking medium and generation of notes. Computer note takers produced more words on average than longhand note takers and more verbatim sequences. In the future, a larger sample of computer preferred participants would produce a clearer result demonstrating if computer preferred participants produce more 3-word verbatim sequences than computer non-preferred participants. Self-reports from computer note takers indicate that they may be more likely to engage in no-note taking behaviors during lecture than their longhand counterparts.

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