VARIOUS METHODS OF NOTE-TAKING AND HOW THEY COMPARE IN TERMS OF INFORMATION RETENTION

by

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The use of electronic devices to take classroom notes rather than writing them using pencil and paper is increasingly common. Previous studies have attempted to establish a connection between the use of devices in the classroom and decreased classroom performance, hindered memory, and poor attention. These studies have mainly examined students' ability to multitask and the effect of distraction when laptops are used for note-taking. The intent of this study was to examine how varying methods of note-taking compare by measuring how much information is retained immediately after a simulated lecture and a week after first exposure. To add to previous findings, this research focused on how context of note-taking and test-taking interact to influence information retention as well. Lastly, individual differences among students, such as their Need for Cognition, Sensation Seeking, and Optimal Level of Arousal impact test performance, based on note-taking method. Analyses conducted as part of this study found that there are no significant differences in how well students retain information based on note-taking method, match/mismatch in context between note-taking and test-taking, or various individual differences. The only significant finding of the current research is that taking notes, regardless of method, leads to better information retention than not taking notes at all.

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INFORMATION RETENTION

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CHAPTER 1: INTRODUCTION & LITERATURE REVIEW

The ways that students are learning in classroom settings are quickly evolving in response to an influx of new technologies (Abachi & Muhammad, 2014). In fact, even kindergarten students are now being expected to utilize and understand technological methods in order to accomplish classroom tasks (Sackes, Trundle, & Bell, 2011). One of the biggest changes in how technology is being used in the classroom, and one that has been under debate in recent years, is how students use technology to take notes (Barrett, Swan, Mamikonian, Ghajoyan, Kramarova, & Youmans, 2014). Before the mid 2000's, the vast majority of students only had one option when they needed to take notes for class, and that was to write information with a writing utensil on a piece of paper (Brown, 2001). Now, the "pen and paper of our time" can come in a variety of devices, as students of all ages have access to a personal laptop computer, tablet, or cell phone (Warlick, 2006, p. 1). Reports show that over 50% of college-aged students use a personal laptop in class during at least one out of every three class meetings (Zhu, Kaplan, Dershimer, & Bergom, 2011).

The shift towards these high-tech note-taking methods is a controversial topic for students in all school settings (Fried, 2008). School system superintendents and administrators who write grants are supporting the idea of spending money to ensure that every child is issued a personal laptop or tablet for school purposes (Zucker & Light, 2009). Teachers and professors are concerned that the students who use these devices during class may not be encoding the lecture-based information in a way to sufficiently retain the concepts of their lessons, thus not learning as much from the presentation (Mueller & Oppenheimer, 2014). The reality of this newfound controversy is that students are increasingly choosing to type their notes instead of writing them by hand (Dahlstrom & Bichsel, 2014).

Students report that using their devices during class motivates them to be actively involved in the lecture, saves time transcribing the notes, and is easier when compared to the traditional pen-and-paper method of note taking (Trimmel & Bachmann, 2004). Students are likely biased in favor of electronic note-taking, as it allows them to access a variety of pleasurable and entertaining content and non-class related material (Fried, 2008). Although this may make class time more enjoyable, the greater level of enjoyment could come at the expense of learning, and create bias for some students' opinions on the matter. For this reason, some professors feel as though laptops and tablets do not belong in their lecture halls, as non-class, computer-based opportunities are too distracting for students and because electronic note-taking may not be the best means to retain the information being taught (Hembrooke & Gay, 2003). It is not surprising that previous literature is supportive of limiting the amount of distractions in a classroom setting in order to improve class performance. For example, research has been conducted to examine the effects of multi-tasking and how it negatively impacts performance (Rubinstein, Meyer, & Evans, 2001). This research showed that students who multi-task do not perfrom as well as student who have one primary goal in mind during class. It is also not surprising that most of the research in this area focuses on the distractibility factor of using a personal computer during class (Trimmel & Bachmann, 2004).

Computer-Based Distractions

Distraction, regardless of its source or duration, happens when students stop their current learning activity and shift their focus to attend to a different task (Mark, Gonzalez, & Harris, 2005). Distraction is also more likely to take place when individuals are presented with favorable tasks in the presence of non-favorable tasks (Taneja, Fiore, & Fischer, 2015). Students who bring their devices to class are now drawn to things such as social media, online shopping, video

games, and email, especially when given these options over listening to a lecture that is not actively engaging (Gupta & Irwin, 2016). With increased access to the internet with personal computers and tablets, there has been an increase in the percentage of students who multi-task during lectures, studying, and while working. One study suggests that students who bring a device to class multi-task approximately 42% of their total class time (Kraushaar, & Novak, 2010). During the documented multi-tasking of this study, it was documented that students were checking social networks (i.e. Facebook, Twitter, Instagram), emailing people for various purposes (both class related and non-class related), completing online work for other classes, and browsing the internet. The commonality in all of these distractors is that they require an electronic device to perform the task. Nonetheless, most college students justify bringing their devices to class by saying that they take notes using them (Taneja, Fiore, & Fischer, 2015).

A majority of the extant research that argues against laptop use in the classroom is based on Broadbent's theory of selective attention, which posits that the availability of unrelated content from the laptop is too distracting for the average student to ignore (Hembrooke & Gay, 2003). Students who use an internet-connected device to take notes may be more likely to multitask, or spend class time performing the preferred online activities previously discussed (Barak, Lipson, & Lerman, 2006; Driver, 2002). As expected, students who multitask using a computer in class, and even students in close proximity to multi-taskers, have lower test scores when compared to peers who attend only to the lecture (Sana, Weston, & Cepeda, 2013). Students who use a computer or tablet in class also have a higher likelihood of divided attention during lecture, which leads to lower levels of retention and comprehension when compared to students who are not exposed to such distractions (Junco & Cotten, 2012). In a study that examined how college students prepare for an upcoming test and used survey data to control for

the amount of distracting medias present during the studying process, researchers found that limiting the number of possible distractions during preparation relates to better performance in the test in the classroom (Patterson, 2017). In the study, the possible distractions included watching television, attending to a cell phone for calls or text messages, and using a computer or tablet for non-academic tasks. The median number of distracting technologies based on the self-report data was 4.88. The students who performed better on the test incorporated fewer than 4 distracting mediums into their study time, whereas students who had 5 or more mediums of distraction scored below the class average.

Although the idea that computer-based distractions negatively impact learning and information retention is grounded in theory and in practice, it could be argued that distraction is not confined strictly to individuals who take notes with computers. For example, how is browsing the internet any different from doodling in the margins of a notepad? Distractions will play a role in any classroom setting, regardless of whether or not the student has access to a web-enable device. It is difficult to determine the degree to which class performance or information retention is negatively impacted by web-based distraction alone since there are so many other ways in which a student's attention can be diverted away from the lecture (Murray, 2011).

Individual Differences

Individual differences among students play a role in determining how well they retain information and their preferences for note taking. Students can differ in how they approach learning and how much they are motivated for new information input (Kühl, Eitel, Damnik, & Körndle, 2014). Some students may perform better in busy environments whereas other students need a quiet atmosphere (Therriault, Redifer, Lee, & Wang, 2015). One particular individual difference that plays a role in this phenomenon is Need for Cognition. Need for Cognition

(NCog) is a measure of how likely a person is to engage in mental processes and their overall enjoyment of thinking about new material and situations (Cacioppo, Petty, Feinstein, & Jarvis, 1996). Need for Cognition can best be characterized as a person's enjoyment of mental stimulation, desire for understanding new concepts, and their commitment of towards expanding their own knowledge (Lord & Putrevu, 2006). The construct of NCog was developed by Cacioppo and Petty in 1984 to explore individual differences related to thinking, and to quantify these differences on a continuum from low to high levels in future studies by using their scale (Cacioppo & Petty, 1982). Need for Cognition has also been shown in previous studies to positively correlate with individuals' verbal ability (Bors, Vigneau, & Lalande, 2006), performance on college entrance exams (Jarvis & Petty, 1996), and crystallized knowledge (Tidwell, Sadowski, , & Pate, 2000).

Individuals differ in their needs for arousal provided by their environment (Nielson & Arentsen, 2012). Like the NCog continuum, individuals vary from low to high in terms of the amount of external stimulation that they need from their environment to maximize performance and comfort (Hebb, 1955). Even further, classic research has suggested that performance across a variety of tasks differs based on how the external environment impacts individuals' arousal levels, based on the Yerkes-Dodson Law (Yerkes & Dodson, 1908). Yerkes and Dodson discovered that there is an optimal level of arousal that leads to better performance on tasks, and that without meeting the optimal level of arousal, individuals have no reason to act or react. Once the level of optimal arousal is met, stress beyond this treshold seems to hinder performance. Some individuals have an elevated optimal arousal threshold that requires high levels of exposure to external stimuli for them to feel comfortable, whereas individuals on the lower end of the arousal spectrum need a calmer environment to be able to reach their full potential

(Greene, Bahri, & Soto, 2010). Level of optimal arousal has been assessed using the *Brief Sensation-Seeking Scale* (BSSS), whereas a section of the *Brief Mood Introspection Scales* (BMIS) has been used to measure current momentary arousal states (Hoyle, Stephenson, Palmgreen, Lorch, & Donohew, 2002; Mayer & Gaschke, 1988). Students who are rated higher in their need for arousal are likely to be unresponsive to lower levels of external stimuli, whereas students who are rated lower on the arousal scale will respond to minimal levels of external stimuli (Clapper, 1990). When examining personal differences among students scoring low and high on the arousal scale, it is speculated that students with higher ratings may feel more comfortable having the extra stimulation from a computer or tablet, compared to students with lower arousal thresholds. In that particular case, electronic devices should not have an adverse effect on students' attention to the lecture being presented.

Embodied Cognition

The theory of embodied cognition may be applicable to questions about the relationship between note-taking methods and information processing (Varela, Thompson, & Rosch, 1991). This theory proposes that processes such as memory and perception depend on more than just the brain. Sensorimotor capacities throughout our bodies have an impact on what we remember and how we learn about our environment (Wilson, 2002). This idea of embodied cognition can be used to better understand memory, even though studies that examine the performance effects of physically writing things are limited. One study in particular examined how movement and interaction with others affects the amount of recall of a particular play. The authors' motive was to examine how reenacting the play impacted memory, but they also had a writing condition, among three other conditions, in their experiment. As expected, participants in the reenactment condition had the greatest overall recall, suggesting that their embodiment of the play and its

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environment played a role in their memory of the details of the play. However, of the remaining conditions, the participants in the writing condition had the second highest amount of recall, which was only marginally different from that of the reenactment condition (Scott, Harris, & Rothe, 2001).

There are many different fine motor skills that are involved in writing: there is a specific grip to the writing utensil, dominant-hand control and movement, stabilizing effects from the non-dominant hand, and eye movement as a person follows what they write. Fine motor skills such as these contribute to how a student perceives what they write, and eventually how their cognitive development (Carlson, Rowe, & Curby, 2013). Although there are movements associated with typing as well, the movements for each letter are almost identical and are more difficult to distinguish between when compared to writing the letters. Based on the theory of embodied cognition, these specialized fine movements are likely to generate more meaningful connections with the subject matter of the notes taken, compared to the movements of simply typing the notes.

Furthermore, research has shown that when students write their notes, there is more freedom to personalize what is written (Mueller & Oppenheimer, 2014). This study further discusses how students can write all over the page and draw diagrams or pictures to better remember the content, which is also a completely different and unique movement when compared to typing. With the ability to make these unique movements with a writing utensil and a piece of paper, students have more opportunities to differentiate information that is attached to these movements. Since there is a higher degree of personalization while writing notes, students can tailor their notes so that they actually mean something to them, compared to students who type notes verbatim.

Context of learning

In regards to memory, similarities in one's environment and the contexts of learning have been proven to improve information retrieval (Smith & Vela, 2001). One study in particular compared word list retention levels where participants were taught word lists while scuba diving, and later given a recall test in either a similar underwater setting, or in a different on-land setting (Godden & Baddeley, 1975). In the study, when the contexts of learning and retrieval were the same, there was an increase in the percentage of words recalled compared to when the contexts were mismatched. This is could be applicable to classroom learning and note-taking if the methods of testing are in question. When online tests are being used in a classroom setting, students who incorporate computerized note-taking methods might have some advantage in information retrieval. Based on the findings from the context-dependent memory study, similarities in the learning process and the testing method are conducive for better test performance. The current study will incorporate a design that will allow the researchers to determine whether a mismatch in the note-taking and testing methods is detrimental to test performance.

There is minimal research that addresses and compares measures of information retention from individuals that write notes and individuals that type notes. Previous studies have either restricted students in how they transcribe notes by instructing them to record lecture information verbatim (Bui, Myerson, & Hale, 2013), or incorporate word lists to structure the layout of the notes (Lin & Bigenho, 2011). One limitation of these aforementioned studies is that students did not have the freedom to paraphrase their notes in either condition. Participants should have the freedom to take notes as they would in a real lecture setting instead of being instructed to produce verbatim notes, so that the results will be applicable to how students actually process the

information that they write or type. The purpose of this study is to test multiple hypotheses related to these construct.

Purpose of the Study & Hypotheses

The current study employed a 3 X 2, between-subjects design, where the variables in question were the method of note-taking (handwritten, typed, or no notes) and the method of testing (typed test or handwritten test). Consistent with the theory of embodied cognition and the current research available on the topic of note-taking, it is predicted that there will be a main effect of note-taking style on performance such that compared to participants who type notes, participants who write notes by hand will have a higher percentage of correctly answered questions when tested on the information presented. This prediction is will be referred to as the Note-Taking Method Hypothesis. Furthermore, based on the theory of context-dependent learning, it is predicted that participants who are tested in the same format in which they took notes will perform better than participants who complete the same test than in a format that does not match their note-taking condition. This predication will be referred to as the Contextual Dependence Hypothesis.

Consistent with the research covered in this literature review, individual differences such as varying levels of NCog, arousal levels, and sensation seeking are expected to interact with students' note-taking style to impact their performance. NCog is expected to act as a continuous moderator of the effect of note-taking format such that a significant effect will not be observed among participants who score higher on NCog whereas participants with lower NCog scores will tend to perform better in the in the hand-written notes conditions. This prediction will be referred to as the NCog Hypothesis. Sensation seeking, similarly to NCog, is also predicted to serve as a continuous moderator such that participants with a higher level of sensation seeking will tend to

perform better in the computerized notes conditions whereas participants who have lower levels of this trait will perform better when handwriting their notes. This will be referred to as the Sensation-Seeking Hypothesis.

The last prediction is that there will be an interaction between individuals' mood rating at the time of testing and level of sensation-seeking, such that individuals who exhibit a match in their arousal level and sensation-seeking behavior (i.e. high arousal level and high sensation-seeking rating) will perform better than individuals who do not have a match in these areas (i.e. high arousal level and low sensation-seeking rating). More specifically, the current work predicts that when students who have a high sensation-seeking score are experiencing high levels of arousal, they will demonstrate superior memory performance compared to student who have a mismatch between their arousal level and level of sensation-seeking. This prediction will be referred to as the Arousal Hypothesis.

CHAPTER 2: METHODS

Participants

A power analysis employing an expected effect size of $\eta^2=0.13$ (Barrett, Swan, Mamikonian, Ghajoyan, Kramarova, & Youmans, 2014) revealed that a total sample size of at least $n = 68$ would be required to achieve 80% power. Students who were enrolled in an Introduction to Psychology course (PSYC 1000) at East Carolina University during the 2015-2016 academic year were recruited to participate in this study. Students enrolled in PSYC 1000 at ECU are required to either participate in a specific number of research studies or to complete an alternative assignment (the majority choose to complete research studies). An online system advertises current studies to the students in PSYC 1000, so that they have access to multiple options and have a general understanding of the study expectations when choosing to participate in the research. Participants for this study were recruited via this online system. Inclusionary criteria were that they are proficient with the English language and physically able to observe a lecture-styled video and take notes accordingly.

The sample for this study included 79 students in all, but of those students only 72 participated in both sessions. In this sample, 90.1% of the participants were not of Hispanic/Latino ethnicity, and 9.9% of the population was Hispanic/Latino. Racially, the participants identified as follows: 75.3% white, 11.1% Black, 11.1% Asian, and 2.4% other races. The participants ranged from 18 to 26 years of age, with a mean age of 19.12 years (SD=1.76). The sample consisted of 61.7% women, 37.0% men, and 1.2% of the population chose "other" when asked about the gender in which they identify. The demographic makeup of this sample is similar to that of East Carolina University, and is therefore generalizable to the student population at the university (East Carolina University, 2016).

Measures

  Independent Variables. Multiple rating scales and demographic questions were combined into a single questionnaire to assess introspection, sensation seeking, and need for cognition. All of the individual measures that were used in this study have been widely used by other researchers and have been shown to have acceptable levels of internal consistency upon original publication (Mayer & Gaschke, 1988; Hoyle, Stephenson, Palmgreen, Lorch, & Donohew, 2002; Cacioppo & Petty, 1984).

  Brief Mood Introspection Scale **(BMIS).** The *Brief Mood Introspection Scale* (Mayer & Gaschke, 1988) assessed each participant's current level of arousal at the time of testing. The BMIS is frequently used to measure mood states in psychological studies. Participants indicated how closely sixteen varying adjectives (i.e. Lively, Nervous, Fed-up, Active) described their current mood on a four-point intensity scale which increases stepwise in the following order: Definitely Do Not Feel, Do Not Feel, Slightly Feel, Definitely Feel. The mood states examined for this study were the arousal–calm dimensions, since researchers have maintained that this mood state is the most-related to cognition (Mayer & Gaschke, 1988). In previous studies, this measure has also been shown to have favorable internal reliability, with Cronbach's α ratings ranging from −.76 to .83 (Preeshl, George, & Hicks, 2015). On this measure, low scores represent negative moods (minimum = 16) and high scores represent positive moods (maximum = 64).

  Brief Sensation Seeking Scale **(BSSS).** Along with the BMIS, the BSSS, which is a measure of sensation seeking behaviors, assessed participants' optimal level of arousal (Hoyle, Stephenson, Palmgreen, Lorch, & Donohew, 2002). This scale consists of eight items in which the participants rate their opinions about thrill and adventure seeking by using a five-point Likert

scale which increases stepwise in the following order: Strongly Disagree, Disagree, Neither Disagree nor Agree, Agree, and Strongly Agree. The minimum score for this scale is 8, and the maximum score is 40. In a previous study, this measure has also been shown to have favorable internal reliability, with a Cronbach's α rating of 0.81 (Obrien, Mccoy, Egan, Goldin, Rhodes, & Wolfson, 2013). Lower scores on this scale indicate limited sensation-seeking behaviors, whereas higher scores relate to elevated levels of sensation-seeking behaviors.

Need for Cognition Scale. To assess each participant's need for cognition, a revised version of the *Need for Cognition Scale* was used (Cacioppo & Petty, 1984). Need for cognition (NCog), a term used to describe the degree to which a person is intrinsically motivated to engage and think about new topics, may determine how often a student is distracted in the classroom, regardless of which method of note-taking they prefer. NCog exists on a normally distributed continuum, in which individuals vary from low to high levels of intrinsic motivation and willingness to learn. Individual ratings have been assessed using the NCog scale (Cacioppo & Petty, 1982). Individuals who score higher on the NCog scale have a higher likelihood of actively seeking out relevant information, enjoying the learning process, and performing better on challenging tasks when compared to individuals who score lower on the NCog scale (Espejo, Day, & Scott, 2005). Those who have a lower NCog may be more likely to become distracted by laptop usage in the classroom, and therefore more likely to have deficits in their academic performance when compared to individuals on the higher end of the NCog scale (Cacioppo, Petty, Feinstein, & Jarvis, 1996).

Demographic Questionnaire. Lastly, the students were given a questionnaire assessing their gender, age, race, major field of study, preferred note-taking methods, and whether or not they have seen the presented TED talk video before or not. The information gathered from the

questionnaire was not directly analyzed as part of this study. Information like the students' age, gender, and ethnicity were used in order to describe the sample and determine the generalizability of the results of the study.

Dependent Variable. Students' information retention was assessed by their performance on a multiple-choice quiz that was relevant to the information presented in a TED talk lecture in the first session of the study. The same quiz was administered twice: once immediately after the presentation, and again at least one week after. Retention of information over time was measured by the proportion of change in score from Test 1 to Test 2, which was calculated by subtracting Test Score 2 from Test Score 1, and then dividing by the Test 1 score. The method of testing varied across conditions, but the quizzes given at the end of both sessions was consistent across testing methods. The quiz used in this research can be found in Appendix B.

Procedure

Students volunteered for the study using the online system discussed previously. After recruitment, all students who signed up to participate were randomly assigned to one of the six conditions. The entire sample was divided such that groups were randomly assigned to either take notes on a computer during the experiment, hand-write their notes, or take no notes at all. Each group was assigned to a testing format that was implemented later in the study, either an online test or a handwritten test. The six different conditions were established in order to examine differences in test performance that are dependent on the note-taking style, and also to determine whether the similarity in note-taking and testing methods has an effect on test performance.

After being randomly assigned to their condition, the participants were contacted via email regarding when to come to the computer lab for the initial meeting and the materials they

needed to bring to the meeting. There were two separate meeting times scheduled for each of the six conditions due to space availability and in order to be flexible with students' schedules. Each meeting consisted consisted of 10 to 20 students. In the first meeting for all of the conditions, the participants came into the computer lab and were given a random identifying number upon signing-in. They were then informed of the expectations to participate in the research, and signed consent forms. The number that was assigned to each participant was be used to ensure confidentiality, as they identified all future tests and questionnaires with it instead of their name. Participant names were only used for attendance purposes, in order to assign credit for participation.

When the informative process was complete, the students were then shown a TED talk presentation by Martin Seligman, entitled "A New Era in Positive Psychology", on the room's projector screen (Seligman, 2004). Similar to the Mueller and Oppenheimer (2014) study, the TED talk was used as a control to ensure that the students in each meeting session were exposed to the same instructional material. The students were instructed to takes notes on the material presented in the TED talk, using the assigned method of note taking, which varied by condition. Students in one of the typed notes conditions were instructed to take notes using Microsoft Word on the desktop computers that were provided in the lab. After the presentation, the participants were instructed to save their notes to their personal campus online drive. Students who were assigned to take hand-written notes were provided a pencil and a blank sheet of unlined paper on which to take their notes. Those who were in the no-notes conditions were told to just watch the presentation without taking notes at all. The TED talk lasted approximately twenty-three minutes and played for the participants in each session on the classroom projector. The lights in the classroom were turned off and the volume for the speakers were set on 75%. The researcher

started the video for the group, and then sat at the back of the classroom to observe the participants and to be available for questions. Periodically, the researcher walked around the room to ensure that the participants were taking notes as instructed. Prompting was issued to individual students if they were caught being off-task during the study. Once the presentation was over, the participants were given access to an online questionnaire that gathered demographic information, asking whether or not they had seen the presentation before, and also to assess their NCog rating using the *Need for Cognition Scale* (Cacioppo & Petty, 1982) and optimal arousal levels using the BMIS (Mayer & Gaschke, 1988). When finished with the questionnaire, the participants were given an untimed, closed-notes quiz based on the material from the presentation. The format of the quiz was dependent on the condition of which the participants were assigned; roughly half of the participants took the quiz on the computer, and the other half took it by using pen and paper. Once finished with the questionnaire and short quiz, participants were informed about when the second meeting would take place. Each participant was instructed to wait one week between scheduling their first and second meetings, in order to resemble the demands of an actual class. The students were also encouraged to study their notes during the break between meetings before they were dismissed.

At the time of the second meeting, the students were told to sit at a computer or an empty desk (depending on their assigned condition). During the second meeting, half of the participants took an untimed, closed-notes quiz online that has questions based on the video that they watched the previous week, while the other half took the same quiz in a written format. Each student used their previously assigned code number when signing into the online test or when taking the test on paper, in order to match results to the different conditions. Prior to the test, the participants were instructed to try their best and were given the opportunity to ask the researcher

if they had any questions. Regardless of their testing condition, each student was exposed to the same test, with questions and answers in the same order, during both meetings. When all of the students completed their tests, they were debriefed and given information about how to follow-up with the researcher if they had any further questions.

Data Analysis

The computerized test scores were automatically graded via *Qualtrics* survey software, using a percent correct criterion. The written tests were scored by hand using the same criterion. The main independent variables expected to impact information retention in this study were note-taking style and testing style. Comparisons were made between subjects, and the data were analyzed using an analysis of covariance. A MANCOVA was used to test for the main effects of and interactions between the two manipulated independent variables (note-taking style & testing format) while controlling for individual differences in NCog, BMIS, and BSSS. The MANCOVA was configured to test for Main Effects of each Independent Variable as well as all two-way interactions between the independent variables. Tukey's post-hoc tests were used to determine the nature of the between-group differences.

CHAPTER 3: RESULTS

A one-way between subjects ANOVA was conducted to compare the effect of note-taking style on Test 1 performance for conditions in which the participants wrote their notes using pen and paper, typed their notes using a computer, or took no notes at all. There was a significant effect of note-taking style on Test 1 performance at the $p < 0.05$ level for the three conditions ($F_{(2,76)} = 6.50$, $p = 0.002$, $\eta^2 = 0.146$).

TABLE 1: Descriptive Statistics of Test 1

Note Condition	Number of Participants	Mean Test Score on Test 1	Standard Deviation
Paper	28	69.61%	14.02
Typed	29	64.63%	14.20
No Notes	22	53.75%	19.03
Total	79	63.37%	16.69

Post-hoc Tukey's HSD tests showed that for Test 1, the mean difference in performance between the "no notes" conditions and the "paper notes" was significantly higher than the comparisons between the other conditions. The mean difference in performance between the

TABLE 2: Test 1 Condition Comparison

Note Condition (A)	Comparative Note Condition (B)	Mean Difference (A-B)	Significance (*p* value)
Paper	Computer	4.93	0.455
	No Notes	15.86	0.002*
Computer	Paper	-4.98	0.455
	No Notes	10.88	0.042*
No Notes	Paper	-15.86	0.002*
	Computer	-10.88	0.042*

* The mean difference is significant at the p=0.05 level.

"computer notes" and "no notes" conditions was also significant at the .05 level of significance. All other comparisons were not significant.

TABLE 3: Descriptive Statistics of Test 2

Note Condition	Number of Participants	Mean Test Score on Test 1	Standard Deviation
Paper	26	63.75%	16.66
Typed	26	54.76%	11.84
No Notes	20	53.60%	22.45
Total	72	57.69%	17.41

A one-way between subjects ANOVA was also conducted to compare the effect of note-taking style on Test 2 performance for conditions in which the participants wrote their notes using pen and paper, typed their notes using a computer, or took no notes at all. There was not a significant effect of note-taking style on Test 2 performance at the $p < 0.05$ level for the three conditions ($F_{(2,69)} = 2.61$, $p = 0.081$, $\eta^2 = 0.081$).

TABLE 4: Test 2 Condition Comparison

Note Condition (A)	Comparative Note Condition (B)	Mean Difference (A-B)	Significance (*p* value)
Paper	Computer	8.99	0.146
	No Notes	10.15	0.119
Computer	Paper	-8.99	0.146
	No Notes	1.16	0.971
No Notes	Paper	-10.15	0.119
	Computer	-1.16	0.971

* The mean difference is significant at the p=0.05 level.

Post-hoc Tukey's HSD tests showed that there were no significant mean differences when comparing the different methods of note-taking for Test 2.

TABLE 5: Proportion of Change Means from Test 1 to Test 2

Match/Mismatch	Note Condition	Proportion of Change ([T1-T2]/T1)	Standard Deviation	Participants (N)
Match	Paper	-0.14	0.16	12
	Computer	-0.12	0.17	13
	Total	-0.13	0.16	25
Mismatch	Paper	-0.01	0.26	14
	Computer	-0.15	0.18	12
	Total	-0.08	0.23	26
No Notes	Total	-0.01	0.40	19
Total	Paper	-0.07	0.22	26
	Computer	-0.14	0.17	25
	No Notes	-0.01	0.40	19
	Total	-0.07	0.27	70

Table 5 lists the proportion of change in score from Test 1 to Test 2 for participants in each note condition and overall for the experiment. Each condition is broken down further to examine the proportion of change from Test 1 to Test 2, which was used as a measure of information retained, depending on a match or mismatch of the participants' note-taking style and test format.

TABLE 6: Descriptive Statistics of Scales Used

Scale	Mean Rating for Scale	Standard Deviation
BMIS	26.91	6.12
NCog	4.44	8.33
BSSS	4.59	7.13

The student ratings on all of the scales used as part of this research were gathered, and mean ratings for each scale were calculated. Table 6 includes the calculated means for each scale, across all conditions.

TABLES 7: Effects and Interactions Between Subjects

Independent Variable	df	F	Significance (p value)	η^2
Note Condition	1	1.87	0.18	0.04
Match / Mismatch	1	0.04	0.84	0.00
NCog	1	2.13	0.15	0.04
BMIS	1	3.83	0.06	0.07
BSSS	1	0.01	0.93	0.00
Note Condition X NCog	1	0.26	0.61	0.01
Note Condition X BSSS	1	0.01	0.92	0.00
BMIS X BSSS	1	0.01	0.95	0.00

A MANCOVA was also conducted in order to test for main effects note-taking style, having a match or mismatch between note-taking style and testing format, as well as interactions between Need for Cognition and note taking style, sensation seeking and note-taking style, as well as arousal level and sensation seeking. The dependent measure in this analysis was the amount of information retained between the two test sessions, as reflected in the proportion of change between test scores between sessions (Test 1 score minus Test 2 score, divided by Test 1 score).

The first hypothesis of this study, which focused on the method of note-taking, stated that students who write their notes will retain more information than students who type notes, was not supported. There was not a significant main effect of note-taking style on retention ($F_{(1,50)}$ = 1.87, p = 0.18, η^2=0.04).

The second hypothesis, which focused on the contextual dependence of note-taking and testing methods, stated that retention would be better among students whose testing format matched their note-taking format than among those whose testing format differed from their

note-taking format, was not supported. There was no main effect of having a match vs. mismatch between note-taking and testing formats (F (1,50) = 0.04, p= 0.84, η^2=0.00),

The third hypotheis, which focused on individuals' NCog and note-taking method, stated that NCog would interact with note-taking style such that students who wrote their notes would display improved retention regardless of their level of NCog whereas students who typed their notes would display higher levels of retention if they had higher levels of better than students who were low in NCog across note-taking conditions whereas students who are low in NCog will display better retention after taking handwritten notes. This hypothesis was not supported as there was not a significant interaction between NCog and note-taking format (F (1,50) = 0.26, p= 0.612, η^2=0.01).

The fourth hypothesis, which focused on individuals' level of sensation seeking behaviors, stated that students with lower levels of sensation seeking would display improved retention after writing notes than after typing notes. This was not supported as there was not a significant interaction between sensation seeking and note-taking style (F (1,50) = 0.01, p= 0.92, η^2=0.00).

Lastly, the fifth hypothesis, which focused on the relationship between arousal and sensation seeking, stated that if arousal level at the time of testing and level of sensation seeking behaviors will interact such that when they are congruent, students will display better retention whereas they will display inferior retention if they are incongruent. There was no evidence supporting the existence of this interaction (F (1,50) = 0.01, p= 0.945, η^2=0.00). There we no other statistically significant main effects or interactions.

CHAPTER 4: DISCUSSION

The primary goal of this research was to investigate how students' method of note-taking impacted their learning and their retention of information from a classroom lecture. The secondary goal of this research was to discover if there are situations in which one particular note-taking style is more beneficial than others, based on how a person is tested on the material. A final goal of this research is to examine how individual differences in NCog, arousal states, and sensation-seeking interact with note-taking style to impact information retention. This research is intended to inform stakeholders such as professors, students, and administrative staff about how different note-taking styles compare in terms of associated retention outcomes so that future instructional tactics and policies might be modified in accordance with these findings.

The current study provided no evidence to suggest that either handwritten notes or typed notes are better than the alternative in terms of information retention and associated test performance. Significant differences in performance were only discovered when comparing Test 1 scores of who did not take notes to Test 1 scores of students in both of the typed notes and handwritten notes conditions. This is evidence that immediate retention of information is impacted by note-taking; taking notes, regardless of method, increases the likelihood of retaining the information for the short-term. In a similar comparison with Test 2 scores, which was intended to measure the amount of information retained after a week's time from first exposure to the material, there were no significant differences across the varying note-taking conditions, indicating that the method of note-taking does not impact the distal retention of information. These findings do not support the Note-Taking Method Hypothesis, which was based on the results of the Mueller and Oppenheimer (2014) study that current study was intended to replicate. The current study implemented the methods as a classroom approach, compared to a

small group approach that was used in the previous study, which could have impacted the results. Students in the laptop conditions of the previous study were also persuaded against taking verbatim notes during the sessions, whereas the students participating in the current study were not limited in their approach to note-taking, in order to better resemble an actual classroom setting.

Expanding upon the previous research that examines the contexts in which individuals learn and how these contexts affect performance, the current study was designed to test the hypothesis that contextual congruence between the learning environment and the testing environment would positively impact test performance. The contexts examined as part of this study included the methods in which the participants took their notes (writing or typing) compared to the methods in which they were tested (written test or a typed test). Similar to the overall performance results, the performance based on context match or mismatch was evaluated proximally by using Test 1 scores and distally using Test 2 scores. Immediately after being exposed to the lecture material, students who were assigned to contextually congruent conditions, with a match in their note-taking and test-taking methods, performed slightly better than students who were in conditions in which there was a mismatch in their note-taking and test-taking contexts. Although these students performed nominally better in the contextually congruent conditions, the difference was not statistically significant, and therefore fails to provide support for the hypothesis that contextual congruence has an effect on test performance or information retention. Similar findings were established when comparing the test scores from Test 2, further suggesting that contextual congruence alone is not a main influential factor impacting how students perform on academic tasks.

When examining retention of information over time, the proportion of change in score from Test 1 to Test 2 was calculated as a measure of performance and compared between conditions. The proportion of change measured the overall change in score from Test 1 to Test 2, while accounting for the proximal Test 1 score to exclude floor and ceiling effects. There were still no significant differences between the contextually congruent and non-congruent conditions. Although not significant, the results show that students in the mismatched conditions did not exhibit as much change in score from Test 1 to Test 2 as students in the matched conditions. After comparing the Test 1, Test 2, and proportion of change results, there was no statistically significant differences between contextually congruent and non-congruent conditions to support the Contextual Dependence Hypothesis that was outlined as a goal for this study.

Individual differences among students were also examined as part of this study in order to determine if they interact with note-taking style to impact information retention. Although students are different in many aspects of personality and preferences, previous research led to the hypothesis that differences in NCog, optimal arousal levels, and sensation-seeking are key contributors in how students respond to varying note-taking methods. However, the results of this study do not provide significant evidence to support any of the individual difference hypotheses: Ncog, sensation-seeking, or arousal. Students who rated themselves as having a high NCog did not establish a pattern of better performance low NCog students on either Test 1 or Test 2, regardless of their note-taking method. Similarly, students who rated themselves as having a high level of sensation-seeking did not establish a pattern of better performance low sensation-seeking students on either Test 1 or Test 2, regardless of their note-taking method. Sensation-seeking was also examined in relation to arousal levels at the time of testing, to determine if students who met their arousal needs, based on their sensation-seeking behaviors,

performed differently than students whose arousal needs and sensations seeking were not congruent. In comparison, students who matched in sensation-seeking and arousal levels at the time of testing did not exhibit a significant difference in performance from students without a match in these areas. It is likely that factors other than the three individual differences discussed interact to impact information retention, but it is difficult to isolate what these differences may be and how they interact.

Limitations

One limitation to this experiment is that the results are generalizable to only college aged students. This sample of participants was a convenience sample, since the Introduction to Psychology students were actively seeking participation for class credit. Results from a wider sample of individuals would allow the researchers to isolate varying age ranges, and would likely produce different outcomes.

When examining how context dependence impacts information retention, this study used a recognition-based task in order to test what the students learned from the presentation. Although this type of task is similar to what can be seen in a college lecture, the previous research that indicated context dependence as a factor in how we learn was conducted using a recall-based task. Recognition tasks, more specifically multiple choice questioning, was used in this research for its similarity to classroom testing and ease of grading. Recall tasks do not allow the participants to rely on guessing, as they have to generate the answer themselves without the help of answer choices.

It is also likely that the individual differences of NCog, arousal, and sensation-seeking have no effect on participants' ability to retain information, as these variables were not examined in previous similar studies. It may be the case that a combination of these and other individual

differences interact such that one style of note taking is more favorable than another. With so many personality differences to differentiate, it is difficult to single out one particular personality trait or interaction between traits that significantly impact a person's disposition as to which style of note-taking is optimal for information retention. These constructs were also measure by self-report data, which can be problematic due to response-biases from the participants.

Directions for Future Research

Since the results from this study were not significant, future researchers may wish to include more participants when studying similar procedures. Although a power analysis based upon previous studies was conducted prior to this experiment, the estimate for the amount of participants needed to generate a strong enough effect size was lower than what was actually needed. Future researchers may want to advertise their study school-wide to incorporate a wider range of students, instead of focusing on students within their freshman or sophomore years of school. Future studies might also benefit from including high school or middle school students. It is likely that the younger students may feel more comfortable with alternative note-taking methods, as they have been taught by using more technology in the classroom compared to somebody who is currently in college.

It is possible that the individual differences examined in this study could interact with other individual differences that were not measured in the study. These interactions could impact how we learn and how we retain what we learn. More research needs to be conducted to further examine what other individual differences should be measured. As stated previously, it is difficult to isolate interactions between individual differences to the point that we can say there is a significant effect on how we learn, especially abstract differences like NCog, arousal, and sensation-seeking, which are all measured by self-report data. All things considered, future

researchers may benefit from examining traits directly related to ADHD instead of NCog, sensation-seeking, and/or arousal. ADHD traits are more objective that the previous measures, do not rely on self-report data, and are more closely related to learning outcomes.

Conclusion

The use of electronic devices in classrooms for all ages of students has been increasing in prevalence. Although previous studies have shown that devices that have access to the Internet can distract students, this study's aim was to to show the impacts of students' note-taking behavior, the context of how they learn, and their individual differences on how they retain information. Using both a proximal and distal approach to testing after exposure to a simulated lesson, this research indicated that participants using laptops to take notes and students that wrote their notes by hand did not perform significantly different on on tasks meant to gauge their understanding of the material shown to them in lecture. However, it was found that students who took notes, regardless of their method, performed better on this task than students who did not take notes. Moreover, results from this study also indicate that the context in which a student learns the material and the context in which they are tested on the material do not significantly impact their retention of the information. Lastly, it was discovered that individual differences such as NCog, arousal at the time of testing, and sensation-seeking do not interact with note-taking method to impact how well a person retains information from a classroom presentation. Based on the information gathered as part of this research, it is safe to make the assumption that student preference is the main contributing factor in determining which method of note-taking is more conducive for enhanced information retention. Although theories from previous studies would discuss otherwise, there is not enough significant data from this study to support an

argument favoring either method of note-taking, a match or mismatch in context of learning or

testing, or that individual differences and note-taking style interact to impede performance.

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APPENDIX A: Demographic Information Questionnaire

Participant ID Number: _____

Please respond to the following questions as they apply to you personally:

Age: _____

Sex (Circle one):   Male / Female

Gender:_____

Ethnicity (select one):
_____ Hispanic or Latino
_____ Not Hispanic or Latino

Race (select any that apply):
_____ American Indian or Alaska Native
_____ Asian
_____ Black or African American
_____ Native Hawaiian or Other Pacific Islander
_____ White
_____ Other (describe) _____

Class Status (Circle one):   Freshman / Sophomore / Junior / Senior

Major/Intended Major: _____

Have you previously seen the video that was presented today? (Circle one)   Yes   /   No

Which method do you use to take notes in a normal classroom setting? (Circle one)

   Typed notes   Written notes   I don't take notes

Which method did you use to take notes in high school? (Circle one)

   Typed notes   Written notes   I didn't take notes

APPENDIX B: Presentation Quiz

1. When CNN asked Seligman for a three-word sound bite to describe the state of modern psychology, what did he reply?

A "Am I on?"
B "Cause for celebration"
C "Not good enough"
D "Way beyond Freud"
E "Need twelve words"

2. Seligman suggests that extremely happy people differ from the rest of us in one significant way:

A They're better-educated
B They watch less TV
C They're very well-rested
D They're quite affluent
E They're extremely social

3. According to Seligman, what are the drawbacks to "the pleasant life," our experience of positive emotion?

A It creates unrealistic expectations.
B We can't significantly change our individual capacity to experience positive emotion.
C We get accustomed to it, and its effects diminish over time.
D A and B
E B and C

4. How does Seligman define "the meaningful life"?

A He'll reveal that in his next book
B Profound absorption in your work and relationships
C Achieving a sense of harmony and unity with others
D Using your strengths in the service of something larger than you are
E Putting the needs of others before your own

5. How is the field of positive psychology different from traditional psychology?

A Advocates for a less-formal relationship between psychologist and patient
B Offers interventions to help relatively untroubled people feel happier
C Does not use drugs to treat disorders
D A and C
E B and C

6. Although Seligman believes that psychology's focus on the "disease model" has had drawbacks, he's also proud of what the field has accomplished over the past 60 years. What does Seligman identify as the main achievements?

A Many disorders have become treatable
B Psychologists can now categorize everyone based on their mental health.
C A science of mental illness has been developed
D People are physically healthier than they have ever been.
E Both A and C.

7. After giving the story about Len, how does Seligman differentiate flow from pleasure?

A Pleasure encompasses the idea of flow, whereas people who have fluidity in their life tend to be happier individuals than those who lack fluidity.
B Pleasure is about knowing your strengths, and flow concerns using them together to become happier.
C Pleasure has aspects of thought, feeling, and timeliness that are very distinct. People who are capable of flow get lost in the moment and their happiness requires minimum thought and effort.
D Pleasure is a short-term goal, and flow typically includes being happy over the course of a lifespan.

8. The disease model that Psychology and Psychiatry once followed has three costs, according to Seligman. Which of the answers below is NOT a cost of following the disease model?

A People start to think that they are always a victim of some external event.
B Measurement of interventions used are unreliable.
C "Normal people" are forgotten, and there is no more focus on improving their feeling of fulfillment
D Positive Interventions to make people happy are not being used

9. As one of the given reasons why the disease model is not good for the field of Psychology, Seligman states that practitioners have become "victimologists". What type of view would a victimologist have?

A "If you are in trouble, bricks fell on you"
B "People have choices, decisions, and responsibilities that affect their outcomes"
C "the mission is to make seemingly normal people happier and more fullfilled"
D "Everybody is a victim of something, and happiness is a measure of how well one overcomes being a victim."

10. What are the three different types of life, according to Seligman?

A Happy Life, Fulfilled Life, Depressed Life
B Pleasant Life, Good Life, Meaningful Life
C Meaningful Life, Normal Life, Life of Potential
D Pleasant Life, Positive Live, Miserable Life

11. According to Seligman, what are the things that lastingly change the three types of lives discussed?

A Positive Interventions.
B Positive Relationships with other people
C Positive Reinforcement
D Positive Feedback

12. How does Seligman parallel the industries of technology, entertainment, and design to psychology?

A Each industry is not at its peak, but moving in the right direction.
B It is possible for all these drivers to increase a person's happiness, meaningfulness, and engagement.
C The only way to increase human happiness is by these industries working together.
D Each discipline has radically changed its ideas from the time of its origin.
E To be truly satisfied, one must be in tune with each of these disciplines.

APPENDIX C: Documentation of IRB Study Approval

EAST CAROLINA UNIVERSITY
University & Medical Center Institutional Review Board Office
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Notification of Amendment Approval

From: Social/Behavioral IRB
To: Troy Eason
CC:
          Michael Baker
Date: 4/11/2016
Re: Ame1_UMCIRB 15-001326
          UMCIRB 15-001326
          Note-taking methods and information retention

Your Amendment has been reviewed and approved using expedited review on the date of 4/11/2016. It was the determination of the UMCIRB Chairperson (or designee) that this revision does not impact the overall risk/benefit ratio of the study and is appropriate for the population and procedures proposed.

Please note that any further changes to this approved research may not be initiated without UMCIRB review except when necessary to eliminate an apparent immediate hazard to the participant. All unanticipated problems involving risks to participants and others must be promptly reported to the UMCIRB. A continuing or final review must be submitted to the UMCIRB prior to the date of study expiration.The investigator must adhere to all reporting requirements for this study.

Approved consent documents with the IRB approval date stamped on the document should be used to consent participants (consent documents with the IRB approval date stamp are found under the Documents tab in the study workspace).

The approval includes the following items:

Document	Description
Learning Styles Questionnaire.docx(0.02)	Surveys and Questionnaires
Protocol for Note-Taking study.docx(0.04)	Study Protocol or Grant Application

The Chairperson (or designee) does not have a potential for conflict of interest on this study.