Notes on Note-Taking: Review of Research and Insights for Students and Instructors

Michael C. Friedman

Harvard Initiative for Learning and Teaching

Harvard University

TABLE OF CONTENTS

Preamble and recommendations

Students' notes, created in class or while reviewing course material, are an important tool for learning. Many students and instructors feel that note-taking is an obvious and intuitive skill to have, yet few consider or encourage best practices. Unfortunately, many students are unaware of or do not appreciate the benefits that effective note-taking may have on their learning, and the importance of cultivating their note-taking skills over the course of their education. Good note-taking practices can lead to efficient study practices, better course outcomes, and improved retention of content beyond a course's conclusion.

This literature overview is designed as a resource for both students and instructors to gain insight into what education research reveals about note-taking. Specifically, this review discusses the cognitive mechanisms behind note-taking, how to assess the quality of notes, and optimal practices. I have briefly summarized some suggestions below for students and instructors to consider regarding note-taking.

For students:

- Avoid transcribing notes (writing every word the instructor says) in favor of writing condensed notes in your own words.
- Review your notes on the same day you created them and then on a regular basis, rather of cramming your review into one long study session prior to an exam.
- Test yourself on the content of your notes either by using flashcards or using methodology from Cornell Notes. Testing yourself informs you what you do not yet know from your notes and successful recall of tested information improves your ability to recall that information later (you will be less likely to forget it).
- Carefully consider whether to take notes on pen and paper or with a laptop. There are costs and benefits to either option. For example, note-taking on a laptop may allow you to include more content in your notes, but at the risk of being distracted

by unrelated tasks.

- Avoid the misperception that you know lecture content better than you actually do, which can lead to poor study habits. While course topics may appear easy to understand in class, they may be rather difficult as you are reviewing them several weeks later while preparing for the exam. Be aware that you will forget some of what you have learned and adopt better study habits to address the gaps in your knowledge.

For instructors:

- Explain your course policies on note-taking and/or better learning practices and their rationale at the beginning of term. Support your reasoning with data from prior terms and/or educational research, particularly if students feel that your policies are counter-intuitive or different from their preferred practices.
- Provide students with materials prior to lecture that allow them to become familiar with the main ideas or topics. Students will be more likely to identify the important concepts during class and take more selective notes. However, avoid giving students so much material that they elect poor study behaviors such as relying on the materials instead of attending class and taking notes.
- Encourage students to take notes in their own words rather than record every word you say in class. Doing so will lead to deeper understanding during lecture, more student engagement in class, and better retention of course content.
- Make connections between current and previously discussed course concepts, and encourage students to make such connections on their own. Doing so will help students retrieve related ideas when they are needed (i.e., during an exam).

Introduction

Note-taking is valuable skill to individuals in both academic and non-academic settings. However, note-taking is not necessarily a skill that students have upon arriving at campus or learn through trial-and-error during their education (van der Meer, 2012). Particularly during fast-paced lectures, many students have little to no skill in note-taking

during instruction, and it is unclear whether students' note-taking behaviors change over the course of their education. The goal of this review is to provide insights into note-taking based on experimental research and address common questions asked by learners and instructors alike. The subsequent responses are designed to give students and instructors practical advice on note-taking behaviors aimed at advancing learning, memory, and long-term retention of course content[1].

Why do we take notes? What cognitive mechanisms are involved with note-taking?

People take notes for many different reasons, including: to learn, to enhance long-term retention, and to document events. Note-taking allows people to outsource their memories to an external source (paper), as well as make content explicit for future reference. Critically, learning can occur during both the production and review of notes by allowing the learner to make connections between idea units and engage in deep processing of course content (Bohay, Blakely, Tamplin, & Radvansky, 2011; Piolat, Olive, & Kellogg, 2005). The act of note-taking also assists the learner in generating and semantically processing information (essentially, helps the learner think about course content in such a way to better understand it upon later review), in addition to facilitating and strengthening the internal connections between ideas (Kiewra et al., 1991). Lastly – and of particular importance to instructors – note-taking can result in broader learning

---

[1] A majority of the work presented originates from experimentally controlled research and not actual classrooms. Therefore, some of the insights presented below, while valuable, may not reflect the most optimal strategies to use in real-world note-taking, in which a variety of internal and external factors could contribute. A majority of the work presented originates from experimentally controlled research and not actual classrooms. Therefore, some of the insights presented below, while valuable, may not reflect the most optimal strategies to use in real-world note-taking, in which a variety of internal and external factors could contribute.

outcomes in addition to improving mastery within course content due to this generative

processing and making connections between idea units, allowing students to apply their

gained knowledge to novel contexts (Peper & Mayer, 1978).

In addition to helping students learn and retrieve information, note-taking can also

be used in professional settings to help people make better decisions, solve problems, and

work more efficiently as a group. For example, reviewing notes before voting on a

verdict protected individuals from stereotype bias in a mock trial (Strub & McKimmie,

2011). The act of note-taking also improves recall of applicant facts for job interviewers,

while the act of reviewing notes improves judgment accuracy (selecting the best

applicant) for interviewers (Middendorf & Macan, 2002). However, not every non-

academic setting receives a benefit from note-taking, and in some cases it may be

detrimental to take notes rather than focusing exclusively on content in the moment. To

that point, Hartley (2002) reviewed note-taking studies in the context of professional and

clinical counseling and found that clinicians that took notes were perceived as less

effective and less likely to be visited again by participants than clinicians that did not take

notes.

Many mental processes occur simultaneously during the act of note-taking. The

learner has to pay attention to the instructor, understand the material, identify what is

important to write down in their notes, and coordinate the physical writing or typing of

their notes, all while usually under severe time pressure. Note-taking is further

complicated by the fact that people typically speak at a faster rate than which they are

capable of writing or typing, making it extremely difficult to remember what the

instructor said and write the associated information down before the instructor moves on

to the next topic. To provide a comparison, note-taking has been found to be as cognitively demanding as playing chess is for an expert, as both require the retrieval of knowledge, planning, and the development of solutions (Piolat et al., 2005).

Cognitively, note-taking depends upon working memory (WM) – the memory store responsible for both short-term storage (what you are currently thinking about) and the mental transformation of information (manipulating and modifying what you are currently thinking about; Baddeley, 2000). In the context of note-taking, WM is used for both comprehension (attention and understanding of course content) and production (identifying important content and physically generating notes). Due to the limited capacity of WM, however, the balance or tradeoffs between comprehension and production during note-taking make the process a dynamic one that changes from one moment to the next (Piolat et al., 2005). For example, a student in a lecture class may elect to reduce their cognitive "burden" during instruction and devote all WM resources to production, and simply write everything that the instructor is saying without worrying about comprehension during class. This strategy is sub-optimal because the student would not actually be treating class-time as a learning event, but rather a transcription event. In doing so, the class content would be minimally processed, deferring all of the student's learning to a later time, if at all (see Muller & Oppenheimer, in press). Additionally, with the increasing digital availability of course resources for students (e.g., lecture slides) such notes might be largely redundant. Conversely, a student may opt to abandon note-taking entirely, and divert his mental resources exclusively to comprehending the lecture. While prior research (e.g., Di Vesta & Gray, 1973) has shown that such a strategy may be acceptable for an immediate test of memory, the student

would lack notes to review for a test that occurs several days or weeks later and would not have the opportunity to strengthen the connections between idea units during a review session.

Due to these constraints, students often struggle to find the balance between understanding and production during note-taking. One solution is to reduce the cognitive burden associated with production by using stenography, or shorthand, while note-taking. To some degree, learners do adopt a unique version of shorthand while note-taking, yet interestingly there is considerable variability in shorthand practices, even by the same note-taker and within the same set of notes (Piolat et al., 2005). Note-taking affects language on three different levels. First and as already discussed, abbreviating practices like shorthand can sometimes be decipherable only by the author. Second, syntax can be transformed on notes, with arrows and other symbols being used to represent relationships that would otherwise be too time-consuming to write out with normal syntax and language. Last, the physical format of notes may be vastly different relative to other texts. Importantly, learners do not have to organize their notes in a traditional text-based or linear fashion (i.e., for English writers, writing coherently from left to right on a page and then from top to bottom) if they think it helps to convey the meaning of course content. Based on these qualities, the form with which notes can take is variable based on both the student's WM limits and their transformation of language during note-taking. As students become more familiar in a course's subject matter their shorthand and overall quality of notes may change, thus leading to variability within a given learners' notes for a course as well.

How can we assess the quality of notes?

Due to various ways in which language can be changed by note-taking, in addition to the variety of note-taking styles to be discussed, it is relatively difficult to establish quality criteria that are valid for all forms of notes. Generally, notes are considered private and meaningful only to the note-taker, making it that much more difficult to establish a good criteria for high-quality notes (Piolat et al., 2005). For example, single words in notes that appear to be nonsensical to others may cue the creator of the notes to think about a personal experience and how it relates to the topic of the notes. It could even be argued that note quality cannot be assessed by anyone other than the user of the notes, as a specific note format ideal for one person may not be the best quality or way to convey content to someone else (Bui, Myerson, & Hale, 2013). Supporting this claim, Kiewra and colleagues found that reviewing self-produced notes lead to better recall performance than reviewing another student's notes (Kiewra et al., 1991).

Despite the variability across notes, researchers have used several measures to assess note quality. The most common measure of quality used appears to be the number of idea units or critical lecture points recorded the learner's notes (Fisher & Harris, 1974; Robin, Foxx, Martello, & Archable, 1977). Others have used a combination of factors to assess note quality such as: number of details, number of words, clarity, legibility, sequencing, and accuracy of notes (see Vekaria, 2012). However, some researchers have argued that the highest-quality or most effective notes are those that can be understood by someone unfamiliar with content of the notes (Williams & Eggert, 2002). Ultimately, the learner's own subjective judgment of quality about his or her own notes may be the most

important factor to consider regarding quality. If a student believes that they have created poor quality notes (regardless of the accuracy of their own assessment), that student may engage in behaviors or strategies that they would not have used otherwise to ensure they understand the associated content (e.g., borrowing another student's notes and comparing details). Importantly, the *quality* of notes should not be confused with the *quantity* of notes. Just because a student takes an excess of notes does not necessarily make those notes more beneficial to the learner (Bui et al., 2013), and in some cases, even detrimental to learning outcomes (Mueller & Oppenheimer, in press).

What is the optimal method of note-taking?

The answer to this question is multi-faceted and complex. Broadly, the optimal note-taking behaviors for long-term retention of course content includes using a framework or organization, using generative activities (e.g., testing yourself) to facilitate connections between ideas, and reviewing notes multiple times (Kiewra, 1989).

What is the best note-taking format?

Note-taking styles can be broadly classified into two categories: linear and non-linear styles. Linear styles, or note-taking in a format similar to conventional written texts or outlining, are some of the most common styles of notes used by students (Piolat, 2001). In contrast, non-linear styles that use graphical representations (e.g., the mapping method) allow students to organize the content of their notes in a systematic, yet unconventional fashion that may be difficult for others to understand easily. Importantly, whatever style of note-taking the learner chooses to adapt (linear, non-linear, or a

combination of the two) does not reduce the cognitive effort required for note-taking, therefore the differences between note styles has a minimal impact on content comprehension. However, Piolat et al. (2005) argue that non-linear styles of note-taking are more effective than linear styles because non-linear styles facilitate the process of making connections between idea units, which enhances learning through deeper processing and strengthens long-term retention of content. Additionally, systematic behavioral procedures that train students to be effective note-takers may not only enhance the accuracy of content within their notes (i.e., accurately recording critical points from lecture) but also improve learning outcomes (test performance; Robin et al., 1977).

Advocating for a particular note-taking format, several university resources suggest using the Cornell Notes format. Cornell Notes are formatted such that pages of notes are split lengthwise: the right side of the page is used for formal notes while the left side of the page is reserved for keywords and questions relevant to the notes on the right. At the bottom or footer of each page, the note-taker writes a brief summary of that page of notes. While easiest to create with pen and paper, a savvy note-taker could adapt a Cornell format into a word processor on a computer, provided the learner used appropriate formatting (which could be achieved with a table or modified margins).

One advantage of Cornell Notes is that they could also be incorporated with the linear and non-linear styles explained above, allowing greater flexibility with this format. Although not directly supported by an abundance of empirical research (but see Jacobs, 2008), the Cornell Notes format does employ several of the principles supported by cognitive psychology, if used properly. In particular, the Cornell format may help students make connections between ideas, synthesize information, and better apply

acquired knowledge to novel contexts (as discussed later).

Is it better to transcribe as much lecture content as possible or to summarize what the instructor is saying while note-taking?

In essence, does the quantity or quality of notes matter more for long-term retention? While writing down or generating content is beneficial for learning (Rabinowitz & Craik, 1986), if a learner chooses to transcribe everything the instructor says, his or her WM will be taxed greatly by production procedures and reduce their ability to comprehend content during class. Overly wordy notes may also make it difficult for the learner to go back and review specific content. In contrast, organized notes (i.e., non-linear notes) or writing notes in your own words reduce some of the burden on WM associated with production processes, in favor of learners focusing more on comprehension. Despite the costs of transcribing, additional content within notes may further enhance learning while reviewing, especially if the test on that content occurs later. In a recent series of experiments, Bui and colleagues found that note-takers who did not transcribe a recorded lecture had better memory performance than note-takers who did try to transcribe. However, the transcribing note-takers had better memory performance than non-transcribing note-takers on a delayed test, when given a prior opportunity to review first (Bui et al., 2013, but see Mueller & Oppenheimer, in press). This interaction between the quantity of notes and the delay between study and test on performance also supports the theory that managing WM is an essential component for effective note-taking. Specifically, if the learner dedicates most of his cognitive resources towards transcribing the lecture, rather than comprehending it, immediate test performance will be lower relative to learners that dedicated more resources to

comprehension. Conversely, having that additional content in their notes may allow those transcribing note-takers to have greater comprehension of the material when they select to review their notes, after some of the associated content was forgotten.

Is it better use pen and paper or a laptop to take notes?

Education researchers are still investigating the optimal note-taking medium (especially as laptop use in class becomes more common than pen and paper), but some initial insights can be drawn from current works, framed by the positive and negative aspects of laptop use relative to pen and paper note-taking. Laptop use may reduce the cognitive resources required for production, allowing for additional resources to be dedicated to comprehension during lecture relative to pen and paper note-taking, assisting in learning and long-term retention (Bui et al., 2013). However, the additional cognitive resources required for production in pen and paper note-taking may be alleviated in people who write relatively faster or in shorthand, as those people have automatized their writing so that their WM system is not extensively taxed during the act of note-taking (Peverly, 2006). Due to the relative ease of taking notes on a laptop, learners may also be inclined to take more notes than they would with a pen and paper medium.

Despite the benefits, there are also several costs associated with laptop note-taking. Although the relative ease of laptop use may encourage students to produce more notes than they would with pen and paper, there is an equal risk that learners may be susceptible to reproduce what the instructor is saying word-for-word rather than write notes in their own words. As mentioned earlier, note-taking in such a fashion dedicates too many cognitive resources to production and not enough to comprehension during

lecture, which can be detrimental to learning outcomes, especially for examinations testing conceptual questions (Muller & Oppenheimer, in press). Conversely, pen and paper note-taking, due to the limitations of handwriting speeds, discourages learners from writing everything the instructor says in favor of writing selective notes in their own words (which encourages deeper processing and long-term retention of content). Additionally, pen and paper note-taking is typically easier to use with non-linear styles of note-taking, unique abbreviations, and transformed syntax. While non-linear styles are possible with a laptop, the process of producing non-linear notes similar to that seen in pen and paper mediums is cumbersome and difficult to incorporate spontaneously during lecture. However, despite the drawbacks of laptop note-taking there are several "hybrid" note-taking systems available that incorporate many of the advantages associated with both laptop and pen and paper mediums, although their benefits have yet to be thoroughly investigated (see Box 1).

Additionally, there is no consensus regarding whether note-taking on a laptop may impede the learning of students immediately surrounding the individual using a laptop, especially if that individual engages in multi-tasking during lecture (e.g., doing activities unrelated to instruction on their computer such as checking email, chatting with friends, and watching videos). Many students find that peers' use of laptops during instruction can be distracting, even if the laptop-user is focused on note-taking. Students report that laptop use by peers is the greatest distraction during instruction (Fried, 2008), and specific distractors include what is on the peer's screen as well as the sound of keystrokes (Borbone, 2009). However, the largest hazard to laptop use in class may be associated with multi-tasking. In an experimental design, Sana and colleagues found that

laptop use impedes laptop-user's learning, in addition to those around the laptop-user based on the frequency of multi-tasking. Participants who multi-tasked during instruction, or were in the presence of peers that multi-tasked (those participants that could see their peers working on unrelated course content), produced lower quality notes and remembered less. Additionally, when asked about how multi-tasking during instruction may impede learning, participants thought multi-tasking would only impede the learning of the individual that was multi-tasking, and not the surrounding peers (Sana, Weston, & Cepeda, 2013). Aguilar-Roca and colleagues found contrasting findings with a study conducted in a college biology course in which the class was separated into laptop-free and laptop-approved areas (Aguilar-Roca, Williams, & O'Dowd, 2012). Although students that used laptops performed worse on examinations than pen and paper students, laptop use did not impair surrounding students' performance (i.e., pen and paper students that chose to sit in the laptop-approved area). The contrasting findings from Sana et al. (2013) and Aguilar-Roca et al. (2012) could be attributed to a variety of factors (student motivation or preferences, learning goals, violation of cultural norms, etc.).

Is it better to create your own notes, use instructor's handouts, or use another resource for notes?

Providing students with lecture slides, or handouts, before class begins is becoming increasingly common, as is the demand from students requesting these materials. Giving students such handouts in advance may allow them to review the material before lecture, assisting with their ability to comprehend the material during instruction, which may help students (especially those with learning difficulties or cognitive impairments) better remember and incorporate the material into long-term

storage (Boyle & Rivera, 2012). Handouts can also help students orient to the topics covered in lecture, identify important concepts during lecture, and guide them to make meaningful connections between concepts. However, the wording and layout of handouts should be considered carefully, in order to make sure students are making the proper associations between concepts (Huxham, 2010).

The benefits such handouts do come with a cost relative to the student producing their own personal notes during lecture. Providing students with handouts or instructor's notes before lecture are can impede learning because they constrain student engagement with the material making them *less* likely to make connections between idea units that they would have otherwise made with other note-taking procedures (Peper & Mayer, 1978; 1986). Giving students access to such materials before lecture may dissuade students from taking generative notes in their own words, which can make their learning inefficient. Additionally, reviewing instructor notes did not impact memory performance for a later test (Fisher & Harris, 1974). The above findings support the notion that reviewing the instructor's notes is sub-optimal to reviewing your own notes, in the sense that the student cannot review the connections they made between ideas during instruction as effectively. Although untested, a possible compromise between giving students too much material in advance and not enough would be to provide students with a list of key terms or topics that will be covered in that day's lecture, and leave space for students to fill in the associated content.

What is the impact of the individual or course structure on note-taking?

There are considerations that affect note-taking beyond the physical act of

producing notes. Specifically, are there individual differences that make a learner more likely to receive learning benefits from note-taking, and does the location or structure of the course impact learning during note-taking?

Are there individual differences in note-taking and performance?

Note-taking, due to its reliance on WM, makes the learner's WM capacity critical for optimal note-taking, as both comprehension and production processes tax WM (Piolat et al., 2005). Learners with high WM capacity receive a larger memory benefit from note-taking (i.e., production) than learners with low WM capacity (Di Vesta & Gray, 1973) and also benefit more from listening and not taking notes (i.e., comprehension) than learners with low WM capacity, provided they have an opportunity to review the material before a memory test (Hadwin, Kirby, & Woodhouse, 1999). The benefits high WM individuals receive from comprehension and production may be due to the fact that high WM capacity individuals can adopt different strategies of note-taking more easily than low WM capacity individuals, which may reduce the amount cognitive effort needed to take notes. However, individuals with low WM capacity can offset note-taking differences by reducing the amount of cognitive load associated with production by using a laptop to take notes, in favor of dedicating additional resources to comprehension (Bui et al., 2013). Additionally, students with learning disabilities associated with WM deficits can be trained on note-taking techniques, which ultimately improve achievement measures, the quantity of notes produced, and the quality of notes produced (Boyle & Rivera, 2012).

Does course structure or the context of note-taking matter?

The physical location, or context, of where instruction and note-taking occurs is also an important consideration regarding the effectiveness of learning during note-taking. While the most common location for note-taking would be an actual classroom which may confer more immersive and interactive benefits than other environments, potential distractors from other students may influence the individual student's ability to learn and take-notes effectively (Sana et al., 2013; but see Aguilar-Roca et al., 2012). An alternative environment for note-taking is online lectures, or a hybrid course that combines residential and distance learning. Recently, websites such as Coursera and edX have been offering free-to-enroll online courses, making higher education more widely available, yet this comes at the cost of placing a greater responsibility on the student to effectively regulate their own learning. Bjork, Dunlosky, and Kornell (2013) recently reflected on the importance of self-regulated learning, especially in the context of online courses in which faculty oversight of students is minimal, if not entirely absent. Online learning, depending on where the student is physically learning the material, also comes with the possibility of additional distractions relative to traditional classrooms (for a review, see Szpunar, Moulton, & Schacter, 2013). Although research on distance learning is relatively new, effective note-taking is likely one critical factor that may determine a student's success in such courses (e.g., course performance, attrition rates, etc.).

After lecture, what is the optimal method for reviewing notes?

One of note-taking's largest benefits is the opportunity for the student to review their own notes (Carter & Van Matre, 1975). Learning occurs during the construction and

review of notes, because during both events learners are able to make new connections or strengthen connections between ideas, allowing for deep processing of content (Piolat et al., 2005). Reviewing notes after some time has passed since instruction, but before taking a test on the content covered in notes, tends to reduce some performance differences between note-taking styles and methods used (e.g., pen and paper vs. laptop-based notes), but still leads to superior performance over those that do not take notes initially (Bohay, Blakely, Tamplin, & Radvansky, 2011). Review opportunities can even reverse established note-taking effects, such as test performance based on whether notes were conceptually organized or transcribed by the learner during lecture (Bui et al., 2013). Additionally, producing your own notes and reviewing them appears to be more beneficial to long-term learning than reviewing another's notes, due to the generative processing that occurs during review, facilitating internal connections (Kiewra, 1985; 1987).

The most important issue associated with reviewing notes is how to optimally review and better retain content. The largest factor associated with optimal review is for the learner to transform their notes in some interactive way, rather than simply reading or copying their notes (Bjork et al., 2013). For example, the quality of summaries produced by learners after reviewing their notes was the best predictor of later test performance, which was an even better predictor than differences in WM capacity (Hadwin et al., 1999). Overall, it appears that many methods or exercises that encourage learner interaction or engagement with content during review improves learning, even the act of trying to understand a peer's notes has been found to be beneficial (Kiewra, 1989).

One effective method for reviewing notes is though retrieval practice or self-

testing. Several works, both theoretical and applied, have investigated the effectiveness of practice testing on learning outcomes (e.g., McDaniel et al., 2011; Roediger & Karpicke, 2006; Zaromb & Roediger, 2010). By testing yourself, retrieval pathways are strengthened, slowing the forgetting rate of content and making successful retrieval in the future more likely (Bjork, 1975). However, many students are either unaware or do not fully appreciate the benefits of testing on learning. In a survey of psychology undergraduates, a majority reported that they felt testing (or quizzing themselves) helped them to figure out what information they had learned while studying. While testing does provide the learner with feedback that is metacognitively informative, it also confers a secondary (and perhaps more valuable) benefit in that it helps students learn content better than rereading would (Kornell & Bjork, 2007). By reviewing notes in a way that functions as a test or retrieval event, a student can effectively study in a way that will benefit long-term retention. Although adapting notes into flashcards seems like an obvious review method, Cornell Notes may lend themselves to self-testing seamlessly. By covering the "notes" portion of a page in a Cornell Notes format, students can use the questions and keywords on left portion of the page as a cue to retrieve the information from memory. After, the student can write down their responses and compare their answers to their original notes. When the student has successfully retrieved the information in their notes, they will have the much more likely to accurately retrieve the content when it is needed (i.e., during an exam).

The last recommendation for reviewing notes is to do so early and often. By early, students should review their notes, even if only briefly, shortly after creating them (ideally, the same day). Doing so provides the opportunity to clarify any ambiguities or

questions that may linger from notes before they are forgotten and eclipsed by new content. Returning to the Cornell format, reviewing your notes early would give a student the opportunity to write brief summaries at the bottom of each page which would function as both an opportunity to review and a retrieval event for that content. By reviewing often, students should space out their study sessions. Spacing out the frequency of study events, rather than study all content in one large review session (i.e., cramming), information is forgotten to a degree and needs to be relearned. This relearning process is valuable because, although counterintuitive, benefits long-term learning and retention (Bjork & Allen, 1970; Whitten & Bjork, 1977, Zechmeister & Shaughnessy, 1980). By spacing study sessions out over time, a student can also prepare for later lectures within a course, by orienting himself with the topics covered in previous lectures which will help him in identifying recurring course themes or concepts. Additionally, studying in a spaced fashion can also keep students engaged during subsequent lectures and assist with identifying important information that they should take notes on while in lecture.

Suggestions for students and instructors

Keeping in mind the research discussed above, as well as several university resources offered to students on note-taking, this penultimate section summarizes suggestions for both students and instructors. In no particular order, these suggestions are by no means all-encompassing, but they capture the ideas supported by empirical research.

For students:

- **Take generative notes.** Taking notes in your own words means you will actively

think about lecture content (i.e., comprehension), which may facilitate retrieval of information from lectures or texts during review sessions. By comparison, taking notes verbatim or transcribing every word the instructor says is maladaptive as it dedicates too many cognitive resources towards production, reducing the effectiveness of learning during the note-taking process. Importantly, notes should be made brief, yet understandable, reflecting your comprehension of the material and providing you with a condensed resource for future review.

- **Review early and often.** Review your notes shortly after lecture—clarify any questions or ambiguities you may have lingering from lecture, either by consulting peers, instructors, course materials, etc. Ideally, this brief review should occur on the same day of the lecture, and can assist you in identifying what is important from lectures/texts and help you take higher quality notes in future instances. Write down any questions or important keywords in margins, and try to write brief summaries of your notes' contents at the bottom of each page (Cornell Notes are ideal for this review method). Additionally, spacing your learning over several study sessions is more effective for long-term learning than cramming all of your studying at once. Regular review also provides you with the added opportunity to familiarize yourself with course topics before subsequent lectures, aiding your ability to comprehend content during class.

- **Test yourself.** Although counterintuitive, testing yourself is an effective strategy for learning and retaining course content relative to passively rereading content from your notes. Self-testing with feedback also identifies what content you do and do not know, helping you detect what material you still need to review. By

taking notes in such a way that allows you to keep track of your questions and important topics, you will have a built-in method to test yourself during study (i.e., recall or write down what content is related to that topic). The Cornell Note format effortlessly loans itself to this self-testing process. Whenever possible, try incorporating some version of self-testing into your study sessions.

- **Carefully consider how you want to take notes.** Specifically, think about whether you would prefer taking notes on pen and paper or with a laptop, as there are costs and benefits to each. Given the constraints on handwriting (e.g., fewer words per minute than typing) you are forced to be more selective in what you write down (which may assist with taking notes in your own words), but makes you at risk for missing important lecture topics. However, there is a temptation to transcribe lecture content verbatim with a laptop, and you may find yourself recording more information in your notes than you would otherwise (making your notes too dense and a less effective study aid). There is also the additional temptation to multi-task on other things besides taking notes with laptop use (e.g., checking email), which may not only distract yourself from learning but others around you.

- **Be careful of misperceptions during learning.** As learners, we are often deceived into thinking that content presented during lectures, if it is easy to understand or fluent, will be memorable. Avoid this misperception! Such faulty thinking can lead to poor study behaviors or decisions (e.g., not taking notes on important material). Although much of the research on effective note-taking and learning may be counter-intuitive to common practices, try incorporating some of

these techniques into your own study habits for more effective learning and long-term retention.

For instructors:

- **Explain your rationale for course policies.** As mentioned, many practices for effective note-taking may be counter-intuitive to learners. If you wish to incorporate any policies into your course that may improve student learning, you should explain your rationale those policies at the beginning of the term, especially if, according to common sense, structuring the course in that fashion seem *less* effective (e.g., talk about the empirical research that support those behaviors). Also students may be resistant to such policies, even if structuring your class in such a way may help students retain course content and ideas better than they otherwise would.

- **Provide students with material before lecture to orient them towards important ideas or topics.** Providing students material to familiarize themselves with prior to lecture may help with learning during class, even if the material is minimal. By giving students the opportunity to review before class, they can orient themselves to the topics covered, which in turn will assist them in creating higher quality notes than they may have otherwise. Importantly, these materials should not be so thorough that students will elect to not take notes during class, as taking notes in their own words is important component for their learning. For example, providing students with a list of key terms prior to that lecture with space to fill in the associated content would be an acceptable compromise for most students. If you wish to provide students with more thorough materials (e.g.,

lecture slides), make those materials available after class.

- **Encourage students to take notes in their own words.** As mentioned, creating selective or condensed notes is an important learning tool and skill for students to develop. Rather than frantically transcribe every word you say, students should try to actively think about the material and comprehend it before committing the information to their notes. Provided students are not changing the meaning of the information, you should encourage them to write their notes in a way that will make sense to them during review, as it will facilitate student learning in your course. Providing students with comprehensive lecture slides prior to class may impede the development of this skill, as students may be less likely to take notes in their own words (or choose not to take notes entirely), and therefore this practice should be avoided when possible.

- **Help make connections between current and past content.** One way to improve student learning in your course is to help students make connections between content of the day's lecture with previously discussed topics. Doing so will help students to appreciate the inter-relatedness between ideas and concepts in your course. Additionally, making these connections or encouraging students to make such connections independently may assist students in retrieving course ideas (e.g., during an exam). Illuminating the relationships or similarities between ideas will facilitate the retrieval of such related information in the future.

- **Carefully consider a laptop policy in your classroom.** While many students value their computers as a note-taking device, they are a potential source of distraction for both students that use them as well as students adjacent to a laptop

user. Although many students and instructors may find the benefits of laptop use to outweigh the cost, the risks to students that choose to take notes with pen and paper should be considered as well. While a no-laptop policy in class is likely too harsh and will be met with resistance, a laptop-approved section of the classroom seems to be a suitable compromise. By requesting laptop-users to sit in a specific area of the classroom, you can potentially limit any negative impact laptop note-takers on their pen and paper neighbors.

Future directions and conclusion

Although the current research and findings on note-taking are broad, there are still many questions that need to be investigated and explored further. Relevant to higher education, it is unclear whether students' note-taking skills change during the course of their college education, and whether those changes beneficially impact their learning. As the distribution of instructor-created handouts and notes becomes a more common practice in higher education, researchers should investigate how note-taking practices are changing in the current generation of students, as advances in technology (and its adaptation into the modern classroom, see Box 1) make information more readily available for learners (van der Meer, 2012). Such technological advances may also make instructors question whether the development student note-taking skills are worthwhile, as more "standardized" notes become available for students to review. However, the physical act of creating and producing notes during instruction does confer a learning benefit which technological advances may never be able to replace (Bohay et al., 2011; Kiewra, 1989; Kiewra et al., 1991; Kobayashi, 2005; Peper & Mayer, 1978; Piolat et al.,

2005; Rabionwitz & Craik, 1986). The effectiveness of note-taking for online courses should also be further investigated and compared to note-taking practices in residential courses, as added distractions outside of traditional classrooms emphasize the need for students to become better at monitoring and self-regulating their own learning (Bjork et al., 2013). As more students opt into online courses and Internet access becomes more widespread, instructors may also see more collaborative note-taking environments created by learners, in which groups of students construct notes simultaneously using online platforms (e.g., Google Drive; see Valtonen, Havu-Nuutinen, Dillon, & Vesisenaho, 2011). The impact of such collaborative note-taking on individual learning should be investigated.

Additionally, future work should investigate the self-reflective, or metacognitive, components of note-taking. Many students (especially as they begin their college education) question why some instructors do, or do not, provide instructor notes or handouts, or handouts that are incomplete that students need to fill-in during instruction, nor do learners understand the benefits conferred by such course practices (van der Meer, 2012). Instructors rarely explain their motivation or reasons for instituting particular course policies, nor how they would expect students to take notes and optimize their learning for the material covered (reflecting an oversight in the instructor's awareness). As a means to improve learner understanding and note-taking, instructors should be encouraged to take a moment during one of the first few lectures to explain their policies on instructor notes or handouts and why the policy was designed in that particular way, as well as briefly discuss ways to optimize student learning in their course (especially for introductory courses or courses designed for first year college students).

Note-taking is an acquired skill that improves student learning and retention of information in a variety of domains and subjects. Importantly, comprehension and production processes (which both require working memory resources) are needed simultaneously for optimal learning to occur, making effective note-taking difficult to accomplish. The methods of assessment for notes can be relatively subjective or inconsistent from one study to the next, which makes it difficult to uniformly capture what makes for high-quality notes. Many other aspects of note-taking such as the style or format of notes, different mediums (pen and paper, laptop, handouts), the physical setting, and the act of reviewing notes (including how those notes are reviewed) all have the ability to impact the student learning and understanding of course content. These factors need to be considered carefully by both students and instructors alike, especially given rapid advances in technology and reforms to higher education.

A Note on hybrid note-taking systems

A hybrid note-taking system is any hardware or software that combines the advantages of laptop and pen and paper note-taking. Although many forms and variations of hybrid systems exist, this review outlines three such systems. Importantly, many of these systems have yet to be assessed in terms of how they may affect note-taking behaviors and long-term learning:

● Livescribe (starts at $100) – Livescribe is a smartpen that records audio on a microphone and memory stick built into the pen as the learner takes notes. This system also includes a camera built into the tip of the smartpen to identify what is being written down on a second by second basis. The advantage of this system is it

allows the learner to record the lecture and easily replay particular portions of the lecture by tapping the physical figure or words written in their notes. Additionally, the file can be uploaded (either through a wired or wireless connection, depending on the model of smartpen) to a computer allowing the learner to review the lecture and watch a video of their notes being re-created line by line in sync with the lecture audio. The largest drawback to this system is that notes have to be written on specialized dot paper, which can be either created at home via a printer or purchased.

- Evernote (free, or $5 per month to $45 per year) – Evernote is an application that allows you to store files online, making review any digital or scanned document relatively easy on a computer, tablet, or smartphone. By allowing users to create folder and tags, the user can quickly find the desired documents needed. Evernote is also a "master" application that can connect with several other linked applications (including files from Livescribe) that can allow the user to review notes anywhere. Additionally, the user can also use applications such as Penultimate on a tablet to create handwritten notes. The largest issue with Evernote is that it was not specifically designed for note-taking, but rather for storing all files digitally (text, audio, video, etc.) in one place. Although a learner could use Evernote exclusively for note-taking and be relatively productive, more simplified systems may be ideal.

- Audionote ($5) – Audionote is an application that uses some of the elements from Livescribe, but in a tablet format. Audionote allows the learner to start a recording and take notes on their tablet at the same time using a keyboard, while also allowing the user to draw figures or other relevant non-text information using either their finger or a stylus. Like Livescribe, Audionote allows learners to review the audio

recorded, watch a video of the notes being re-created in sync with the audio, and review specific sections of the audio by touching the associated content in the notes. The main drawbacks to this system are that it is relatively inefficient switching between typing notes with a tablet and physically drawing figures, and Audionote is an application optimized for tablets, due to the nature of how it functions (although similar applications are available for laptops).

References

Aguilar-Roca, N. M., Williams, A. E., & O'Dowd, D. K. (2012). The impact of laptop-free zones on student performance and attitudes in large lectures. *Computers & Education*, *59*(4), 1300–1308. doi:10.1016/j.compedu.2012.05.002

Baddeley, A. (2000). The episodic buffer: A new component of working memory? *Trends in Cognitive Sciences*, *4*, 417–423.

Bjork, R. A. (1975). Retrieval as a memory modifier. In R. Solso (Ed.), *Information processing and cognition: The Loyola Symposium* (pp. 123-144). Hillsdale, NJ: Lawrence Erlbaum Associates.

Bjork, R. A., & Allen, T. W. (1970). The spacing effect: Consolidation or differential encoding? *Journal of Verbal Learning and Verbal Behavior*, *9*, 567-572.

Bjork, R. A., Dunlosky, J., & Kornell, N. (2013). Self-regulated learning: Beliefs, techniques, and illusions. *Annual Review of Psychology, 64*, 417-444.

Bohay, M., Blakely, D. P., Tamplin, A. K., & Radvansky, G. A. (2011). Note taking, review, memory, and comprehension. *The American Journal of Psychology*, *124*, 63–73. doi:10.5406/amerjpsyc.124.1.0063

Borbone, M. (2009). From doodle to Google: Exacerbating old problems or causing new ones? The relationship between laptop usage and in-class student behavior. Master's Thesis. University of North Carolina at Chapel Hill: Chapel Hill, North Carolina.

Boyle, J. R., & Rivera, T. Z. (2012). Note-taking techniques for students with disabilities a systematic review of the research. *Learning Disability Quarterly*, *35*, 131–143. doi:10.1177/0731948711435794

Bui, D. C., Myerson, J., & Hale, S. (2013). Note-taking with computers: Exploring alternative strategies for improved recall. *Journal of Educational Psychology, 105*, 299-309. doi: 10.1037/a0030367

Carter, J. F., & Van Matre, N. H. (1975). Note taking versus note having. *Journal of Educational Psychology*, *67*, 900–904. doi:http://dx.doi.org/10.1037/0022-0663.67.6.900

Di Vesta, F. J., & Gray, G. S. (1973). Listening and note taking: Immediate and delayed recall as functions of variations in thematic continuity, note taking, and length of listening-review intervals. *Journal of Educational Psychology, 64*, 278-287.

Fisher, J. L., & Harris, M. B. (1974). Note Taking and Recall. *The Journal of Educational Research*, *67*, 291–292. doi:10.2307/27536604

Fried, C. B. (2008). In-class laptop use and its effects on student learning. *Computers and Education, 50*, 906–914.

Hadwin, A. F., Kirby, J. R., & Woodhouse, R. A. (1999). Individual differences in notetaking, summarization, and learning from lectures. *The Alberta Journal of Educational Research, 45*, 1-17.

Hartley, J. (2002). Notetaking in non-academic settings: A review. *Applied Cognitive Psychology*, *16*, 559–574. doi:10.1002/acp.814

Huxham, M. (2010). The medium makes the message: Effects of cues on students' lecture notes. *Active Learning in Higher Education*, *11*, 179–188. doi:10.1177/1469787410379681

Jacobs, K. (2008). A comparison of two note taking methods in a secondary English classroom. Retrieved from http://soar.wichita.edu/handle/10057/1388

Kiewra, K. A. (1985). Investigating note taking and review: A depth of processing alternative. *Educational Psychologist, 20*, 23-32.

Kiewra, K. A. (1987). Note taking and review: The research and its implications. *Journal of Instructional Science, 16*, 233-249.

Kiewra, K. A. (1989). A review of note-taking: The encoding-storage paradigm and beyond. *Educational Psychology Review, 1*, 147-172.

Kiewra, K. A., DuBois, N. F., Christian, D., McShane, A., Meyerhoffer, M., & Roskelley, D. (1991). Note-taking functions and techniques. *Journal of Educational Psychology, 83*, 240-245.

Kobayashi, K. (2005). What limits the encoding effect of note-taking? A meta-analytic examination. *Contemporary Educational Psychology, 30*, 242-262.

Kornell, N., & Bjork, R. A. (2007). The promise and perils of self-regulated study. *Psychonomic Bulletin & Review*, *14*(2), 219–224.

Manalo, E., Uesaka, Y., Pérez-Kriz, S., Kato, M., & Fukaya, T. (2013). Science and engineering students' use of diagrams during note taking versus explanation. *Educational Studies*, *39*, 118–123. doi:http://dx.doi.org/10.1080/03055698.2012.680577

McDaniel, M. A., Agarwal, P. K., Huelser, B. J., McDermott, K. B., & Roediger, H. L. (2011). Test-enhanced learning in a middle school science classroom: The effects of quiz frequency and placement. *Journal of Educational Psychology*, *103*(2), 399–414. doi:10.1037/a0021782

Middendorf, C. H., & Macan, T. H. (2002). Note-taking in the employment interview: Effects on recall and judgments. *Journal of Applied Psychology*, *87*, 293–303. doi:http://dx.doi.org/10.1037/0021-9010.87.2.293

Muller, P. A., & Oppenheimer, D. M. (in press). The pen is mightier than the keyboard: Advantages of longhand over laptop note-taking. *Psychological Science*.

Peper, R. J., & Mayer, R. E. (1978). Note taking as a generative activity. *Journal of Educational Psychology, 70*, 514-522.

Peper, R. J., & Mayer, R. E. (1986). Generative effects of note-taking during science lectures. *Journal of Educational Psychology, 78,* 34-38.

Peverly, S. T. (2006). The importance of handwriting speed in adult writing. *Developmental Neuropsychology*, *29*, 197–216. doi:10.1207/s15326942dn2901_10

Piolat, A. (2001). La prise de notes [Note Taking]. Paris: Presses Universitaires de France.

Piolat, A., Olive, T., & Kellogg, R. T. (2005). Cognitive effort during note taking. *Applied Cognitive Psychology, 19*, 291-312.

Rabinowitz, J. C., & Craik, F. I. M. (1986). Specific enhancement effects associated with word generation. *Journal of Memory and Language, 25,* 226–237. doi:10.1016/0749-596X(86)90031-8

Robin, A., Foxx, R. M., Martello, J., & Archable, C. (1977). Teaching note: Taking skills to underachieving college students. *The Journal of Educational Research*, *71*, 81–85. doi:10.2307/27537081

Roediger, H. L., & Karpicke, J. D. (2006). The Power of Testing Memory .: Basic Research and Implications for Educational Practice. *Perspectives on Psychological Science*, *1*(3), 181–210. doi:10.1111/j.1745-6916.2006.00012.x

Sana, F., Weston, T., & Cepeda, N. J. (2013). Laptop multitasking hinders classroom learning for both users and nearby peers. *Computers & Education*, *62*, 24–31. doi:10.1016/j.compedu.2012.10.003

Strub, T., & McKimmie, B. (2012). Note takers who review are less vulnerable to the influence of stereotypes than note takers who do not review. *Psychology, Crime & Law*, *18*, 859–876. doi:10.1080/1068316X.2011.581241

Szpunar, K. K., Moulton, S. T., & Schacter, D. L. (2013). Mind wandering and education: From the classroom to online learning. *Frontiers in Perception Science*, *4*, 1-7. doi:10.3389/fpsyg.2013.00495

Valtonen, T., Havu-Nuutinen, S., Dillon, P., & Vesisenaho, M. (2011). Facilitating

collaboration in lecture-based learning through shared notes using wireless technologies. *Journal of Computer Assisted Learning*, *27*, 575–586. doi:10.1111/j.1365-2729.2011.00420.x

Van der Meer, J. (2012). Students' note-taking challenges in the twenty-first century: Considerations for teachers and academic staff developers. *Teaching in Higher Education*, *17*, 13–23. doi:10.1080/13562517.2011.590974

Vekaria, P. C. (2012). Lecture note-taking in postsecondary students with self-reported attention-deficit/hyperactivity disorder. *Dissertation Abstracts International: Section B: The Sciences and Engineering*, *72*, 4333.

Whitten, W. B., & Bjork, R. A. (1977). Learning from tests: The effects of spacing. *Journal of Verbal Learning and Verbal Behavior*, *16*, 465-478.

Willams, R. L., & Eggert, A. C. (2002). Notetaking in college classes: Student patterns and instructional strategies. *The Journal of General Education*, *51*, 173-199.

Zaromb, F. M., & Roediger, H. L. (2010). The testing effect in free recall is associated with enhanced organizational processes. *Memory & Cognition*, *38*(8), 995–1008. doi:10.3758/MC.38.8.995

Zechmeister, E. B., & Shaughnessy, J. J. (1980). When you know that you know and when you think that you know but you don't. *Bulletin of the Psychonomic Society, 15*(1), 41-44.