Examining increasing playback speed in recorded lectures on memory, attention, and experience

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Abstract

Recorded lectures represent a popular means of delivering educational content. These lectures afford increasing the playback speed which could be used to reduce time demands and increase the likelihood that a lecture is consumed. In two experiments (*N* = 320), we examined the impact of increasing the playback speed of lectures across a range of speeds on memory for the lecture material, mind wandering, and the learner's experience of the lecture. For speeds up until 2x, findings revealed no significant differences in memory for the material, mind wandering, and learner's subjective experience of the lecture, with the exception that "enjoyment of speed" decreased as speed increased. Beyond a speed of 2x, however, significant impairments in memory for the lecture material and decreases in liking towards both the video lecture and the speed were observed. Moreover, the increase in mind wandering with time on task often observed in recorded lectures was not modulated by lecture playback speed. These results reinforce extant results in the literature on the effects of increasing playback speed on memory for lecture material and add new insights in terms of this strategy's influence on mind wandering and learner's subjective experience of the lecture.

Keywords: increasing playback speed, recorded lectures, memory for lecture material, mind wandering, subjective experience

1. Introduction

With the commencement of the digital age, we have seen the emergence and popularization of novel forms of communicating educational content (Beetham & Sharpe, 2007). One particularly salient example is the recorded lecture, typically viewed online. With online courses increasing in popularity (e.g., Coursera, Khan Academy) and the COVID-19 pandemic forcing much of education to the online realm, this mode of communicating educational content has now become commonplace. Indeed, it might be hard nowadays to find a post-secondary student who has not consumed a recorded lecture before.

While most recorded lectures resemble those one might have encountered in a live lecture hall, the affordances differ significantly. For instance, a recorded lecture allows the instructor or the learner to increase the playback speed of the lecture. This can reduce the time demands placed on the learner, potentially increasing the likelihood that the content is consumed. Consistent with this idea, Lang et al., (2020) demonstrated in a large study of online learners that those that had their video's defaulted to 1.25x the speed of the original lecture attempted more course content and did better in the course overall. While the latter results are encouraging, there remains much to understand about the influence of increasing playback speed. For example, in a recent review of research on increasing playback speed, Cheng et al., (2022) concluded, "More studies are in critical need to examine the effect of different speeds on student's cognitive, affective, and behavioral learning outcomes." (p. 17). In the present investigation, we extend previous research by examining the effects of different recorded lecture speeds on memory for the lecture material, attention, and the subjective experience of the video lecture across two experiments.

1.1. Theoretical Frameworks

Cognitive load represents a key construct in the Cognitive Load Theory and the Cognitive Affective Theory of Learning with Media (e.g., Mayer & Moreno, 1998; 2003; Paas et al., 2003; Sweller, 2011). With learners having a limited cognitive capacity, instructional design needs to ensure that the task load is within that limited capacity. Increasing the playback speed of a lecture can increase task load, a form of extraneous load. That is, while the intrinsic properties of the to-be-learned information remains unchanged, the rate of the information uptake has increased. Risko et al., (in press) recently found that both self-reported invested effort and required effort increased in a 1.5x condition relative to a 1x condition. Whether this increase in task load impairs memory for lecture material is likely a product of a number of factors (e.g., how much it is increased, the learner's background knowledge, the intrinsic complexity of the material) that need to be further investigated. In the Cognitive Affective Theory of Learning with Media (Moreno & Mayer, 2007), the learner's experience of the lecture can also be considered to play a critical role in learning via its influence on cognitive engagement. For example, according to the affective mediation hypothesis, affect influences learning through its influence on cognitive engagement. Negative learning experiences are unlikely to encourage the requisite cognitive engagement needed for learning. From this theoretical perspective, understanding how elements of instructional design impact affect and engagement can provide important insights into learning. Thus, in the present investigation we examine how increasing the playback speed of a lecture impacts learning (memory), engagement (via mind wandering), and the learning experience (affect). The goal of the present investigation was to both closely extend (i.e., conceptually replicate) and add novel insights to the emerging literature on the influence of increasing playback speed on learning from recorded lectures. Theoretically, playback speed represents a novel variable to examine. Existing literature suggests that it can influence several factors related to learning (i.e., subjective load, attention, affect). In addition, investigating playback speed across a range of speeds can provide novel insight into interactions between learning and task load. For example, as discussed further below, increases in playback speed often do not impact memory, suggesting that learners can manage increases in load in a manner that does not negatively impact learning.

1.2 Increasing the Playback Speed of Recorded Lectures: Effects on Memory

Although it is technologically feasible to increase the playback speed of a recorded lecture, there is reasonable concern that this increase might impair learner's memory for lecture material. While speech is normally transmitted at approximately 150 words per minute (WPM; Benz, 1971; Nichols & Stevens, 1957), humans are able to understand speech at a faster rate, with studies demonstrating that speech may be increased to 200-300 wpm with minimal loss in comprehension (Foulke & Sticht, 1967; 1969). Recently, researchers have extended this line of research to the investigation of increasing playback speed on learning material in the context of recorded lectures (e.g., Nagahama & Morita, 2017; 2018). Results have been generally consistent with this earlier work. For example, Nagahama and Morita (2017) compared speeds of 1x (i.e., normal speed), 1.5x and 2x using voice over presentation slides. The authors found scores on a memory test to be higher in the 1.5x condition than in the 1x condition with no differences between the 1x and 2x conditions or between the 1.5x and 2x conditions (see also Nagahama & Morita, 2018). In a study conducted by Ritzhaupt et al., (2015), university participants were randomly assigned to watch one of six videos at speeds of 1x, 1.25x, and 1.5x with captions in three of the videos and no captions in the other three. Across video speeds, no significant differences in learner performance were found (see also Ritzhaupt et al., 2008).

While in many studies increasing lecture playback speed appears to have little effect on memory for learning material, this is not always the case, particularly as lecture speeds increase (e.g., Cheng et al., 2022). For example, Pastore (2012) compared 1x, 1.25x, and 1.5x and found that those in the 1x and 1.25x outperformed those in the 1.5x condition. Wilson et al., (2018) compared a 1x condition to a 1.6-1.7x condition and in one experiment, no significant impact of speed on comprehension in a group of undergraduates who were likely to have experience with the lecture material was found, but a significant impact of speed on comprehension in a subsequent experiment in a sample with less prior knowledge was found. Jacobson et al., (2018) moved beyond 2x by comparing speeds of 1x, 2x, and 3x. Performance on memory tests in the 1x and 2x conditions were comparable but in the 3x condition, decreases in performance were found. Murphy et al., (2022) also examined speeds beyond 2x comparing 1x, 1.5x, 2x, and 2.5x conditions in a group of undergraduate students. While minimal costs in terms of memory performance were found when increasing speeds from 1x to 1.5x to 2x, a decline in performance was evident in the 2.5x condition. Lastly, Ritzhaupt and Barron (2008) examined learner's ability to recall and recognize information on Australian destinations when they were presented at one of four speeds: 1x, 1.5x, 2x, and 2.5x. While there were no statistically significant differences in cued-recall and content recognition tasks across the 1x, 1.5x, and 2x conditions, statistically significant differences were found at 2.5x the normal speed, where students performed lower. Taken together, these studies (and others Murphy et al., 2022; 2023; Risko et al., in press; Yang et al., 2020) suggest that lectures can be sped up to 1.5x and possibly up to 2x with either no cost or a small cost to learning but beyond that, costs in terms of memory performance start to emerge. The present investigation further examines the effects of increasing the playback speed on memory for lecture material across 7 speeds (1x, 1.25x, 1.5x, 1.75x, 2x, 2.5x, 3x) via two experiments.

From a task load perspective, the lack of a cost at moderate amounts of increasing playback speed might suggest that at the typical speaking rate (e.g., approximately 150 wpm), there exists sufficient spare processing capacity to absorb the increases in load associated with increasing the playback speed moderately, but that a sufficiently speeded lecture will impair performance (i.e., induce cognitive overload). Consistent with this idea, as noted above, Risko et al (in press) found an increase in self-reported effort in a speeded condition and, importantly, this was true even in an experiment where there was no test performance cost. To the extent that the increases in extraneous load can be absorbed into "slack," increasing playback speed arguably represents an adaptive strategy given the time savings. Thus, individuals might have had sufficient processing capacity to increase their effort investment without a cost to performance.

1.3. Increasing the Playback Speed of Video Lectures: Effects on Attention

While research on increasing playback speed for video lectures has focused largely on learning material presented in lecture, increasing playback speed may also impact other features of the learning experience. Here we focus on attention as an index of engagement. As noted above, the Cognitive Affective Theory of Learning with Media identifies engagement as an important factor in multimedia learning. Provided the important role that attention plays in learning, understanding how increasing playback speed might influence learner's ability to sustain attention is critical.

One common means of measuring attention in lectures is via mind wandering probes (e.g., Kane et al., 2017; Wammes & Smilek, 2017). As defined by Smallwood and Schooler (2006), mind wandering represents a decoupling of attention from an external stimulus to internal thoughts. The previously mentioned research by Wilson et al., (2018) also explored the effects of increasing playback speed on mind wandering. As participants watched the lectures, one at a normal speed and one at an accelerated speed (1.6-1.7x), participants responded to periodic mind wandering probes, asking them if they were intentionally or unintentionally mind wandering. Intentional mind wandering was defined by the authors as “thoughts which are deliberately experienced that are not related to the material presented, for example, consciously thinking about what you will be making for dinner.” Unintentional mind wandering was defined as “thoughts which are spontaneously experienced that are not related to the material presented, for example, a random thought about your friend coming to mind.” (Wilson et. al., 2018). In Experiment 1, there was no effect of speed on overall mind wandering, but increasing playback speed did lead to a reduction in unintentional mind wandering. In Experiment 2, there was again no effect of speed on overall mind wandering but there was an increase in intentional mind wandering in the speeded condition. Murphy and colleagues (2023) also examined the effects of increased video speeds (0.75x, 1x, and 2x) on mind-wandering in younger and older adults in two experiments. Participants watched the video at one of the three speeds, with mind wandering probes appearing every 60 seconds, asking participants to describe their current cognitive state using 1 of 5 options (e.g., focused on current task, thinking about performance on task or how long it is taking, distracted by information present in room, zoning out/mind wandering, or other). Results revealed that older adults reported less mind-wandering than younger adults and overall, as the speed increased, the mind wandering reported by participants decreased. Murphy and colleagues conducted another experiment with different materials, but in contrast to the previous experiment, video speed did not affect mind-wandering rates. Thus, the limited research on mind wandering and increasing playback speed to date has been mixed but suggests that increasing the playback speed of a lecture might impact mind wandering and that the influence of increasing playback speed on mind wandering might differ based on whether that mind wandering is intentional versus unintentional, though no clear theoretical predictions are available in the case of increasing the playback speed. Moreover, the limited research to date on increasing the playback speed and mind wandering has not examined increasing the playback speed across a range of speeds. Thus, the present investigation examines the effects of increasing playback speed on mind wandering across seven speeds via two experiments.

One unique opportunity afforded by investigating mind wandering as a function of playback speed is that it could provide insight into how time on task relates to mind wandering. A number of experiments exist demonstrating that mind wandering increases as a function of time into a recorded lecture (e.g., Farley et al., 2013; Risko et al., 2012, 2013). That is, when watching a recorded lecture, individuals mind wander more towards the end of the lecture relative to the beginning. This kind of pattern might reflect attention waning as a function of the amount of time elapsed. Alternatively, this kind of pattern might reflect attention waning as a function of the information consumed. Critically, when playback speed is increased, these two potential explanations can be contrasted because the amount of information consumed remains constant (in principle) while the information consumption rate varies (i.e., rate increases as playback speed increases). For example, if individuals mind wander more towards the end of the lecture relative to the beginning because of the amount of information consumed, then increasing the playback speed to 2x should produce a similar increase in mind wandering despite the fact that the lecture now takes half the time to view. This is because the amount of information consumed is the same in both the 1x and 2x condition, even though the amount of time that the individual needs to invest is now cut in half. On the other hand, if individuals mind wander more towards the end of the lecture relative to the beginning because of the amount of time passed (or a factor directly related to the amount of time passed), then increasing the playback speed would represent a useful mitigation strategy as it shortens the lecture. Understanding why mind wandering increases over time in recorded lectures is central to developing a means of mitigating the potential negative impact of this pattern of waning attention.

1.4 Increasing the Playback Speed of Recorded Lectures: Effects on Learner's Subjective Experience of the Lecture

As noted above, in the Cognitive Affective Theory of Learning with Media, individuals' affective experience is a critical feature of multimedia learning. Research on the influence of increasing playback speed on recorded lecture consumption has also featured various measures of the learner's subjective experience of the lecture. These measures provide a critical window into the lecture experience. In Wilson et al., (2018), they found no differences in participants' perceptions of effort, interest, benefit, or difficulty of the lecture between the two playback speed conditions. However, those who watched the speeded lecture were marginally less likely to choose a course presented like the one they just watched, and individuals who watched the speeded lecture were significantly less likely to choose to watch a lecture at that pace in the future. They also perceived a more negative impact of speed on understanding and reported lower enjoyment of the speed of the lecture. In a similar vein, Risko et al., (in press) showed decreases in liking, in the likelihood of watching a lecture in the same format in the future, and an increase in negative affect when lectures were sped to 1.5x. In Nagahama and Morita (2017), participants were asked to rate the degree to which they liked the video speed and the duration of the video lectures. Results revealed that in both the 1x and 1.5x conditions, liking of the video playback speed and the duration of the video were rated more favorably than in the 2x condition. Taken together, participant's evaluations of playback speed appear mixed for modest increases in playback speed and seemingly turn more clearly negative around 2x the normal speed. That said, we know little about evaluations of playback speed beyond 2x and there has been limited consistency in the type of items asked across the speeds available. Thus, the present investigation examines the effects of increasing playback speed across a large range of speeds using the same items to index the participant's subjective experience.

1.5 *Present Investigation*

In the present study, we report a comprehensive investigation of the effects of increasing recorded lecture speeds on memory for the lecture material, attention, and learner's subjective experience of the lecture. As reviewed above, while there are some emerging consistencies in the literature, in particular with respect to memory for lecture material, a need for additional clarity remains, especially for speeds beyond 2x the normal rate and for attention and subjective experience. While previous studies have looked at speeds from 1x to 3x separately, different material and methods were used. To date, there has not been one study that looked at the full range of speed using the same material and methods across a broad range of measures. Doing so allows us to examine how memory, attention, and subjective experience change as playback speeds increase. Our research questions are thus as follows:

1. How is memory for recorded lecture material impacted by increases in playback speed ranging from 1.25x to 3x?
2. How is mind wandering while viewing recorded lecture material impacted by increases in playback speed ranging from 1.25x to 3x?
3. How is the increase in mind wandering with time-on-task (i.e., probe number) impacted by increases in playback speed ranging from 1.25x to 3x?
4. How is the learner's subjective experience of the lecture impacted by increases in playback speed ranging from 1.25x to 3x?

Across two closely related experiments, we examined seven experimentally manipulated speeds (Experiment 1a: 1x, 1.25x, 1.5x, 1.75x, 2x; Experiment 1b: 1x, 2.5x, 3x). Participants completed two different post-tests to measure memory for the lecture material - a self-paced free recall test and a multiple-choice test. We also measured attention and how attention varied across the lecture using mind wandering probes placed throughout the video. Lastly, we examined learner's subjective experience of the lecture via a series of four post-lecture evaluation questions focusing on enjoyment of the video lecture, enjoyment of the speed of the lecture, how disruptive the mind wandering probes were, and how distracting the visual presentation was. Experiment 1a was pre-registered (https://osf.io/6uvbx). Experiment 1b was not pre-registered but followed the plan in the Experiment 1a pre-registration.

2. *Method*

2.1. Research Sample

In Experiment 1a, two hundred undergraduate psychology students (72.5% female) between the ages of 17 and 30 (M = 19.9, SD = 2.0) were recruited from the University of Waterloo for course credit. In Experiment 1b, one hundred and twenty undergraduate psychology students (59.5% female) between the ages of 18 and 46 (M = 20.64, SD = 4.0) were recruited from the University Waterloo for course credit. Table 1 includes demographic information regarding our sample including highest level of education received, as well as English proficiency in reading and listening. In both experiments, these sample sizes were chosen to give us enough power to detect medium to large effects in paired comparisons.

Table 1. Demographic information of each sample

Measure		Experiment 1a	Experiment 1b
Highest level of education	High school diploma	87.0%	83.3%
	College diploma	3.5%	3.3%
	Bachelor's Degree	9.5%	12.5%
	Masters Degree	0%	0.8%
English proficiency in reading	High proficiency	72.5%	85.0%
	Moderate Proficiency	25.5%	12.5%
	Low Proficiency	2.0%	2.5%
	No Proficiency	0.0%	0.0%
English proficiency in listening	High proficiency	73.0%	83.3%
	Moderate Proficiency	25.5%	15.8%
	Low Proficiency	1.0%	0.8%
	No Proficiency	0.5%	0.0%

There were five speed conditions, with forty participants in each condition for Experiment 1a. There were three speed conditions, with forty participants in each condition for Experiment 1b. Within each condition, there were four video lectures. Ten participants in each speed condition viewed each video lecture. In other words, for Experiment 1a, each participant saw only one of five video speeds and one of the four video lectures and for Experiment 1b, each participant saw only one of three video speeds and one of the four video lectures.

2.2. Research Design.

A between-subjects design was used. In both experiments, there was one independent variable (IV) – speed condition with Experiment 1a having five levels (1.0x, 1.25x, 1.50x, 1.75x, and 2.0x), and Experiment 1b having three levels (1.0x, 2.5x, and 3.0x).

2.3. Research Stimuli & Measures.

Four different video lectures were used in this study, two of which were lecture capture and two of which were voice over presentations. In lecture capture, the instructor is recorded while they are teaching a live lecture, with slides often used as an aid (Danielson et al., 2014; Ilioudi et al., 2013; Wiese & Newton, 2013). In voice-over presentations, audio recordings are synchronized to accompany a slide deck via specialized lecture recording software (e.g., Microsoft Producer or PowerCam; Griffin, et al., 2009). The purpose of including four different video lectures was to introduce some variability in our "items," rather than drawing conclusions based on results from one item (as most previous studies have done). This will also help to increase the generalizability of the results.

In the 1.0x speed condition, each video was approximately ten minutes. Ten minutes was chosen through a combination of sampling lecture durations from popular online courses as well as following instructional advice provided by multiple Canadian universities who suggest to keep videos approximately ten minutes. Throughout the video lecture, participants were unable to pause, play, rewind or fast forward the video. All four videos were within the Psychology field. Two videos were selected from Open Yale Psychology Courses (https://oyc.yale.edu/NODE/231), specifically from a Psychology Introduction Course taught by Professor Paul Bloom (Yale University, n.d.). The topics for these two videos included a lecture on Freud on the id, ego, and superego, as well as the theory of psychosexual development (WPM at 1x = 150) and a lecture on Skinner on habituation, and classical conditioning (WPM at 1x = 134). Another two videos were selected from an online Cognitive Psychology course and voiced by Professor Jonathan Fugelsang. The topics for these two videos included an introduction to the brain: structure and function, and static imaging and dynamic imaging techniques (WPM at 1x = 160), and a module on thinking, problem solving, and reasoning on four different domain-general problem solving techniques: the generate and test technique, means-end analysis, working backwards, and reasoning by analogy (WPM at 1x = 186). In each experiment, participants were randomly assigned to view one of the four video lectures with the constraint that across each lecture type appeared equally often in each speed.

In both experiments, the same measures were utilized. At the beginning of the study participants responded to a number of demographic questions (e.g., age, gender, education), were asked about the number of online courses they had taken and reported their English proficiency levels in reading and in listening (i.e., no proficiency, low proficiency, moderate proficiency, and high proficiency).

Attention was assessed by examining the proportion of yes responses given by participants to mind wandering probes. There were four mind wandering probes, each placed after the content assessing memory recall from the post-test. Provided that the video was 10 minutes at a 1x speed, we had selected 4 mind wandering probes. This number of probes was selected to limit their impact on the lecture, particularly when playback speed is increased (and would lead to a high rate of interruption at faster playback speeds). At the normal speed, the four mind wandering probes were evenly distributed across the video lecture (around 2-3 minutes between each probe) and each mind wandering probe was tied to a particular point in the content of the video rather than to a particular time in the video. This meant that as the lecture was sped up, mind wandering probes occurred at earlier times and closer to each other. For the first lecture capture video on Freud, the probes appeared at 1:28 mins, 3:15 mins, 6:33 mins, and 9:40 mins. For the second lecture capture video on Skinner, the probes appeared at 44 seconds, 4 minutes, 7:01 minutes and 9:31 minutes. For the voice over presentation about the brain, the probes appeared at 29 seconds, 3 minutes, 6:14 mins, and 9:58 mins. Lastly, for the second voice over presentation on thinking, problem solving, and reasoning, the probes appeared at 38 seconds, 3:51 mins, 6:42 mins and 8:48 mins. When a mind wandering probe appeared, the video stopped, and participants responded by clicking a radio button, and then the video started again. Mind wandering probes asked if participants had just been intentionally mind wandering, unintentionally mind wandering, or not mind wandering at all (e.g., Seli et al., 2016a, Seli et al., 2016b, Seli et al., 2017). Intentional mind wandering was defined as allowing oneself to think about something else for a few moments. Unintentional mind wandering was defined as not noticing that one's mind had drifted to thoughts unrelated to the task at hand.

To assess learner experience, four statements were asked. Specifically, after watching the video lecture, participants were asked how much they identified with each statement in general on a scale of 1 to 5, with "1" being strongly disagree and "5" being strongly agree. The statements asked were, "I enjoyed watching this video lecture," "I enjoyed the speed at which the video lecture was presented," "I found the mind wandering probes to be disruptive during the video lecture," and "I found the visual presentation to be distracting during the video lecture.".[1]

To assess memory recall performance after watching the video lecture, participants first completed a self-paced free recall task that required participants to type in everything that they could remember about a certain topic from the video lecture that they had just watched. These topics included the id and ego, habituation, the generate and test technique, and static imaging. Point form was acceptable and participants were also told that there was no word limit. To score the free recall test responses, each lecture was broken into idea units and participants scored one point for each idea that was included. An idea unit was defined as, "the minimum meaningful utterance having a beginning and an end" or an idea that stands alone (Hatfield & Weider-Hatfield, 1978, p. 46). Two researchers independently coded for the total number of idea units. The two

[1] For one of the counterbalances in Experiment 1a, there was an error in the options provided to the participants for the subjective evaluation questions. Although the instructions had been correctly stated, whereby participants were asked to rate how much they identified with each statement, with a "1" being Strongly Disagree and a "5" being Strongly Agree, the options provided to participants in this specific survey link were "1. Strongly Disagree" and "5. Strongly Disagree" instead. Three out of the 10 participants ended up selecting the option "5. Strongly Disagree." Given that the instructions were stated correctly and both the inclusion and removal of these 3 participants did not materially influence our results, these 3 participants were included in all of the Experiment 1a analyses.

coders used in Experiment 1a and Experiment 1b were different due to coder availability. In Experiment 1a and Experiment 1b, the correlation between the two coders was high, $r(198) = 0.82$, $p < .01$; $r(118) = 0.96$, $p < .01$, respectively. One coder was selected to use in our statistical analyses.

The multiple-choice post-test consisted of a four-item multiple choice test, with material taken from the video lecture that the participants had just viewed. For example, “When does the id emerge?” with options “a. At birth b. During infancy c. During preschool age d. During elementary years.” The multiple-choice post-test was scored based on whether the answer was correct or not. One answer on one multiple-choice test had two correct answers, both of which were scored as correct. Provided that there were four lectures, there were four different tests, only one of which would correspond to the lecture any given participant viewed. We computed the reliability of each multiple-choice post-test using the Kuder-Richardson formula. The values ranged from low to reasonable (“Freud”: .58; “Skinner”: .59; “Introduction to the Brain; Structure and Function”: .43; “Introduction to Thinking, Problem Solving, and Reasoning”: .22). Modest reliability in a short test is not unexpected given there are only 4 items, and each test is based on fact retrieval and thus the items are not designed to be homogenous (i.e., 4).

For each participant, the three multiple-choice tests for the three other video lectures that they would not view were administered prior to watching their assigned lecture. For example, if a given participant was assigned to watch the lecture on “thinking, problem solving, and reasoning” their multiple-choice post-test would contain items testing the content from the “thinking, problem solving, and reasoning” lecture and prior to the lecture would be given the tests from the other three lectures (i.e., “Freud,” “Skinner,” “Introduction to the Brain; Structure and Function”).

2.4. Research Procedure

In both experiments, the study took place online, and lasted for thirty minutes. Participants were first briefed about the study via an information letter and a consent form. Participants were asked to complete the study using a desktop computer so that the recorded lectures presented properly as well as to ensure that they had as stable an internet connection as possible. Following consent, demographic information was collected from each participant and participants completed the tests from the three lectures they would not view. Participants were then informed that mind wandering probes would appear throughout the video and that they would be required to answer whether they were mind wandering (intentionally or unintentionally) or not mind wandering in the moments prior to the probe. Before viewing the lecture, participants first read a description of the distinction between intentional and unintentional mind wandering and answered a multiple-choice comprehension check question. The correct answer was provided after the participant responded. Participants then completed the multiple-choice tests for the lectures they would not view. They then watched the video lecture that they were randomly assigned to (at one of the five video speeds for Experiment 1a and at one of the three video speeds for Experiment 1b) and responded to the four mind wandering probes. After watching the video, participants answered four subjective experience questions followed by the self-paced free recall task and the multiple-choice post-test. At the end of the study, participants were asked if they had experienced any video or audio quality issues (an open-ended response format) and whether they had multitasked and/or navigated away from the screen while watching the video lecture (a multiple-choice format). Participants were then given a feedback letter and thanked for their time.

3. Results

All data have been made publicly available at the Open Science Framework and can be accessed at https://osf.io/h4b7g. In total, four hundred and seventy-three participants were collected in both Experiment 1a and Experiment 1b before exclusion (two hundred and ninety-eight participants for Experiment 1a, and one hundred and seventy-five participants for Experiment 1b). We outlined a number of criteria for exclusion in our pre-registration. See Table 2 for the breakdown of the number of participants that were excluded and why. It should be noted that including the oversampled participants did not qualitatively change the results.

Table 2. Breakdown of the number of participants excluded from the study

	Number of Excluded Participants
Experiment 1a	
Withdrawal from the study	1
Self-report of experiencing video and audio quality issues	38
Incomplete of self-paced recall task and/or MC post-test	25
Oversampling	34
Total Number of Exclusions	98
Experiment 1b	
Self-report of experiencing video and audio quality issues	24
Incomplete of self-paced recall task and/or MC post-test	12
Excluded for more than one of the reasons listed above	1
Oversampling	18
Total Number of Exclusions	55

Although it was stated in our pre-registration that participants who self-reported themselves multitasking or having navigated away from the screen would be excluded, we did not end up excluding these participants given the large number of people (N=88, 44% of our final sample in Experiment 1a and N=44, 36.7% of our final sample in Experiment 1b) who responded yes to this question. Instead, statistical analyses including multitasking as a factor were examined. In Experiment 1a and Experiment 1b, no significant interactions were found between speed and multitasking for any of the variables, all Fs < 1.22, ps > .30, $\eta_p^2 s$ < .02. We pre-registered an analysis including participant's reading and listening proficiency in English, however, there was insufficient variation in this measure to justify an analysis. Otherwise, all analyses were conducted according to our pre-registration for Experiment 1a and when we deviated from them, we note it explicitly.

To examine the effects of increasing playback speed, a one-way between-subjects analysis of variance (ANOVA), with speed as the IV and each of our dependent variables, self-paced free recall test, multiple-choice post-test, overall mind wandering, intentional mind wandering, unintentional mind wandering, enjoyment of video, enjoyment of speed, how disruptive the mind wandering probes were, and how distracting the visual presentation was, was conducted. Means and standard errors for each condition and dependent variable are presented in Table 3 for each experiment. Including performance on the three multiple-choice tests that the participants did not view as a co-variate in the ANOVAs reported below did not alter the results substantively. Lastly, in an exploratory analysis, we included lecture type (2 levels: lecture capture vs. voice over presentation slides) as a factor in an ANOVA with speed for each dependent variable and separately an ANOVA with lecture (4 levels: each video lecture) with speed. In both of the latter cases, we focus on the presence/absence of interactions with speed. We note those cases where there was a significant interaction.

Table 3. Means (M) and standard errors (SE) as a function of speed and Experiment across all of the dependent variables.

	Speed													
	1x		1.25x		1.5x		1.75x		2x		2.5x		3x	
Experiment 1a	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
Overall MW	0.57	0.05	0.53	0.04	0.59	0.05	0.50	0.04	0.54	0.04				
Intentional MW	0.29	0.04	0.23	0.04	0.23	0.03	0.21	0.04	0.28	0.04				
Unintentional MW	0.28	0.03	0.31	0.04	0.37	0.04	0.29	0.04	0.27	0.03				
Enjoyment of video	3.10	0.19	3.40	0.16	3.08	0.19	3.10	0.20	2.98	0.23				
Enjoyment of speed	3.33	0.17	3.13	0.17	2.55	0.19	2.50	0.21	2.35	0.21				
MW Probe Disruptive	3.13	0.18	3.52	0.18	3.35	0.17	3.35	0.15	3.45	0.16				
Visual Presentation Distracting	2.42	0.15	2.65	0.18	2.25	0.16	2.10	0.15	2.35	0.15				
Idea Units Post-test	2.48	0.35	1.75	0.30	2.50	0.42	2.33	0.37	1.55	0.27				
MC Post-test	0.66	0.05	0.64	0.04	0.60	0.05	0.66	0.05	0.52	0.05				
Experiment 1b														
Overall MW	0.51	0.05									0.59	0.05	0.52	0.06
Intentional MW	0.20	0.04									0.26	0.04	0.22	0.04
Unintentional MW	0.31	0.04									0.33	0.04	0.30	0.04
Enjoyment of video	3.27	0.15									2.18	0.19	1.95	0.18
Enjoyment of speed	3.02	0.17									1.74	0.17	1.68	0.18
MW Probe Disruptive	3.13	0.17									2.97	0.16	3.42	0.17
Visual Presentation Distracting	2.27	0.13									2.41	0.17	2.40	0.20
Idea Units Post-test	3.23	0.43									1.18	0.35	0.85	0.23
MC Post-test	0.71	0.04									0.54	0.04	0.42	0.05

Note: *M* and *SE* represent mean and standard error, respectively

How is memory for recorded lecture material impacted by increases in playback speed ranging from 1.25x to 3x?

In Experiment 1a, there was no significant effect of speed on the multiple-choice post-test, $F(4, 195) = 1.47$, $p = .21$, $\eta_p^2 = .03$, or the self-paced free recall test, $F(4, 195) = 1.62$, $p = .17$, $\eta_p^2 = .03$. In Experiment 1b, there was a significant effect of speed on the multiple-choice post-test, $F(2, 117) = 11.00$, $p < .001$, $\eta_p^2 = .16$, and on the self-paced free-recall test, $F(2, 117) = 14.00$, $p < .001$, $\eta_p^2 = .19$. To follow up, a simple effect analysis using a Tukey test was conducted. Results revealed that participants in the 1x condition had higher scores on the multiple-choice post-test than participants in the 2.5x condition, $p = .02$, and 3x condition, $p < .001$. In addition, participants in the 1x condition produced a greater number of idea units than participants in the 2.5x condition, $p < .001$, and 3x condition, $p < .001$. The 2.5x and 3x conditions did not differ for either dependent variable.

In Experiment 1a, a significant interaction was found between video lecture type and speed for multiple-choice post-test scores, $F(4, 190) = 2.68$, $p = .03$, $\eta_p^2 = .05$, but not for the self-paced free recall test, $F(4, 190) = .90$, $p = .46$, $\eta_p^2 = .02$. The interaction for multiple-choice post-test scores appears to reflect a nonlinear variation in speed across the two lecture types. In particular, at 1x, performance was better for lecture capture, but at 1.5x, performance was better for voice over presentation, and finally for 1.75x and 2x, performance for lecture capture was again superior (lecture capture; 1x = .75; 1.25x = .64; 1.5x = .51; 1.75x = .75; 2x = .58; voice over; 1x = .56; 1.25x = .64; 1.5x = .69; 1.75x = .56; 2x = .46). Lastly, in Experiment 1b, there was a significant interaction between speed and lecture in the multiple-choice post-test, $F(6, 108) = 2.32$, $p = .04$, $\eta_p^2 = .11$, such that the "Skinner" lecture was particularly negatively impacted in the 3x speed condition. Removal of this lecture eliminated the interaction between speed and lecture, $F(4, 81)$

= 0.38, p = .83, η_p^2 = .02, but the main effect of speed remained, F(2, 81) = 3.72, p = .03, η_p^2 = .08 (hence the effect of speed was not driven solely by this video lecture).

How is mind wandering while viewing recorded lecture material impacted by increases in playback speed ranging from 1.25x to 3x?

In Experiment 1a and Experiment 1b, there was no significant effect of speed on overall mind wandering , F(4, 195) = .61, p = .66, η_p^2 = .01; F(2, 117) = .64, p = .53, η_p^2 = .01, intentional mind wandering, F(4, 195) = .72, p = .58, η_p^2 = .02; F(2, 117) = .64, p = .53, η_p^2 = .01, or unintentional mind wandering, F(4, 195) = 1.19, p = .32, η_p^2 = .02; F(2, 117) = .10, p = .91, η_p^2 = .002.

How is the increase in mind wandering with time-on-task (i.e., probe number) impacted by increases in playback speed ranging from 1.25x to 3x?

We next examined mind wandering as a function of both probe and speed. This analysis was not pre-registered. We combined the data for probe 1 and 2 and compared this to probe 3 and 4 for overall mind wandering, intentional mind wandering, and unintentional mind wandering as a function of speed in both Experiment 1a and Experiment 1b (see Table 4 for descriptives).

In Experiment 1a, there was a significant effect of probe for overall mind wandering, F(1, 195) = 27.71, p < .001, η_p^2 = .12, and intentional mind wandering, F(1, 195) = 27.54, p < .001, η_p^2 = .12, such that participants reported more mind wandering to the last two probes than the first two. There was no significant effect of probe on unintentional mind wandering, F(1, 195) = 0.23, p = .63, η_p^2 = .001. There was no interaction between probe and speed for any type of mind wandering, Fs < 1.81, ps > .13, $\eta_p^2 s$ < 0.04.

In Experiment 1b, there was a significant effect of probe for overall mind wandering, $F(1, 117) = 24.78$, $p < .001$, $\eta_p^2 = .18$, and intentional mind wandering, $F(1, 117) = 35.44$, $p < .001$, $\eta_p^2 = .23$, such that participants reported more mind wandering to the last two probes than the first two. There was no significant effect of probe on unintentional mind wandering, $F(1, 117) = .54$, $p = .47$, $\eta_p^2 = .005$. There was no interaction between probe and speed for any type of mind wandering, $Fs < 0.54$, $ps > .0.59$, $\eta_p^2 s < 0.009$.

In Experiment 1b, for the ANOVA including lecture type and lecture, there were significant three-way interactions between probe, speed, and lecture type for intentional mind wandering, $F(2, 114) = 4.07$, $p = .02$, $\eta_p^2 = .07$, and probe, speed, and lecture for intentional mind wandering, $F(6, 108) = 2.41$, $p = .03$, $\eta_p^2 = .12$. The effect of probe (late probes – early probes) in the lecture capture lectures was smallest for 2.5x (1x: .38; 2.5x: .10; 3x: .23) but was largest for 2.5x in the voice over lectures (1x: .13; 2.5x: .35; 3x: .15). In addition, the effect of probe in the “Introduction to Thinking, Problem Solving, and Reasoning” lecture was larger in the 2.5x and 3x conditions than 1x (1x: 0; 2.5x: .2; 3x: .2), was largest in the 2.5x condition in the “Introduction to the Brain; Structure and Function” lecture (1x: .25; 2.5x: .50; 3x: .10), was smallest in the 2.5x lecture in “Freud” lecture (1x: .3; 2.5x: .05; 3x: .35) and decreased from the 1x to the 3x condition in the “Skinner” lecture (1x: .45; 2.5x .15; 3x: .10). These analyzes are based on rather small cell sizes and should be interpreted with caution.

Table 4. *Means (M) of the proportion of mind wandering as a function of Speed, Experiment, and Probes for each measure of mind wandering. MW = Mind Wandering*

			Probes 1 and 2	Probes 3 and 4	Difference
Experiment 1a	**MW Type**	**Speed**	***M***	***M***	
	Overall	1x	0.53	0.61	0.08
		1.25x	0.48	0.59	0.11
		1.5x	0.49	0.70	0.21
		1.75x	0.43	0.58	0.15
		2x	0.40	0.69	0.29
	Intentional	1x	0.20	0.38	0.18
		1.25x	0.14	0.31	0.17
		1.5x	0.18	0.28	0.10
		1.75x	0.14	0.29	0.15
		2x	0.19	0.36	0.17
	Unintentional	1x	0.33	0.24	-0.09
		1.25x	0.34	0.28	-0.06
		1.5x	0.31	0.43	0.12
		1.75x	0.29	0.29	0.00
		2x	0.21	0.33	0.12
Experiment 1b	Overall	1x	0.44	0.59	0.15
		2.5x	0.48	0.70	0.22
		3x	0.43	0.61	0.18
	Intentional	1x	0.08	0.33	0.25
		2.5x	0.15	0.38	0.23
		3x	0.13	0.31	0.18
	Unintentional	1x	0.36	0.26	-0.10
		2.5x	0.33	0.33	0.00
		3x	0.30	0.30	0.00

How is the learner's subjective experience of the lecture impacted by increases in playback speed ranging from 1.25x to 3x?

In Experiment 1a, there was no significant effect of speed on enjoyment of the video (liking of the video), $F(4, 195) = .69$, $p = .60$, $\eta_p^2 = 0.01$, how disruptive the mind wandering probes were, $F(4, 195) = .81$, $p = .52$, $\eta_p^2 = .02$, or how distracting the visual presentation was, $F(4, 195) = 1.63$, $p = .17$, $\eta_p^2 = .03$. There was a significant effect of speed on enjoyment of speed (liking of the speed), $F(4, 195) = 4.99$, $p < .001$, $\eta_p^2 = .09$. To follow up this main effect, a simple effect analysis using a Tukey test was conducted. Results revealed that participants in the 1x condition gave higher ratings than participants in the 1.5x condition, $p = .04$, 1.75x condition, $p = .02$, and 2x condition, $p =.004$. Additionally, participants in the 1.25x condition also gave higher ratings than participants in the 2x condition, $p = .04$. The remaining pairwise comparisons were not significant.

In Experiment 1b, one participant did not provide subjective experience ratings and was removed. In Experiment 1b, there was no significant effect of speed on how disruptive the mind wandering probes were, $F(2, 116) = 1.87$, $p = .16$, $\eta_p^2 = .03$, or how distracting the visual presentation was, $F(2, 116) = .20$, $p = .82$, $\eta_p^2 = .003$. There was a significant effect of speed on enjoyment of the video, $F(2, 116) = 16.90$, $p < .001$, $\eta_p^2 = .23$, and enjoyment of speed, $F(2, 116) = 19.50$, $p < .001$, $\eta_p^2 = .25$. Again, to follow up this main effect, a simple effect analysis using a Tukey test was conducted. Results revealed that participants in the 1x condition gave higher ratings for both enjoyment of the video and speed than participants in the 2.5x condition and 3x condition, all *p*s < .001. The 2.5x and 3x condition did not differ for either dependent variable, $p = 62$. $p = .96$ (for video and speed respectively).

Correlations. While not pre-registered, we computed the correlations between dependent variables and we present them in Table 5. Overall, the patterns of correlations are consistent with what we would expect based on prior literature. Multiple-choice post-test scores and the number of idea units recalled were positively related. Mind wandering was negatively correlated with memory for lecture material consistent with the predicted relation between engagement and learning. In addition, enjoyment of the lecture and speed were both positively related to multiple-choice post-test scores, and the number of idea units recalled and were negatively related to mind wandering. This is consistent with the predicted positive relation between positive affect and learning and the predicted negative relation between negative affect and engagement.

Table 5. Correlation between the dependent variables

	Overall MW	Intentional MW	Unintentional MW	Enjoyment video	Enjoyment speed	Probe Disruptive	Distracting Visuals	Idea Units	MC Post-Test
Overall MW		0.65 **	0.59 **	−0.51 **	−0.28 **	0.11 *	0.31 **	−0.29 **	−0.31 **
Intentional MW			−0.22 **	−0.45 **	−0.25 **	0.08	0.20 **	−0.18 **	−0.23 **
Unintentional MW				−0.19 **	−0.10	0.06	0.18 *	−0.18 *	−0.16 *
Enjoyment lecture					0.56 **	−0.02	−0.23 **	0.30 **	0.42 **
Enjoyment speed						0.03	−0.11 *	0.24 **	0.29 **
Probe Disruptive							0.26 **	0.04	0.05
Distracting Visuals								−0.21 **	−0.22 **
Idea Units									0.46 **

**p* < .05; ** *p* < .001

4. Discussion

The aim of the present investigation was to examine the influence of increasing the playback speed of recorded lectures on memory for lecture material, attention, and the lecture experience. Taken together, the results suggest that increasing the playback speed for video lectures, at least for lectures in the 10-minute range, negatively impacts memory for the material as speeds exceed 2x but has minimal impact below that, has limited impact on attention, and can have a negative impact on the lecture experience. In the following, we further examine the present results in the context of existing literature and discuss theoretical implications.

4.2. Increasing Playback Speed and Memory for Lecture Material

For speeds up to 2x in Experiment 1a, there was no effect of increasing playback speed on memory for the lecture material. However, in Experiment 1b, beyond a speed of 2x, decreases in performance were evident. This was true across two different measures of memory for the lecture material – a free recall test and a multiple-choice post-test. Thus, in terms of our first research question (*How is memory for recorded lecture material impacted by increases in playback speed ranging from 1.25x to 3x?*), increasing playback speed has little to no effect on memory for lecture material up to about 2x but decreases thereafter. The present results are consistent with previous findings investigating the influence of increasing lecture playback speed on memory for lecture material (e.g., Murphy et al., 2022; 2023; Nagahama & Morita, 2017; 2018; Ritzhaupt et al., 2015; Wilson et al., 2018; Risko et al., in press). Thus, from a task load perspective, the typical speech rate in lectures (along with the density of the material), might leave some resources on the proverbial table such that moderate increases in speed can be handled without much in the way of costs in terms of memory performance. Of course, the extent to which playback can be increased can reasonably be expected to vary with other factors including, for example, prior knowledge and the complexity of the material. For example, Watts (1971) demonstrated that for those with less prior content-specific knowledge, a greater comprehension cost was evident when they were listening to compressed lecture tapes that were difficult in nature, whereas a benefit was seen for easier lectures, in this case, live auditorium presentations. In the present investigation, the participants were university students enrolled in a psychology course and the to-be-learned material was from psychology. Thus, participants could be assumed to have a fair amount of background knowledge (and might have been exposed to similar material in the past). Another factor worth considering is the nature of the test. Here we examined fact retrieval from the lecture. Increasing playback speed might have greater costs in terms of memory performance if the tests required "deeper" processing of the content.

4.3. Increasing Playback Speed and Mind Wandering

In terms of our research questions pertaining to mind wandering (*How is mind wandering while viewing recorded lecture material impacted by increases in playback speed ranging from 1.25x to 3x? How is the increase in mind wandering with time-on-task (i.e., probe number) impacted by increases in playback speed ranging from 1.25x to 3x?),* increasing the playback speed of a recorded lecture appears to have limited effects on reports of mind wandering. With respect to overall mind wandering, these findings are consistent with those reported by Wilson et al., (2018) and one experiment in Murphy et al. (2023). With respect to intentional and unintentional mind wandering, Wilson et al., (2018) found mixed results. Here, there was no effect of increasing playback speed on either type of mind wandering. Furthermore, when we examined mind wandering as a function of when the probe occurred in the lecture, we replicated the increase in mind wandering as a function of probe position (i.e., more mind wandering for probes occurring later in the lecture). Interestingly, this pattern was present only in intentional forms of mind wandering. Critically, this pattern was also uninfluenced by increasing playback speed. This result is informative as it suggests that the increase in mind wandering for probes later in a lecture does not reflect the mere passage of time. Instead, these results appear to provide evidence that the pattern reflects an effect of probe position. That is, given a series of probes presented in a lecture, earlier probes are associated with less mind wandering than later probes. This might reflect the information processing demands imposed. For example, the cumulative effect of processing lecture information might make it more difficult to sustain attention. Another interesting possibility is that the effect reflects participant's beliefs about their own attention systems such that they become more likely to report mind wandering in later probe positions. Taken together, it seems clear that increasing the playback speed will not reduce mind wandering (by reducing the length of the lecture), at least for what could be considered shorter lectures (i.e., approximately 10 minutes). With the limited work currently examining increasing playback speed and its influences on attention, results from this study help to provide more clarity. However, how increasing playback speed and attention might interact with substantially longer lectures (e.g., 1 hour) remains an open question.

From the Cognitive Affective Theory of Learning with Media perspective, the lack of an effect of increasing playback speed on mind wandering suggests that engagement is neither impaired nor improved using this technique. This is interesting to consider given the negative effects observed on the lecture experience, particularly with speeds beyond 2x. According to the Cognitive Affective Theory of Learning with Media, an increase in negative affect could cause a decrease in engagement. While we observed what can be considered an increase in negative affect (i.e., a decrease in liking), we did not observe a concomitant decrease in engagement (at least as we have operationalized here in terms of mind wandering). Future studies further examining interactions between engagement, affect and learning would be valuable.

4.4. Increasing Playback Speed and Lecture Experience

An important part of the present investigation was the measurement of individual's experience of the lectures under increased playback speeds. As noted above, the Cognitive Affective Theory of Learning with Media situates affect centrally in its potential impact on learning. In terms of the participant's subjective experience of the lecture in both Experiment 1a and Experiment 1b, increases in playback speed were associated with less enjoyment of the playback speed at which the lecture was presented. In addition, in Experiment 1b, increasing playback speed to 3x also reduced enjoyment of the video lecture. The latter result, taken together with the effects on learning, is consistent with Cognitive Affective Theory of Learning with Media provided both enjoyment and learning are decreasing at high speeds. The negative experience might be reducing individual's motivation (though this did not appear to be reflected in mind wandering rates). Increasing playback speed did not influence how distracting individuals found the mind wandering probes or the visual presentation. Thus, with respect to our research question about the learner's subjective experience *(How is the learner's subjective experience of the lecture impacted by increases in playback speed ranging from 1.25x to 3x?),* increasing the playback speed can negatively impact the experience of the lecture and this increases with greater increases in the playback speed. Importantly, the negative impacts on the learning experience emerged before appreciable costs were observed in terms of memory for the lecture material (and attention). These results are largely consistent with the findings in previous studies (Nagahama & Morita, 2017; 2018; Risko et al., in press; Wilson et al., 2018), though unlike some studies there was no evidence that increasing the playback speed ever improved the lecture experience. There exist various reasons why increases in lecture playback speed might produce a more negative video lecture experience. For example, He and Gupta (2001) and Srinivasan et al., (2004) noted that as speed increases, natural pauses are reduced. In addition, though not measured here, increasing playback appears to increase concentration (Nagahama & Morita, 2017; 2018). The investment of effort is often perceived negatively and avoided (e.g., Dunn & Risko, 2019; Kool et al., 2010), though not exclusively (Inzlicht et al., 2018).

The increase in negative experience is critical to consider from an instructional design perspective. While there might be benefits to increasing playback speed (e.g., reducing the time required), there are also costs to doing so. In the present investigation, these experiential costs emerged before we observed costs in terms of memory performance and despite no observed costs in terms of attention (i.e., mind wandering). This might reflect increased playback speed leading to an increase in the investment of effort (see Risko et al., in press) sufficient to sustain performance at moderate levels of increasing playback speed, but nevertheless increasing negative affect. Of course, at high levels of increased playback speeds (e.g., > 2x), individual's increases in invested effort might not be sufficient to maintain performance, leading to both a more negative experience and poorer performance. Thus, the decision to use an increased playback speed in the design of a recorded lecture needs to be weighed against the pedagogical consequences of potentially compromising the lecture experience. For example, in a course consisting of multiple lectures, a negative lecture experience might demotivate viewing the recorded lectures in the first place. Of course, learners might also value the benefits of increased playback speed more than such costs, and as a result be more likely to view speeded lectures. Future work investigating the impact of increasing playback speed on the choice to consume recorded lecture material in a live course would be valuable. One interesting aspect of the present investigation (and past ones) to consider in this respect is that the increase in playback speed here was externally imposed. That is, the participant did not choose the speed. If the individual chooses a faster playback speed, then this might reduce any resulting negative evaluation caused by the increased playback speed.

5. *Limitations and Conclusion*

5.1. Limitations

The present research consisted of an experimental examination of the influence of lecture speed on memory for lecture material, attention, and learner's experience of the lecture. It is important to note that from a generalization point of view, the lecture stimuli used here were limited to a specific content domain (i.e., post-secondary Psychology), reflected two of the many different types of video lectures (i.e., lecture capture, voice over presentation slides), and were relatively uniform in their duration. Future studies should examine how variation in content domain, lecture type, and lecture duration interact with increasing the playback speed of lectures. With respect to the content domain, while no work to which we are aware has examined the issue systematically, the present work, at least with respect to memory for lecture material, was generally consistent with past research that used other content domains. In a similar vein, past research has used a variety of lecture types. More interesting to consider is how the results might differ across different lecture durations. We chose an approximately 10-minutes duration from sampling lecture durations from popular online courses coupled with instructional advice at multiple institutions to keep them short (e.g., McMaster University, n.d.,; Queen's University, n.d.,; University of Toronto, n.d.,; University of Waterloo, 2020; Wilfred Laurier University, n.d.,; York University, 2022). The present study does not address the impacts of increasing playback speed on lectures that are longer in nature (e.g., universities uploading complete recorded live lectures online). Increasing the length of a speeded lecture might lead to performance, attentional, or experiential decrements at slower speeds than observed here provided the need to invest greater effort for a longer period of time. It would be valuable for future studies to examine the potential influences of individual characteristics. Lastly, the lecture types used here did not feature much visual activity in the lecture relevant to the content, which might explain why there was no influence of increasing playback speed on individual's self-reports of visual distraction. Lecture types that include more of this kind of movement (e.g., Khan-style video lectures) might be more negatively impacted by increasing playback speed.

5.2. *Conclusion*

The present investigation has provided an examination of the influence of increasing playback speed of recorded lectures on memory for lecture material, attention, and learner's subjective experience of the lecture on short video lectures within the domain of psychology. The results highlight both benefits (e.g., time savings without large memory performance costs with moderate levels of increasing playback speed) and costs (e.g., a more negative lecture experience, performance decrements if lectures are sped excessively) of this strategy. While additional research is clearly needed, a consistent pattern is emerging across studies that will hopefully provide those charged with designing recorded lectures with a clear picture of the utility of using this strategy.

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