Video Speed and Interruptions in an Online Learning Environment

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Authorization to Submit Thesis

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Abstract

To investigate relationships between video playback speed, interruptions, and learning performance, taking into account the possible influence of media multitasking behavior, we implemented a 2 x 2 between-subjects factorial design with two video playback speed levels (1.0x vs. 1.5x) and two interruption levels (absent vs. present). Participants were randomly assigned to one of four video conditions: 1.0x speed/no interruption, 1.0x speed/interruption, 1.5x speed/no interruption, or 1.5x speed/interruption. Media multitasking was quantified using the Media Use Questionnaire/Media Multitasking Index. Learning was measured by examining recognition, elaboration, and confidence judgments. Results indicate speed-watching video does not interfere with learning, saves time, and may increase focus. Greater attention to faster video speeds may explain bolstered resistance to interruptions on recognition performance. Interruptions had a significant negative impact on elaboration. Faster video speeds resulted in lowered confidence, except when interruptions were present.

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Chapter 1: Introduction

In the late 1950s, teacher Evelyn Wood attempted to alter reading as-we-knew-it with her speed-reading dynamics® program. Wood claimed people could read more books in less time with no losses (and perhaps even gains) in retention and comprehension. Consequently, people flocked to her method. While the popularity of Wood's training program has faded, the appeal of doing more in less time has not.

Academically, popular technologies for smartphones and mobile devices (Spreeder, n.d.; Spritz, n.d.) have fueled a renewed interest in speed-reading. Based on rapid serial visual presentation (RSVP), a technique in which words are centered on a screen and presented in rapid succession, apps such as *readme!* and *SpreederCX* bolster reading speed by reducing the saccadic eye movements required in traditional reading methods. Intended to facilitate focused reading, the technology promises students an easy way to read more books, learning more in less time (Spreeder, n.d.). Unfortunately, these approaches have fallen short (Rayner, Schotter, Masson, Potter, & Treiman, 2016). Researchers have found RSVP to increase eye fatigue because fewer saccades result in less blinking (Benedetto et al., 2015). Compared to traditional reading, RSVP has been found to reduce comprehension and increase mental workload, especially at higher presented speeds (Rayner et al., 2016; Ricciardi & Di Nocera, 2017). Nevertheless, the desire to process more academic information more efficiently remains.

Most of us carry smartphones and some carry multiple devices such as tablets, laptops, and e-readers. Technology allows us the opportunity to be more productive, doing more in less time, often at the same time, from virtually anywhere. We can do many more things per moment than ever. However, along with this convenience comes an abundance of unexpected distractions in the form of social media and text messages, email alerts, and more, each of which compete for our attention. Real-time notifications pop-up on-screen and we shift our focus from what we were doing to the message we've just received. It may be just a few seconds or minutes before we get back on track, but sometimes hours can pass before we return to our unfinished task. We're becoming accustomed to these interruptions as a part of our daily lives.

Students are no exception. In today's classroom, many take notes on laptops or tablets, or use mobile devices as response tools for instructional technology, e.g. real-time polling. Thus, the prevalence of electronic devices used in classrooms (Fried, 2009) makes learners susceptible to more distractions than ever before (Sana, Weston, and Cepeda, 2013). Outside the classroom, students remain susceptible to such distractions, but also must filter real-world distractions and interruptions when learning. Consider students who attend class on their devices: about a third of college students take at least one online class and roughly one in six is enrolled online exclusively (Ginder, Kelly-Reid, and Mann, 2018). While online classes allow students to fit an educational experience into their existing schedules, online learners may face added interference. Online students are more likely to be parents and more likely to work while attending school (Deming, Goldin, Katz, & Yuchtman, 2015).

Whether lectures are delivered traditionally in the classroom or recorded for online viewers, an old rule-of-thumb suggests college students spend two hours studying for each lecture hour. In terms of a typical eight-hour work day, taking a full course-load equates to four-and-one-half days per week. Squeezing 36 hours of study into a week filled with family and work commitments seems a formidable task; one that, understandably, motivates students to be as efficient as possible when studying.

Over the last decade, professors in higher education have reported students speeding up lecture videos to save time (Cardall, Krupat, & Ulrich, 2008; Young, 2008). Indeed, many students brag about watching videos at speeds faster than normal (statistica, 2017). Cardall, Krupat, and Ulrich (2008) found that over 85% of first- and second-year medical students accelerated lecture videos, claiming benefits such as rapid learning of more information, more time for other things, and improved focus. Results of an informal Internet search on speeding up lecture video include personal accounts of speed-watching benefits, tips and tricks for cutting down study time, and types of software that help a person do it. These results suggest that many believe watching accelerated videos is harmless, saves time, and allows the viewer to quickly learn more information.

The current study was designed to investigate the effects of video speed and interruptions on learning. Specifically, the effect of video speed on recognition. In addition, the study was designed to examine the effect of video speed on deeper types of learning and understanding, such as elaboration and judgments of confidence. Further, we considered the presence of interruptions and media distractions and their potential implications for learning, taking into account the possible influence of media multitasking behaviors.

Knowing more about how learning may be affected by these factors is important when advising viewers about the benefits and risks of speed-watching videos, especially in an online learning environment. Thus, we consider the following research questions: 1) Does video speed affect learning? 2) Do interruptions affect learning? 3) Do potential effects of video speed and interruptions interact? 4) Do individual differences in media multitasking moderate potential effects of video speed and interruptions on learning?

Learning

To understand the potential impact of accelerated video speed and interruptions on performance, we consider some basics about how we learn, i.e., how we process and encode information, store it in memory, and transfer it to new situations. We begin with human memory broadly, a key component of successful learning, before visiting theories of learning based on cognitive limitations and strengths, and then reviewing the literature of video speed, interruptions and media multitasking.

Memory. Memory is paramount to learning; a result of successful learning is a change in memory. We take in new information and combine it with existing information to better understand the world. This is not simply additive; successful learning allows elaboration, permitting “one to go beyond the data to new and possibly fruitful predictions" (Bruner, 1957). For our purposes, we focus on information consciously attended to; salient bits that we pull into conscious, working memory where they are organized, connected to existing knowledge, and ultimately, consolidated in long-term memory (Baddeley, 2012; Baddeley & Hitch, 1974; Wickens, 2008; Wickens, Hollands, Banbury, & Parasuraman, 2015).

In a world teeming with sights, sounds, smells, and more, we filter cues delivered in chorus through multiple sensory channels with just a fraction of them garnering attention (Pavio, 1990; Wickens, 2008; Wickens et al., 2015). Deliberately attending to information is one way of moving it into memory; using rehearsal strategies to keep information active is another (Sternberg & Sternberg, 2012). We often use metamemory techniques such as repetition, reciting items repeatedly, to maintain them in working memory for a short while, and elaboration, incorporating new data into existing information and schemas for long-term retention (Craik & Lockhart, 1972; Ericsson & Kintsch, 1994; Tulving, 1962).

The stores of long-term memory are essentially unbounded (Baddeley, 2012; Baddeley & Hitch, 1974; Bahrick, 2000; Brady, Konkle, Alvarez, & Oliva, 2008); in contrast, we have limited mental resources available in working memory (Miller, 1956). However, rehearsal or practice, permits "chunking" of many everyday activities and trained skills, increasing the amount of information we are able to process at any one time. This skilled memory, e.g. the ability of skilled wait staff to remember large orders, often employs the use of retrieval cues in short term memory to readily activate and access information stored in long-term memory (Ericsson & Kintsch, 1994).

Whether our goal is completing a current task or weaving together new and existing information, how we process information affects our ability to encode and retrieve it from memory (Baddeley, 2012; Bjork, 1994; Bjork, n.d.; Craik & Lockhart, 1972; Ericsson & Kintsch, 1994). Deeper levels of processing, i.e. the meaning we assign to new items, result in better learning than more shallow levels of processing. The more deeply we process information as we encode it, the better we seem to remember and retrieve it (Baddeley, 2012; Craik & Lockhart, 1972).

To the author's mind, Bjork (1994; n.d.) has made perhaps the most comprehensive effort to link cognitive research to educational practice. Of particular relevance here, he has noted the importance of metamemory effects. For example, he notes the impact of how people think about memory on the overall learning process; and, he has discussed the sometimes non-intuitive ways that things we assume would stifle learning sometimes improve it.

Many of us use metamemory, or metacognitive, strategies to enhance learning, yet we can become overloaded quickly. Learning is thwarted when we experience a high cognitive load (Sweller, 1988). Moreover, when the mental activity required to process information in working memory is more than the available resources, we may have difficulty thinking clearly or making decisions.

Cognitive load. Centered on the limitations of working memory, Cognitive Load Theory (CLT) is an established framework for research in learning and instructional design (Paas, Renkl, & Sweller, 2003; Sweller, 1988). CLT specifies three types of cognitive load competing for our working memory resources. Intrinsic load is related to the complexity of information and the interactivity of elements to be learned; extraneous load refers to external conditions, e.g., interruptions, room temperature, pain; and germane load is characterized as the load of learning, e.g., the development or enrichment of schemata and automation (Ayres & Sweller, 2014; Paas & Ayres, 2014; Sweller, van Merriënboer, & Paas, 2019). CLT is useful for identifying methods of presenting information that increase positive germane load and reduce negative intrinsic and extraneous load (faster video speed and interruptions would be considered negative).

Multimedia learning. Another recognized framework for studying how we learn in the everyday world is Mayer's (2005) Cognitive Theory of Multimedia Learning (CTML). CTML has four important elements: Our ability to dual-process visual and auditory information (Pavio, 1990); the corresponding components of working memory responsible for processing that information (Baddeley & Hitch, 1974); active processing; and, information transfer (Mayer, 2005). To better understand and measure what we call elaborative learning, we turn to CTML's three distinguishable multimedia learning outcomes based on retention and transfer of knowledge: No learning, rote learning, and meaningful learning. Obviously, no learning results in poor performance on both retention and transfer. Rote learning results in good retention performance but poor transfer performance, e.g. the learner retains fragmented bits of information but is unable to apply them in new situations. Meaningful learning occurs when learners connect new information to existing knowledge and are able to transfer it to new situations (Mayer, 2005).

Both cognitive load theory and the cognitive theory of multimedia learning are well established and provide a lens through which we may view the learning performance of students watching lecture video. As educators, we hope that our teaching results in meaningful learning. However, when students attend class in learning environments unique to them, we do not have the same opportunity to reduce load. We can regulate the complexity and interactivity of online course content to reduce intrinsic load, but have no influence over extraneous load factors, such as interruptions or students' efforts to hack course technology, e.g., accelerate videos.

Video Speed

Research on the effect of video playback speed on performance appears to be limited and the results inconsistent. Much of the literature has focused on the watcher's subjective experience, reporting that students prefer having control over when they learn and having the option to play video faster (Cardall, Krupat, & Ulrich, 2008; Ritzhaupt, Pastore, & Davis, 2015; Song, Chakraborty, Dawson, Dugan, Adkins, & Doty, 2018). Results specific to learning vary. For example, Ritzhaupt et al. (2015) found no significant difference in learning retention when video was played at normal (1.0x), fast (1.25x) and faster (1.5x) speeds. However, Song et al. (2018) found that novel curriculum presented to medical students at 1.5x speed resulted in poorer retention relative to presentations at 1.0x speed. Ritzhaupt et al. (2015) and Song et al. (2018) tested retention using recognition as the sole measure but found different results. Gaps exist for testing elaboration and judgments of confidence.

Interruptions

To our knowledge, research has not considered the effects of interruption in conjunction with video speed. For this study, we defined interruptions as events that require a shift of full attention from an existing task or goal to another, e.g. family members, pets, a knock on the door, or even mind-wandering. (A related event, distraction, we defined as something that momentarily divides our attention without requiring a shift in task goals, such as a pop-up notification, bouncing app icon, or audio alert signaling new messages. We leave distraction for later research, but feel that what we learn about interruption will be informative about distraction.)

Performance is affected by how we approach our tasks; for example, completing one task before beginning another versus working on multiple tasks and switching between them. Single-tasking has been associated with deeper, elaborative learning while dual-tasking has been associated with shallow, habitual learning outcomes (Foerde, Knowlton & Poldrack, 2006). Shallow learning outcomes also may be associated with our tendency to use available heuristics, or mental shortcuts, particularly when under time constraints (Kahneman, 2011). Working under time constraints can increase cognitive demands. Researchers found that task switching under higher levels of cognitive load resulted in longer resumption periods (Borst, Taatgen, van Rijn, 2010; Monk, Trafton, & Boehm-Davis, 2008). Additionally, interruptions are known to increase errors (Monk et al., 2008; Rosen, Lim, Carrier & Cheever, 2011; Zureick, Burk-Rafel, Purkiss & Hortsch, 2018). In fact, the longer the interruption, the higher the number of errors after returning to the primary task, and the longer the resumption time to the primary task (Borst et al., 2010; Monk et al., 2008). We often cannot remember where we left off in our original task sequence because the information is no longer available in our working memory (Boehm-Davis, Durso, & Lee, 2015; Monk, et al., 2008). Bearing this in mind, we hypothesized that the learning of students who were interrupted during lectures would be negatively impacted. Given the increased possibility of online students being parents and working full- or part-time (Deming et al., 2015), we decided to explore a setting in which interruptions are likely to occur, such as when viewing lecture video at home or other places outside the traditional classroom.

Media-multitasking

Considering the likelihood of online students facing interruptions and distractions, especially those from our screen devices, there was an opportunity to address media-multitasking. People often use multiple types of media simultaneously, such as texting while watching television, messaging a friend while browsing the web, or listening to music while using their computers. Some people seem to be good at it and some not. Given such individual differences, we wondered if better media-multitaskers, i.e., those presumably skilled in managing interruptions, would outperform those who are not good media multitaskers, when watching accelerated video.

In a study of cognitive control in media multitasking individuals, Ophir, Nass, and Wagner (2009) quantified the frequency and intensity of media multitasking that is characteristic of an individual during one hour of media-consumption using the Media Use Questionnaire (MUQ) and the Media Multitasking Index (MMI). Individuals scoring one standard deviation or more below the mean MMI score were referred to as light media-multitaskers (LMM) and those scoring one standard deviation or more above the mean MMI score were designated as heavy media multitaskers (HMM). In the same study, Ophir et al. found LMMs to be better at shifting attention than HMMs, a finding that was replicated by Elbe, Eriksson, Mellqvist, Brandstrom, and Ljungberg (2017). HMMs were found to be more easily distracted by, and less able to filter off-task stimuli, a factor which may have contributed to their poorer performance on task-switching tests when compared to LMMs (Ophir et al., 2009). To the contrary, Alzahabi and Becker (2013) observed HMMs to be better at shifting attention than LMMs when switching between tasks. Finally, another study (Minear, Brasher, McCurdy, Lewis, & Younggren, 2013) found no evidence pointing to differences in task-switching or distractibility when comparing HMMs and LMMs. Subsequently, Wiradhany and Nieuwenstein (2017) conducted a meta-analysis of 14 tests from replication studies, concluding the link between distractibility and media multitasking was indeed unsettled. Despite the uncertainty of the relationship between media multitasking and attentional shifting, we suspected there may be some interplay between media-multitasking behavior, interruptions, video playback speed, and, consequently, learning.

Design

To investigate relationships between video playback speed, interruptions, and learning performance, taking into account the possible influence of media multitasking behavior, we implemented the following 2 x 2 between-subjects factorial design with two video playback speed levels (1.0x vs. 1.5x) and two interruption levels (absent vs. present). Participants were randomly assigned to one of four video conditions: 1.0x speed/no interruption, 1.0x speed/interruption, 1.5x speed/no interruption, or 1.5x speed/interruption. Media multitasking behavior was quantified using the Media Use Questionnaire/Media Multitasking Index. Learning was measured by examining recognition, elaboration, and confidence judgments.

Measurement of learning and memory is difficult because there are many ways of doing it. Typically, some aspect of accuracy is assessed through recognition and/or recall of the material to be learned. Such content memory is certainly a useful place to look for learning, and a recognition procedure was used in this study. However, straightforward retrieval measures like recognition do not tap other processes that might put at risk a speed watcher who might also be experiencing interruptions. Two additional primary measures were used.

First, participants' cognitive elaboration was assessed using a thought listing procedure. In the social cognition literature, cognitive elaboration refers to the process of issue-relevant thinking, e.g., the making of relevant associations in memory, and the scrutiny of content encountered and assignment of value to that content (Fiske & Taylor, 2017). Second, the potential impact of the manipulations on metamemory, or metacomprehension, processes was assessed using a confidence measure. Confidence is often correlated with accuracy. When it is not, it is because a learner is being strategic, or feels he or she cannot be strategic, in the learning situation. More will be said about the latter two measures later in this paper.

We hypothesized that performance in the 1.5x speed playback group would be poorer than in the 1.0x speed group. Secondly, performance would be poorer in the interrupted conditions (regardless of playback speed, with interruptions having a greater negative impact at faster speed). Finally, media multitasking was assessed as a covariate to determine if it offered some protection from interruption. We expected video speed and interruptions to have a greater impact on elaboration and confidence judgments than on recognition.

Chapter 2: Method

Participants

167 students from Psychology courses at a public university in the Northwestern United States participated on a voluntary basis for course extra-credit. Each completed a single online session lasting approximately 25 minutes. The study was approved by the university's human subjects review board. Our sample included 28 men and 129 women, ages 18-64. Seventy-three percent of respondents were between the ages of 18-24 years. The majority of participants were undergraduates, with 69% having a GPA at or above 3.0. Over half (102) had taken five or more online classes. Eight students did not speak English natively, and were represented across all levels of conditions.

Materials

Video. All participants watched a video lecture about the scale of the earth and sun (Khan Academy). This video was part of an earlier project in which we explored video speed levels, lecture topics, and the nature of interruptions experienced by students. Quiz scores for this lecture indicated higher participant engagement compared to other lecture topics. Additionally, participants reported a greater range of prior knowledge which allowed us to examine possible effects on familiar versus novel content. The video was edited to play at the rate of 179 words per minute, which represented a standardized speed based on several lecture videos by the same instructor (Jacobson, 2015).

A second version of the speed-standardized lecture was created with two simulated technical delays embedded in the video (see Figure 1). An instance of "buffering" was inserted at 2:06 in the video timeline, and an instance of "checking connectivity" was inserted at 5:18. Each delay was animated and lasted approximately 24 seconds at normal speed and 16 seconds at 1.5x speed.

Once completed, the original and interrupted versions of the lecture were recorded at two speeds, 1.0x and 1.5x, adjusting for pitch changes. Video length for the uninterrupted condition was 8:08 minutes at 1.0x speed and 5:26 minutes at 1.5x speed, while video length for the interrupted condition was 8:56 minutes at 1.0x speed and 6:11 minutes at 1.5x speed.

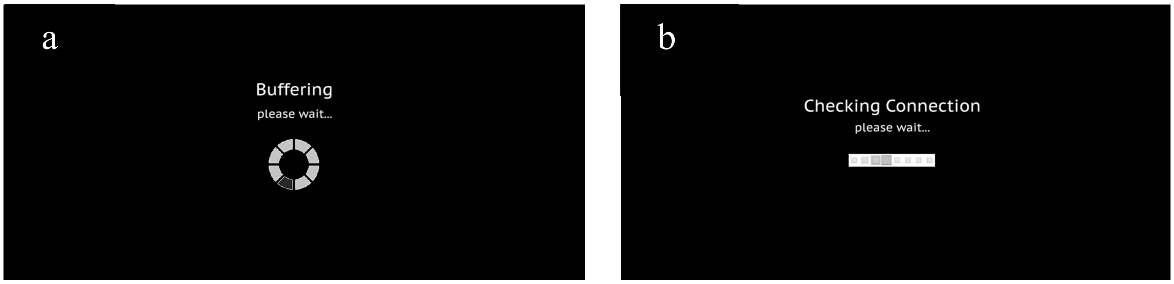

Figure 2.1. Embedded interruptions: a) a simulated buffering instance, b) a simulated network connectivity instance.

Media use questionnaire and media multitasking index. The Media Use Questionnaire (MUQ) developed by Ophir et al. (2009) was used to measure individual tendencies to multitask while using 12 forms of media: print, TV, computer-based video, music, non-music audio, video/computer games, telephone voice calls, instant messaging, SMS/text messaging, email, web surfing, other computer-based applications. First, respondents reported the number of hours per week they use each type of media. Next, participants completed the media multitasking index (MMI), indicating how often they used multiple media forms concurrently, using a 4-point Likert scale (from 0 = "never" to 3 = "most of the time") for each primary medium. Scores representing media-multitasking behavior levels within one hour of typical media-consumption were calculated by summing the number of non-primary media used simultaneously per primary medium, weighted by the percentage of hours each primary medium was used (see formula, Ophir et al., 2009). A copy of the instrument is provided in Appendix A.

Procedure

Participants were recruited for a 25-minute project dealing with student experiences in an online learning environment. Students were made aware of the extra-credit opportunity and if they chose to participate, clicked on a link to the study from their course websites. The first page they saw was a consent page. The consent page also informed participants of the overall procedure: That video was to be presented, after which they would be asked to respond to questions about the video and related matters. All who chose to participate gave consent to allow information collected from them to be used in our research. After giving consent, participants answered questions covering basic demographics, i.e., gender, age, grade point average, year in school, number of online classes taken, and whether English was their native language.

Next, participants were instructed to notify the experimenter via text message if anything affecting video delivery occurred while they were taking the survey, e.g., delays, glitches. We informed participants that delays lasting longer than 60 seconds would be reset by an automated system (fictitious) which would be activated by texting the code “5579” to the research lab mobile number provided. We asked them to jot down both the reset code and mobile number, and to keep the numbers and their phones nearby throughout the study. The idea was to force participants in the interrupted conditions to switch tasks from watching video to texting the researcher when they encountered the simulated “glitches” embedded in their videos, ensuring an interruption of their watching experience.

Then participants watched video. Eighty-nine viewed the lecture at 1.0x speed; 41 without interruption, 48 with interruption. Seventy-eight participants watched video at 1.5x speed, 40 without interruption, and 38 with interruption. Immediately after viewing lecture clips, all participants completed the MUQ and the MMI before they were tested on lecture content. This was intended to hinder working memory influence on questions designed to measure elaborative learning (see Appendix B). First, to capture elaboration, we asked them to imagine they were telling a friend about the video and tell us what information about the scale of the earth and sun they would share, suggesting the use of bullet points, including the type of content that might be included in a follow-up to the lecture. The number of “points” generated with correct information related to the video were counted. Then, to capture judgments of confidence, we presented fourteen true, astronomy-related facts, i.e., “The sun’s diameter is about 400 times larger than the diameter of the moon.” Participants rated their confidence in having seen the items in the lecture video on a scale of one to five with one representing “not confident at all” and five representing “completely confident.” Finally, to capture recognition, respondents were given a nine-item multiple choice quiz on the content of the lecture, i.e., “How long would it take a bullet (assuming it never lost its initial velocity) to get to the sun?”

Following the content assessment, and to address possible confounds, we asked questions related to their prior knowledge of lecture content, speed reading, media multitasking behavior, their previous experience with accelerated videos, and interruptions they experience in learning environments (see Appendix C). Participants rated their prior knowledge of the lecture content on a scale of one to five with one representing “not knowledgeable at all" and five representing "extremely knowledgeable." We also asked if they considered themselves speed-readers and whether they considered themselves media multitaskers. Participants also were asked to rate how often they thought media multitasking interfered with their performance using a five-point scale with one representing "never" and five representing "always."

Participants also rated their comfort with the speed of the video on a five-point scale with one representing "extremely uncomfortable" and five representing "very comfortable." Moreover, they were asked if they had previously watched videos at faster-than-normal speeds. Those who had watched sped-up videos prior to the study were asked at which rate(s) they watched videos, how recently they had watched accelerated videos, how frequently they watched videos at a faster than normal speed, which types of videos they normally speed-up, as well as how likely it was that they would speed up educational/lecture videos in the future.

Further, participants were asked whether they experienced other interruptions while taking the survey, and generally, when in a video learning environment (see Appendix D). They were asked how often the interruptions occurred, both during the survey and generally. They identified types of interruptions they encountered, whether they are external (mobile devices, pop-up notifications, phone calls, people or pets, technical difficulties) or self-initiated (mind-wandering, browsing the web, browsing social media, actively using social media, actively text messaging). Finally, we asked what type of device they used to take the survey, e.g. computer, tablet or mobile phone.

Chapter 3: Results

Learning

We measured learning in three ways. First, we examined recognition by assessing performance on nine-multiple choice items each worth one point. Scores ranged from one to nine (M = 5.72, SD = 1.95). Second, we examined elaboration by analyzing items retrieved from memory. Scores ranged from 0 to 13 (M = 2.71, SD = 1.86). Finally, we examined confidence through self-reported judgments on 14 items with a total of 70 points possible. Scores ranged from 33 to 67 (M = 50.13, SD = 7.35). (Results by condition can be seen in Table 3.1.)

Table 3.1
Means, Standard Deviations, and Standard Error for Learning Measures by Video Speed and Interruption Conditions.

		Conditions			
		No Interruptions		Interruptions	
Variable	Video Speed	1 (n = 41)	1.5 (n = 40)	1 (n = 48)	1.5 (n = 38)
Recognition					
M		5.878	5.650	5.688	5.658
(SD)		2.836	1.718	2.155	1.835
(SE)		0.326	0.272	0.311	0.298
Elaboration					
M		3.854	3.250	2.813	2.921
(SD)		2.351	1.676	1.659	1.194
(SE)		0.326	0.265	0.239	0.194
Confidence					
M		52.32	47.77	49.71	50.76
(SD)		7.083	5.558	8.752	6.828
(SE)		1.106	0.879	1.263	1.108

Results of two-way analyses of variance of video speed (1.0x, 1.5x) and interruption (absent, present) on learning are summarized in Table 3.2. An ANOVA of video speed and interruptions on recognition revealed no significant effects or interactions. However, an ANOVA of video speed and interruptions on elaboration resulted in a significant main effect of interruption $F(1,163) = 6.598$, $p < .014$, $\eta^2_p = .039$, but no main effect of speed or interaction between the variables. Overall, participants in the uninterrupted conditions generated more items (M = 3.55) than those in the interrupted conditions (M = 2.87). Interestingly, participants who watched video at 1.0x speed showed a greater difference in performance between the uninterrupted (M = 3.85, SD = 2.35) and interrupted (M = 2.81, SD = 1.66) conditions compared to those who watched video at 1.5x speed in the uninterrupted (M = 3.25, SD = 1.68) and interrupted (M = 2.92, SD = 1.19) conditions.

Finally, a two-way ANOVA of video speed and interruption on judgments of confidence in learning showed no main effects. However, the interaction of video speed and interruption was significant, $F(1,163) = 6.196$, $p < .014$, $\eta^2_p = .037$. In uninterrupted conditions, participants in the 1.0x video speed group were more confident (M = 53.32, SD = 1.13) than those in the 1.5x video speed group (M = 47.78, SD = 1.14). However, when embedded interruptions were present, mean confidence ratings were similar across speed groups. Those in the 1.0x video speed group were slightly less confident (M = 49.71, SD = 1.05) compared to those in the 1.5x video speed group (M = 50.76, SD = 1.17).

Table 3.2
Results from a series of 2 (video speed) x 2 (interruption) ANOVAs.

Variable	*df*	F	p	η^2_p
Recognition				
Video speed	1,163	.007	.935	.000
Interruptions	1,163	.049	.825	.000
Video speed × Interruptions	1,163	.704	.403	.004
Elaboration				
Video speed	1,163	.573	.370	.004
Interruptions	**1,163**	**6.598**	**.014***	**.039**
Video speed × Interruptions	1,163	.775	.380	.005
Confidence				
Video speed	1,163	2.405	.123	.015
Interruptions	1,163	.028	.866	.000
Video speed × Interruptions	**1,163**	**6.196**	**.014***	**.037**

Note. Type III Sum of Squares
*significant at p < .05 level.

Secondary Analyses

Sex and age revealed no significant impact on learning; nor did prior knowledge of lecture content. Seventy participants reported they were not knowledgeable at all, 58 reported being slightly knowledgeable, and 30 rated their prior knowledge as moderate. Seven participants rated themselves as very knowledgeable, while two reported to be extremely knowledgeable ($M = 1.88$, $SD = .93$).

Video Speed. Survey data indicated almost half of participants (83) had previously watched videos at faster-than-normal speeds. However, about 50 percent (42) of those reporting they speed-watched video previously said they rarely speed up video, compared to just under 11 percent who stated they speed up videos most of the time. The average rate of acceleration reported was close to 1.5 times normal video speed.

19.3 percent of respondents reported it had been more than one month since they had accelerated video. The majority reported they had sped up videos within the month; with 37.3 percent reporting they had watched videos at a faster than normal speed less than one day before the experiment.

Participants reported speeding up multiple types of videos, including movies, lectures, and YouTube videos, among others (i.e., training videos, documentaries required for class, news programs, music and cooking videos, as well as those in which people speak slowly). Twenty-six percent reported they would likely speed up educational/lecture videos in the future compared to over 60% who said it wasn't likely they would. Over three-quarters (77%) of participants in the 1.0x speed group reported being very comfortable with to neutral about ($M = 3.73$, $SD = 1.25$) the video speed compared to about a third (35%) of participants in the 1.5x speed group ($M = 2.36$, $SD = 1.21$).

Interruptions. The majority of participants (78%) experience interruptions, generally, when in a video learning environment and over half (69%) said they were interrupted during the study. The large percentage of students reporting they were interrupted during the study prompted the analysis of an artificial control condition of zero interruptions. This condition included participants who watched video without embedded interruptions and also reported taking the survey uninterrupted. Of participants meeting the criteria, 16 watched video at 1.0x speed and 19 watched at 1.5x speed. One-way ANOVAs of video speed on uninterrupted learning as measured by recognition, elaboration, and confidence were performed. There was no main effect for speed on recognition or elaboration, however there was a main effect for speed on confidence items $F(1,33) = 7.621$, $p < .009$. That is, participants in the 1.0x video speed group (M=52.81, SD=7.69) were more confident in their selection of facts than those in the 1.5x video speed group (M=46.63, SD=5.52) across the uninterrupted control condition.

We also compared the performance of participants in the uninterrupted video conditions by self-reported interruptions. During the uninterrupted conditions, we compared individuals who self-reported interruptions to those who reported taking the survey uninterrupted. We found no significant main effect for speed on recognition, $F(1,77) = .178$, $p < .674$, or elaboration $F(1,77) = 1.312$, $p < .256$. However, there was a significant main effect for speed on confidence $F(1,77) = 10.561$ $p < .002$. There was no significant main effect of interruption on recognition, $F(1,77) = .006$ $p < .936$, elaboration, $F(1, 77)$ .669 $p < .416$, or confidence $F(1,77) = .224$ $p < .637$; nor were there significant video speed x interruption interaction effects.

Media Multitasking. A media multitasking index (MMI) score (Ophir, Nass, and Wagner, 2009) was calculated for each participant based on mean number of media types consumed at the same time per hour of media use. Scores ranged from .19 to 10.05 (M = 3.216, SD = 1.79). Twenty-seven participants scored one standard deviation or more above the sample mean, which classified them as HMM. Twenty-five participants fell into the LMM range, scoring one standard deviation or more below the mean. HMM scores ranged from 5.11 to 10.05, (M = 6.428, SD = 1.28). LMM scores ranged from .19 to 1.4 (M = .989, SD = .280).

Thirty-three percent of participants considered themselves speed-readers; and 57.5 percent self-identified as media multitaskers. Fifty-eight percent of respondents thought media multitasking interfered with their performance “about half the time,” (M = 3.26, SD = 1.05).

An analysis of variance was repeated for each measure with media-multitasking behavior as a covariate with video speed and interruption to determine whether it would moderate the impact of speed and/or interruption on learning (see Table 3.3). There were no significant changes in main effects or interactions after controlling for media multitasking behavior on recognition, elaboration, or confidence.

Table 3.3
Results from a series of 2 (video speed) x 2 (interruption) ANOVAs covarying media multitasking.

Variable	*df*	F	p	η^2_p
Recognition				
Video speed	1,162	.206	.650	.001
Interruptions	1,162	.082	.774	.001
Media Multitasking	1,162	.127	.722	.001
Video speed × Interruptions	1,162	.127	.722	.001
Elaboration				
Video speed	1,162	.922	.338	.006
Interruptions	1,162	6.059	.015*	.036
Media Multitasking	1,162	0.442	.507	.003
Video speed × Interruptions	1,162	1.817	.180	.011
Confidence				
Video speed	1,162	2.157	.144	.013
Interruptions	1,162	.022	.883	.000
Media Multitasking	1,162	.494	.483	.003
Video speed × Interruptions	1,162	5.792	.017*	.035

Note. Type III Sum of Squares
*significant at $p < .05$ level.

Chapter 4: Discussion and Conclusion

Many students play instructional videos at speeds faster than the original presentation and the likelihood they will experience interruptions is high (especially in non-classroom environments). Do those who speed-watch pay a price in learning for gaining time?

Analyses of variance on three measures were hypothesized to show that interruptions would have a greater effect on learning performance at higher video playback speeds than at lower video playback speeds; and that media multitasking ability would moderate effects of video speed and interruptions on learning.

Results show that neither video speed nor interruptions affected recognition performance. As noted in the introduction, literature on video speed is inconsistent. Thus, while recognition results do not settle the issue of whether speed-watching is good or bad with respect to content memory, they suggest that speed-watching does not interfere with content learning. The finding of no speed effect on recognition is consistent with results of Ritzhaupt et al. (2015) but inconsistent with others. For example, Song et al. (2018) found an effect of speed on retention when novel material was presented to medical students. In contrast, the current study's results differ from Song et al. (2018) in that a majority of participants in this study reported they were not knowledgeable at all (70) or slightly knowledgeable (58) about the lecture topic before the experiment.

Returning to theoretical foundations discussed in the introduction, do our results mean that speed-watching adds no cognitive load? Even well-planned lectures have built-in hesitations, sidetracks, bursts of irrelevancy, redundancy, and the like. During those moments, the mind can wander. We hypothesized that speed-watching may compel greater attention which may compensate for any content learning losses associated with load. This would help explain the inconsistencies in previous results, and the neutral results in our study. At 1.0x speed, load might be lighter, while attention might be less. At 1.5x speed, load may be heavier, but attention may be better. Interruptions could be routine at 1.0x speed and better ignored at 1.5x speed. Additionally, it's possible that the perceived difficulty of processing content at faster speeds may have prompted students to exercise deeper processing strategies, resulting in higher recall (Alter, Oppenheimer, Epley, & Eyre, 2007).

With respect to elaboration, our results do not confirm our hypothesis of a main effect for video speed. We suspected that faster video speed would increase cognitive demand, reduce germane load, and result in poorer elaboration (fewer connections in memory). Our results indicate interruption impacted elaboration, confirming that our elaboration measure had some validity and that elaboration may be vulnerable to outside provocation (Petty, Wells, & Brock, 1976), as confirmed by our use of the MMI measure as a distractor task. Mental load increases due to interruptions (Foerde, Knowlton, & Poldrack, 2006; Paas, Renkl, & Sweller, 2003; Sweller, 1988) also may help explain our results. The effect of interruption on elaboration implies that interrupted learners may have trouble connecting new information to existing knowledge and transferring it to new situations (Mayer, 2005), regardless of video speed.

The confidence measure could be seen as an attempt to assess self-understanding of metamemory for, or metacognition of, this particular learning instance. Here, results showed an interaction of video speed and interruption. Watching accelerated video resulted in lower confidence ratings than watching at normal speed, unless there was an interruption present.

As explained by CLT, it's possible that the increased demand on mental resources by video presented at faster speed was moderated or reduced when participants were forced to switch tasks in the interrupted conditions. However, confidence is susceptible to metamemory effects. Similarity between lures and targets can result in inversions between the confidence and accuracy in memory (Roediger & Desoto, 2013). Our tendency to lean on cognitive heuristics extends to metacognitive heuristics, as well. These meta-shortcuts can be tied to familiarity and utilization of cues (Busey, Tunnicliff, Loftus, & Loftus, 2000). Faster video speeds may have provoked participants to use more generally themed retrieval cues rather than rely on memory for specific details, (Chandler, 1994).

Confidence indicates that participants believe they have learned, and is generally indicative of memory accuracy, but not always (Roediger & Desoto, 2013). This is important because it impacts later decisions. In real life, for example, a student with lower confidence might replay a section of video, negating the time advantage of speed-watching. Learners might second-guess themselves on responses or take longer to respond on a timed test (ours was not timed).

Some concerns/questions

What prevents people from watching video too fast? It seems the nervous system knows our upper limit (which varies by individual). Few of us accelerate video beyond what is deemed a reasonable speed, because at those speeds the experience becomes a bit ridiculous; i.e. playing video faster can result in "the chipmunk effect" (a rise in audio pitch). At some point, there is likely a speed cost on learning.

It's possible that reported ratings of little to no prior knowledge of lecture content could be confounded by foundational knowledge, given that our primary education includes basic astronomy. Persons who were not interested in the lecture topic may have been less engaged, which may have affected their performance.

Some have made the distinction between remembering and knowing (Tulving, 1985). Unfortunately, this cannot be addressed with data collected for this study. However, it is an interesting topic for future work, especially when using measures such as confidence.

Conclusion/Recommendation

Students thinking about accelerating video speed should know the implications of doing so in a typical online environment. Our results indicate that speed-watching does not interfere with content learning. Indeed, it may increase focus and offer some protection from interruption. Many students accelerate videos to save time, which is understandably appealing. As long as chosen speeds don't exhaust mental resources, students will realize a time savings benefit (one which can quickly disappear if speeds are too fast).

It is important to note that the increased focus and bolstered protection from interruption provided by speed watching does not apply to elaboration. Retrieval from memory is susceptible to interruptions, which negatively impacted meaningful learning, regardless of video playback speed. Hence, limiting interruptions while watching video is another suggestion for students.

There is a potential upside to interruptions. In a reversal of sorts, interruptions seem to offer protection from the effect of video speed when it comes to confidence. Watching video at speeds faster than normal caused lower confidence in students, except when they were interrupted. Ultimately, speeding up video is a choice. Students who know the benefits and risks associated with speeding up video, especially taking into account learning environments unique to them, can ultimately make an informed choice.

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Appendix A - Media Use Questionnaire (MUQ)

Report the total number of hours per week you spend using each of the following media:

Print media	_________
TV	_________
Computer-based video	_________
Music	_________
Non-music audio	_________
Video/computer games	_________
Telephone/mobile phone voice calls	_________
Instant messaging	_________
SMS/Text Messaging	_________
Email	_________
Web surfing	_________
Other computer-based applications	_________

Media-Multitasking Index (MMI)

For each type of media, indicate how often you simultaneously engage in each of the other types of media.

o = "Never"

1 = "A little of the time"

2 = "Some of the time"

3 = "Most of the time"

	TV	computer-based video	music	nonmusic audio	video/computer games	telephone/mobile phone voice calls	instant messaging	email	web surfing	other computer-based applications	text messaging
Print media											
TV											
computer-based video											
music											
nonmusic audio											
video/computer games											
telephone/mobile phone voice calls											
instant messaging											
email											
web surfing											
other computer-based applications											

Appendix B - Video Content Assessment

1. Imagine you are telling a friend about the video you just saw. What information about the scale of the earth and sun would you share with your friend? They can be facts you learned or conclusions you've drawn; short explanations in the form of bullet points are fine. [Textbox]

2. How confident are you that the items below were covered in the video? [Not confident at all, slightly confident, somewhat confident, fairly confident, completely confident option buttons]

- The circumference of the earth is approximately 40,000 km.
- The speed of light is constant.
- The distance from the earth to the moon is approximately 384,400 km.
- The sun is approximately 8 light-minutes from the earth.
- An astronomical unit is based on the distance from the sun to the earth.
- The sun is bigger than the moon.
- Africa is comparable in size to the area of the moon.
- The size of the earth and sun are very small when compared to our entire solar system.
- A bullet and a jetliner travel at roughly the same speed.
- It takes 8 minutes for light to travel from the sun to the earth.
- If you were to drive a car at highway speeds to the sun, it would take about 163 years to get there.
- It would take a bullet 6,250 days to get to the sun from earth.
- Sydney, Australia is about 8,000 miles from San Francisco, California in the United States.
- The sun’s diameter is about 400 times larger than the diameter of the moon.

3. If there was a follow-up video to this lecture, in your opinion, what content should be covered? [Textbox]

4. The main idea of the video was: [The circumferences of the sun and earth, the speed of a bullet vs. the speed of a jetliner, measuring distance in astronomical units, the scale of the earth and sun, the amount of time it takes for sunlight to reach the earth option buttons]

5. How large is the earth's circumference? [25,000 km, 30,000 km, 35,000 km, 40,000 km, 45,000 km option buttons]

6. How fast is a bullet or jetliner? [800 km/hr, 1,000 km/hr, 1,200 km/hr, 1,400 km/hr, 1,600 km/hr option buttons]

7. An astronomical unit: [can be measured by observing the transit of Venus, was first estimated by Jean Richer and Gian Domenico Cassini, is precisely measured by radar and telemetry from space probes, can be estimated by measuring the parallax of Mars from two locations on the Earth, is based on the distance from the sun to the earth option buttons]

8. How many days would it take you to travel around the circumference of the sun in a jetliner? [~150 days, ~165 days, ~180 days, ~195 days, ~210 days option buttons]

9. How large is one astronomical unit (AU)? [150 km, 150,000 km, 15,000,000 km, 150,000,000 km, 1,500,000,000 km option buttons]

10. How long would it take a bullet (assuming it never lost its initial velocity) to get to the sun? [~7 days, ~7 months, ~17 months, ~7 years, ~17 years option buttons]

11. According to the speaker, if the sun was the size of a medicine ball, the earth was just a speck, and they were both on a football field, how far apart would they be? [The sun was in one end-zone and the earth would be at the nearest 20 yard line, the sun would be in one end-zone and the earth would be on the other end of the field at the 20-yard line, the sun would be at one 20-yard line and the earth would be at the other 20 yard line, the earth would be on one ten-yard line and the sun would be on the other end of the field at the thirty-yard line, the sun would be in one end-zone and the earth would be in the other end-zone option buttons]

12. The partially shown sun (the second sun shown in the video) was how large in diameter, according to the speaker? [15 inches, 20 inches, 25 inches, 30 inches, 35 inches option buttons]

Adapted from Jacobson, 2015.

Appendix C - Post-Experiment Survey

1. Did you have an above average amount of background knowledge in the topic of today's video before you watched it? [Yes, no option buttons]

2. Do you consider yourself a speed-reader? [Yes, no option buttons]

3. Do you consider yourself a media-multitasker? [Yes, no option buttons]

If you answered "no", skip to question #5

4. How frequently do you think media-multitasking interferes with your performance? [Never, rarely, sometimes, most of the time, always option buttons]

5. How comfortable were you with the speed of the video? [Very uncomfortable, somewhat uncomfortable, neither comfortable nor uncomfortable, somewhat comfortable, very comfortable option buttons]

6. Prior to participating in the experiment, had you watched a video at a faster than normal rate before? (i.e., a video sped up by a certain rate, like 1.5x or 2x normal speed) [Yes, no option buttons]

If you answered "no", skip to question #11

7. At which rate do you normally speed up the videos you watch? [1.25x, 1.5x, 1.75x, 2.0x, other:________ checkboxes, text box]

8. How recently have you watched a video at a faster than normal speed? [Less than a day, less than a week, less than a month, more than a month option buttons]

9. When you watch videos that can be sped up, how frequently do you speed them up? [Never, rarely, sometimes, most of the time, always option buttons]

10. What types of videos do you normally speed up? Check all that apply. [Movies, lecture videos, YouTube videos, other (can list more than one type, separated by commas, if applicable): __________________ checkboxes, text box]

11. How likely is it that you will speed up educational/lecture videos in the future? ["Very Unlikely", "Somewhat Unlikely", "Neither Likely nor Unlikely", "Somewhat Likely", "Very Likely" option buttons]

Adapted from Jacobson, 2015.

Appendix D - Interruptions Questionnaire

1. Did you experience interruptions while you were taking this survey?

2. How frequently did you experience external interruptions such as those below, during this survey? [Never, sometimes, about half the time, most of the time, always, option buttons]

- Mobile notifications (on a device other than the one you're using to watch video)
- Online notifications (email or app notifications, web browser pop-up windows)
- Phone calls
- In-person (people, pets)
- Technical difficulty (browser error, buffering)
- Other (please list):________ [text box]

3. How frequently did you experience internal interruptions such as those below, during this survey? [Never, sometimes, about half the time, most of the time, always, option buttons]

- Mind-wandering or daydreaming
- Browsing the web
- Browsing social media
- Actively messaging on social media
- Actively text messaging
- Other (please list):________ [text box]

4. Do you generally experience interruptions when you watch course lectures/video online? [Yes, no option buttons]

5. How frequently, in general, do you experience interruptions when in a learning environment? [Never, sometimes, about half the time, most of the time, always option buttons]

6. In general, how frequently do you experience external interruptions, such as those below, when in a learning environment? [Never, sometimes, about half the time, most of the time, always option buttons]

- Mobile notifications (on a device other than the one you're using to watch video)
- Online notifications (email or app notifications, web browser pop-up windows)
- Phone calls
- In-person (people, pets)
- Technical difficulty (browser error, buffering)
- Other (please list):________ [text box]

3. In general, how frequently do you experience internal interruptions, such as those below, during this survey? [Never, sometimes, about half the time, most of the time, always, option buttons]

- Mind-wandering or daydreaming
- Browsing the web

- Browsing social media
- Actively messaging on social media
- Actively text messaging
- Other (please list):________ [text box]