The Effects of Time-Compressed Instructional Video Presentations on Student Recognition, Recall, and Preference.

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Abstract

The use of streaming video presentations is rapidly growing in higher education and corporate training environments. Archived video presentations represent valuable assets to many organizations and their learners and trainees. The ability to view media in a time-compressed or accelerated way has long been an attractive proposition and has only recently been made widely available. This study explores the effects of learning from time-compressed video on memory. Two video clips in either accelerated or unmodified form were viewed by 30 college students. A test was administered measuring cued content recall, cued context recall, and content recognition. In line with studies of previous years, no overall significant differences were found across any of the measures between participants in accelerated or normal speed conditions. Significant differences were found, however, between video clips. It is concluded that moderate levels of time-compression might be applied to video presentations in learning situations to realize time-efficiencies, with little effect on memory. Implications and directions for further research are discussed.

Introduction

A body of research exists (Barabasz, 1968; Fairbanks, Guttman, & Miron, 1957b; K Harrigan, 1995; K. Harrigan, 2000; King & Behnke, 1989; Olson, 1985; Orr, Friedman, & Williams, 1965; Short, 1977; D. L. Williams, Moore, & Sewell, 1984), suggesting effective learning can occur with time-compressed or accelerated video presentations. Media Richness theory (Daft, Lengel, & Trevino, 1987) might address why one might value the multimodal, multi-channel (rich) approach to instruction that is used in many video presentations, but it does not account for issues of acceleration or specific learning objectives beyond the reduction of message ambiguity. "Parallel processing models acknowledge that a person can simultaneously engage in multiple tasks, such as seeing and hearing, depending on whether the tasks require the use of separate or common resources" (Leigh, 1991, p. 72). Outside of the perhaps obvious time savings benefits, little is known about what type of learning objective or memory is affected by time-compression. This study will help shed needed light on the issues, thereby helping instructors and instructional designers better understand time-compression and learning to aid them in creating more engaging and effective video-based instruction.

Time-compression and rate modification in general can be used in a variety of application areas including teaching, learning, and human-computer interfaces. Time-compression has been used to skim media assets, to speed up message presentation in voice mail systems, and to aid the visually impaired. The technology has also been used to slow down media for learning languages, or for the hearing impaired (Aarons, 1992; Omoigui, He, Gupta, Grudin, & Sanocki, 1999). Over the last few years, schools and programs at many higher education and distance education institutions have incorporated streaming media in their instruction (Galbraith & Spencer, 2002). This use of streaming media for learning has largely taken the form of online archives of lectures and presentations, and as a primary or supportive means of instruction. Large, distributed corporations and government agencies may well be leading the charge (Arlen, 2003; Galbraith, 2000), with online video presentations accounting for a significant portion of corporate training. Scores of inexpensive products and services exist in the market today that facilitate the simple and even fully automatic creation and distribution of rich streaming media and video presentations for education and training purposes.

Radio and television networks have understood and employed time-compressed programming for decades as a means of selling more air time for advertisers (LaBarbera & MacLachlan, 1979). The instructional efficiencies in terms of time-compression are desirable; the concept of time-compressed presentations has also long been an alluring aim in training and education. The functionality to accelerate audio once found in reel-to-reel and cassette tape systems, and more recently, in computer-based training (CBT) systems was not available for web-based media, and had not caught on commercially (Aarons, 1992). Such tools have only recently been made widely available as either player plug-ins (such as *Enounce*) or in Microsoft's case, this variable speed playback functionality was recently added to their most recent Windows Media 9.0 architecture. Due to recent technological as well as time-compression algorithm advances, it could be argued that the ability to accelerate media and retain high intelligibility has never been as widely available as it is today. It is also highly unlikely that wide spread acceleration is being utilized in university and training settings due to the recency of these technological advancements. Not to say that interest in accelerated audio and video presentations has not existed for quite some time, but research appears to have slowed during recent decades.

Acceleration and time-compression studies from the early 1950s to the late 1970s focused primarily on listener comprehension of audio. With the cooling of this research field over the past few decades, combined with the emergence of a new medium, the Internet, there is a need to determine if previous findings still hold true for audio- and video-based instruction in this environment. Given the current interest in media-rich distance education, understanding the potential negative and positive effects of acceleration on learning is critical. Furthermore, increased understanding of how people respond to and use time-compression is important for the design of learning environments and interfaces. Before any studies of substance can be conducted on the various psychological aspects of accelerated video instruction, the feasibility of it as a technology, and its application as a learning tool need to be verified.

With the increase in web-based video instruction and the growing simplicity with which time-compression can be applied to it, this study asks what the effects are of time-compression on memory and learning. What kind of learning does modest acceleration affect (King & Behnke, 1989), and what kinds of learning tasks are most affected (Olson, 1985)? In particular, how might performance on cued recall and recognition tests vary under different time-compressed conditions? While not exhaustive, this study seeks to address these issues from a learning perspective.

Literature Review and Study Rationale

Moderately accelerated presentations have been shown to benefit learning (Fairbanks, Guttman, & Miron, 1957a; Fairbanks et al., 1957b; K. Harrigan, 2000; Short, 1977) as long as intelligibility can be maintained. In normal conversation, people speak and can comfortably hear words that are spoken at between 100 to 180 words per minute (Olson, 1985; Silverstone, 1974; J. R. Williams, 1998). When normal speech is increased to 210 words per minute, there is still no loss in comprehension (Omoigui et al., 1999). A 1965 study (Orr et al.) noticed that listeners could tolerate acceleration up to 2.0x normal speed (twice as fast). Interestingly Orr et al. and others note that with ear training and practice, even higher speeds were possible (Aarons, 1992; Olson, 1985; Silverstone, 1974; Voor & Miller, 1965).

"This creates a speaking/listening discrepancy since a listener can comprehend spoken material up to four times (4x) faster than the speaker can send the message," writes Olson. "The result is a listener [or learner] who becomes bored or whose attention begins to wander" (1985, p. 3). Students themselves have reported anecdotally that accelerated presentations help them speed through boring or redundant material, it helps them stay more focused and attentive, learn more, and achieve higher grades (Galbraith & Spencer, 2002). Some research appears to reject the aforementioned student comments under certain conditions (Gutenko, 1995; K Harrigan, 1995; K. Harrigan, 2000). Numerous studies in the field of communications suggest that fast speakers are perceived as more intelligent, authoritative, competent, articulate, interesting and memorable than slow speakers (Ananova, 2002; Gutenko, 1995; LaBarbera & MacLachlan, 1979; Storck & Sproull, 1995), but these studies fail to mention a crossover to an educational environment.

Time efficiencies are not always the primary concern in schools and corporate environments, where effectiveness has a greater perceived value. While media richness theory suggests that richer media can reduce ambiguity in conveying messages (El-Shinnawy & Markus, 1998), and can aid in converging on shared meaning, the Information Processing model, and more specifically Dual Coding theory, question or temper the "more is better" approach. In her literature review of Information Processing (IP) capacity, channels, and modality, Hsia (1971) makes two particularly noteworthy points. First, human information-processing functions as a multi-channel system until the capacity of the system is overloaded, at which point it reverts to a single channel system. Second, an increase in the amount of information or stimuli presented, does not necessarily increase the rate of information encoding and storage. For example, much research suggests that intelligibility declines for users at some point of acceleration, directly compromising comprehension and memory (Beasley, Bratt, & Rintelmann, 1980; Fairbanks et al., 1957b; Heiman, 1986; Mayer & Moreno, 1998). In another example, King and Behnke's (1989) tests found that while short term and interpretive listening test scores (using the Kentucky Comprehensive Listening Test) did not decay until high levels of compression were reached, comprehensive listening scores and long-term memory showed a linear decay with speed increases. King and Behnke's finding was attributed to the lack of processing time available for long term memory encoding, and the rapid presentation of information in short term memory.

"Memory is typically measured in two ways: recall and recognition. Recall is affected by almost all substructures of memory while recognition tasks typically entail a less rigorous involvement of memory structures" (Sundar, Narayan, Obregon, & Uppal, 1997, p. 2). Lang (1995) also addresses the need to assess recall, and recognition separately when she writes: "Specifically, recognition measures index how much information was encoded, cued recall indexes how much information has been stored, and free recall indexes the information available for retrieval" (p. 86). This is in line with what psychologists have believed for years with the encoding and storage of stimuli within the information processing model. For this study our intention is to follow the distinction posited by Sundar et al., and myriad psychological literature in our testing of memory.

It should be noted that many of the studies in the 1960's and '70s employed destructive time-compression techniques that "involved deletion and subsequent concatenation of portions of the acoustical signal" (Dupoux & Green, 1997). Moreover, many of the studies cited thus far have dealt with simple media representations (usually audio only) and did not factor in the additional cues and associated encoding demands of the even richer multi-modal interfaces outlined in this study. Improved time-scale modification (compression) algorithms tend to be far less disruptive to speech as they overlap, rather than delete portions of the signal. It is our contention that today's signal processing and time-compression algorithms should facilitate higher comprehension than previous technologies and techniques.

The complexity of the stimulus materials and density of ideas presented in the stimulus of this study are central factors when it comes to time-compression and comprehension. IP theory generally holds that complex material would be adversely affected by high rates of time-compression due to overloading and subsequent over-writing of short term memory (Moore, Burton, & Myers, 1996). Along related lines, Limited Capacity models describe the allocation of resources (both voluntary and automatic) to given stimuli, would be working against the notion of acceleration increasing learning. Lang (2000) describes numerous conditions affecting orienting response and cognitive resource allocation relevant to video presentations, and how they are affected by the goals and needs of the individual—whether they are viewing for pleasure/relaxation or for learning. We agree with Lang (2000) when she states that the highly attending learner-viewer is likely to run into resource-limited situations, but due to conscious increase in applied resources, the learner is still likely to process the message more fully.

Olson's (1985) work counters Lang's, and can be best framed in a cue summation (Severin, 1967) context. Olson focused on what augmentation stimuli might be applied to help mitigate these overload effects and “allow the faster compression rates to be as effective as a normal rate” (p. 6). A level of additional stimuli (textual script or simple visuals) might provide the redundancy needed to comprehend the spoken material and “provide enough additional information for the learner to organize or restructure the material” (Olson, 1985, p. 6). It is difficult to know if such visual augmentations exacerbate problems associated with limited capacity models of cognition, or if they in fact aid in the coding of the message. Meyer and Moreno (1998) support the idea of using alternate modalities to avoid any single channel from overloading. Augmenting video or animations with text (another visual medium), where the visuals are important to the message, sets up an undesirable split-attention effect (Mayer & Moreno, 1998).

Yet another factor in time-compressed audio/video presentations is ear training, which is conditioning and acclimation to time-compression stimulus, and it may play a central role in how people respond to and learn from moderately accelerated presentations. Both empirical and extensive anecdotal evidence point to fairly rapid normalizing effects when listening to time-compressed speech (Dupoux & Green, 1997). Beasley and Maki (1976), for example discuss how people’s perception of what “normal speed” is and their preference for accelerated presentations, increase with prolonged exposure to time-compression. When accelerated presentations are returned to their recorded (normal) speed, people perceive the presentation to be artificially slowed down well below “normal” rates. Galbraith & Spencer (2002) findings are in agreement with this statement. In addition, strong negative reactions tend to be expressed when to returning to normal where the “pace may seem dreadfully slow” (C. P. Fulford, 1993, p. 51).

Most of the studies dealing with time-compression focus on simple media representations (typically audio only) and did not factor in the additional cues and associated encoding demands of the even richer multi-modal interfaces proposed in this study. The complexity of the stimulus materials and density of ideas presented are very relevant factors when it comes to time-compression and comprehension. Olson's (1985) work focused on what textual or visual augmentation stimuli might help mitigate these effects and "allow the faster compression rates to be as effective as a normal rate" (p. 6). Olson contends that a level of additional information richness might provide the redundancy needed to comprehend the spoken material and "provide enough additional information for the learner to organize or restructure the material" (p. 6).

Those applying technologies to training and education have always sought for the perfect medium, one that delivers instruction so that learning is both effective and efficient (C. P. Fulford, 1993). Time efficiencies are at the root of much of the research in this field. In measuring time, however, one cannot simply tally the length of the video presentations themselves. Fulford (1993) cautions that, "It is not enough to assume that because the overall effectiveness was equivalent to normal speech and the word rate was faster, the result is greater efficiency" (p. 58). Actual time (viewing and tests) as well as viewing time (without tests) must be calculated for each participant.

Barabasz (1968), in a study on recall and retention with 118 undergraduate students, found that there was no significant difference in experimental groups when lectures were presented at 1.3x presentation speed. This study is particularly interesting in that he used standardized multiple choice tests, common in much of education today, for all covered material and was using statistically equivalent test scores as evidence of equal learning by all groups involved. King and Behnke (1989), in their study with 120 undergraduate students, found no significant difference in short-term listening, and interpretative listening up to 1.9x playback of material. Meaning that the participants faired equally well on administered tests, but the accelerated group was able to complete the task almost twice as fast and the normal playback group. In a preceding study by Williams, Moore, & Sewell (1984) using 131 community college students, found that there was no significant difference over the two week delayed posttests between the accelerated (1.3x) and normal playback (1.0x) groups. A series of studies by Fairbanks, Guttman, & Miron (1957a; 1957b) found that subjects who experienced the 2.0x accelerated playback treatment had a mean post-assessment score within 90% of the scores achieved by the normal 1.0x playback group. According to Sticht (1969), listening to instructional material twice that has been accelerated by a factor of two, is more effective than listening to it once at normal speed. In such cases, obviously no time savings are realized, but the benefit resides in the effectiveness of presentation and learning. Similarly, Fulford (1993) reports that even with the ability to rewind and repeat instruction, accelerated presentations were more efficient. Usage habits and the ways in which participants navigate, repeat sections, stop and start are seldom found in the literature.

Hypotheses

Along the research lines followed by King & Behnke (1989) and Olson (1985), this study sought to better understand the nature or type of learning affected by time-compressed presentations. The main research questions (RQ) and Hypotheses (H) are as follows:

RQ1: For college students viewing instructional video presentations, controlling for speaking speed (wpm), presentation order and style, what is the relationship between time-compressed presentations and cued recall and recognition, where presentation speed and video segment are the independent variables?

H1: There will be no significant difference in performance on **cued content recall** tests between participants experiencing normal speed presentations and participants experiencing time-compressed presentations.

H2: There will be no significant difference in performance on **content recognition** tests between participants experiencing normal speed presentations and participants experiencing time-compressed presentations.

H3: There will be no significant difference in performance on **cued context recall** tests between participants experiencing normal speed presentations and participants experiencing time-compressed presentations.

RQ2: Do participants report a preference for time-compressed presentations over normal speed presentations?

Method

For the purposes of this study, time-compression will be defined as the artificial modification of temporal media. Additionally, time-compressed playback will be defined as a faster rate than at the recorded speed. “Normal speed” (1x), will refer to unmodified playback speed, and “accelerated speed” refers to increasing playback speed by 1.5 times normal speed (1.5x). The study was a 2x2 factorial design with 1 dependent variable (memory).

Thirty-one (n=31) Penn State undergraduate education students (pre-service teachers) enrolled in two “Internet for Educators” course sections were recruited as participants for this study. The two primary presentation video clips were selected specifically to cater to diverse educational interests and to strengthen the generalizability of the potential findings, while remaining relevant to the participants’ coursework. The two video segments were comparable and controlled as to words per minute, but were qualitatively different in term of presentation style, topic, visualization, editing and variety of voices. Both video presentations were preceded with an introductory or “preliminary” video segment. The preliminary video’s purpose was especially to provide the accelerated group participants with time to acclimate to the time-compression condition. Prior to viewing the preliminary clip, both groups were advised they would not be tested on that video segment. The preliminary video was a one minute (1:00) clip. Each video clip was separated with a six second (:06) title card that provided either simple clip identifiers (“Video Clip A”) or instructions (“You have finished viewing the video clips, please remove and complete the test in your packet”). Both primary clips averaged 163 words per minute (wpm) at normal speed, and all acceleration for the time-compression group was fixed at 1.5 times the normal speed, corresponding to an average of 244 wpm.

Video segment “A” ran five minutes (5:00) under normal playback conditions and discussed the industrialization of the US public school system as the nation’s economy evolved from an agrarian, resource-based economy to an industrial, skilled-labor based economy. The sole, male presenter narrated on camera while old images related to the message appeared behind him. At times the images would fill the screen in lieu of the presenter while he continued narrating. Video segment “B” was narrated by multiple on and off camera presenters. The video was focused on outcome-based education and a related secondary education, home economics program in an eastern state. The scenes alternated between the voiceover narrator, and on-camera interviews. During narrator segments, live motion video sequences illustrating the narrator's points would be presented such as high school home economics activities and classrooms.

The independent variables employed in this study are speed of video segment presentation, and the video segment itself. The normal speed treatment group would view the two video segments with a total running time of 11:00 minutes. The accelerated treatment groups viewed the same video segments at a time-compressed rate of 1.5x normal speed with a total running time of 6:36 minutes. The dependent variable employed in this study was memory, specifically, cued content recall, content recognition, and cued context recall.

After completing informed consent forms, participants were randomly assigned to one of two instructional video presentation conditions (normal speed and accelerated). Each condition contained a counterbalanced presentation order to control for any recency effects in assessment. Participants were instructed to pay close attention to video presentations, as they would be quizzed following the treatment. All participants were pre-tested for prior knowledge of the video content and then proceeded to view their treatment materials. Each group viewed a short "preliminary" video segment designed to acclimate the participants to the treatment.

Fulford (1989) reports that "…with systematically designed instruction the text materials augmented with compressed speech audio tapes are more efficient (concepts learned per minute) than text augmented with normal speech audio tapes" (p. 78). This study uses that finding with text augmented by audio and asks if similar findings can be gleaned in with video based instruction. During the course of this study the researchers specifically controlled for: participants ability to stop, pause, rewind or replay video clips; video segment presentation order; participant proximity to peers; start times (varying them to avoid any test anxiety by the slow treatment group); and content, as the video segments were selected for differing, but relevant content of general interest to educators.

Following the video presentation, the participants were administered a 34 item posttest. The test was composed of two series of 17 questions assessing "cued content recall" (6 questions), "content recognition" (6 questions), and "cued context recall" (5 questions). Upon completing the posttest, participants were prompted to view two short video segments, one playing at normal speed and one time-compressed, and then asked to indicate their speed preference. Total running time for both of the preference clips on the page was 50 seconds (:50). Figure 1 provides a timeline of the study implementation for the four treatment conditions.

Figure 1
Overview of study implementation

<table>
<tr><td>Normal</td><td rowspan="4">Instructions</td><td rowspan="4">Pre-test</td><td>Title (:06)</td><td>Preliminary video (1:00)</td><td>Title (:06)</td><td>Video V (5:00)</td><td>Title (:06)</td><td>Video P (5:00)</td><td>End (:06)</td><td rowspan="4">Memory Posttest</td><td>Total time 11:00</td></tr>
<tr><td>Normal</td><td>Title (:06)</td><td>Preliminary video (1:00)</td><td>Title (:06)</td><td>Video P (5:00)</td><td>Title (:06)</td><td>Video V (5:00)</td><td>End (:06)</td><td>Total time 11:00</td></tr>
<tr><td>Accelerated (1.5 x normal speed)</td><td>Title (:06)</td><td>Preliminary video (:37)</td><td>Title (:06)</td><td>Video V (3:12)</td><td>Title (:06)</td><td>Video P (3:12)</td><td>End (:06)</td><td>Total time 6:36</td></tr>
<tr><td>Accelerated (1.5 x normal speed)</td><td>Title (:06)</td><td>Preliminary video (:37)</td><td>Title (:06)</td><td>Video P (3:12)</td><td>Title (:06)</td><td>Video V (3:12)</td><td>End (:06)</td><td>Total time 6:36</td></tr>
</table>

When scoring the participants' responses to the assessment instruments, one point was awarded for each correct answer on recall and recognition questions related to the video segments' content and the video segments' context. All questions were fact-based questions derived from the video segments' content and context. All multiple-choice questions were objectively scored following a scoring key that was created by the researchers. A scoring rubric was devised to evaluate the short answer (cued recall) questions. Subjectivity in scoring the short answer questions was mitigated by using two independent graders. All discrepancies were reviewed by committee, negotiated, and ultimately scored and reported with full agreement.

A small sample of inferential statistics was used to analyze the data produced by the participants of our experiment. T-Tests, Pearson's correlation, and univariate analysis of variance (ANOVA) were used to compare the results between the treatment conditions. An alpha level of .05 was used for all statistical tests. For the pretest, T-tests were used to look for differences between the control (normal speed) group and the treatment (accelerated speed) group. The Pearson's correlation was used to test for a statistically significant relationship among the dependent variables. For the posttests, the analyses of the differences in memory performance utilized an ANOVA and was used to test the treatment effects on the participants performance on the cued content recall, content recognition, and cued context recall test items.

Results

Descriptive Statistics

There were 30 students who participated in this study, with 16 participants in the control group (who viewed the normal speed presentation), and 14 participants for the treatment group (who viewed the time-compressed presentation). After reviewing the video segments, the students were asked to answer 12 cued content recall, 12 content recognition, and 10 cued context recall questions. For their overall performance, please refer to Table 1.

Table 1
Descriptive Statistics for Types of Memory Assessed

			Cued content recall		Content recognition		Cued context recall	
Speed	Order	*n*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Normal	0	8	4.63	2.92	9.50	2.07	3.38	1.19
	1	8	5.75	1.98	11.50	1.77	3.25	1.49
Time-compressed	0	6	5.33	2.42	9.33	2.66	3.00	2.10
	1	8	3.88	2.36	9.25	1.67	3.13	1.46

Note. For order: 0 = **P**eck → **V**ollmer, 1 = **V**ollmer → **P**eck

Inferential Statistics

A pretest was administered prior to any treatments containing eight test items (five multiple choice and three short answer questions), and was designed to test the participants' prior knowledge of the content presented in the videos, including whether the participants had viewed the actual video segments previously. The T-test (two-tailed) was used to test whether treatment group and control group had equivalent performance in terms of prior knowledge and prior exposure to the videos. The results revealed that none of the participants were previously exposed to the video segments, and that there was no significant difference in the pretest performance between the control group (M = 1.81, SD = 0.98) and the treatment group (M = 1.86, SD = 1.03; t (28) = -.06, p = .45, two-tailed).

The post-assessment consisted of thirty-four test items that were given to participants immediately after they reviewed the video presentation. After answering the test items, participants were instructed to indicate their viewing speed preference by reviewing both normal and time-compressed video segments and then choosing their speed preference on the test booklet. The video segments reviewed for the speed preference check were different from the video presentation used during the treatment conditions to avoid any unintended effects.

Manipulation checks

A two-tailed ANOVA was used to test whether presentation order played a statistically significant role across the four conditions. The data revealed that presentation order was not a potential variable and there was no significant difference in the mean score for the four groups in terms of cued content recall (F (1, 28) = .008, p = .45), content recognition (F (1, 28) = .74, p = .17), and cued context recall (F (1, 28) = .001, p = .48).

Pearson's correlation was also used to test the relationships among dependent variables across four conditions, and the data revealed that there is a statistically significant relationship between cued content recall and cued context recall (r = .442, p=.02). However, there was no statistical significance revealed between cued content recall and content recognition (r = .322, p = .083), and recognition and context recall (r = .026, p = .89).

An ANOVA using two independent variables, speed, video segment (and their interaction variable of speed and video segment), was used to analyze the impact on participants' various types of memory (cued content recall, content recognition, and cued context recall) across the four conditions (normal order 0, normal order 1, time-compressed order 0, and time-compressed order 1).

Cued content recall

H1: There will be no significant difference in memory performance in cued content recall between participants experiencing normal speed presentations and participants experiencing time-compressed presentations.

For overall cued content recall, an ANOVA (two-tailed) revealed that there is no significant difference in cued content recall across the speed conditions, F (1, 28) = .29, p = .22. Further analysis showed that the data did not reveal a significant difference in cued content recall for the individual video segments, F (1, 28) = 1.43, p = .051, and the interaction of speed and video segments (F (1, 28) = 0.04, p = .40). The data does not reject H1; there is no difference in cued content recall performance between normal and time-compressed conditions. See Table 2.

Table 2
Cued Content Recall by Video Segment

Source	*DF*	*DFDen*	*SS*	*F*	*p*
Speed	1	28	1.08	0.29	.22
Video segments	1	28	5.26	1.43	.051
Speed* Video segments	1	28	0.13	0.04	.40

Recognition

H2: There will be no significant difference in memory performance in content recognition between participants experiencing normal speed presentations and participants experiencing time-compressed presentations.

For cued content recognition, we looked into the effects of speed on the overall cued content recognition performance of the participants. A two-tailed ANOVA revealed that there was a difference that approached significance in the content recognition performance between the groups across the speed conditions, F (1, 28) = 1.25, p =.06. It was determined that the score participants of the normal speed condition approached significantly higher results (M = 10.50, SD = 2.13) than those in the time-compressed speed condition (M = 9.29, SD = 2.05). Further analysis for each individual video segment showed that there is a significant difference between video segments P and V, F (1, 28) = 30.76, p = < 0.0001, was with the P video segment scoring significantly higher (M = 6.47, SD = 1.72) than the V video segment (M = 3.47, SD = 1.25). Our data does not reject H2 on the basis that speed did not contribute to a significant difference in both overall and individual segment cued content recognition performance. See Table 3.

Table 3
Content Recognition by Video Segment

Source	*DF*	*DFDen*	*SS*	*F*	*p*
Speed	1	28	5.35	1.25	.06
Video segments	1	28	131.22	30.76	<.0001†
Speed* video segments	1	28	4.29	1.00	.08

† p is significant at the .05 level (two-tailed).

Cued context recall

H3: There will be no significant difference in memory performance in ***cued context recall*** *between participants experiencing normal speed presentations and participants experiencing time-compressed presentations*.

An ANOVA revealed no significant difference between the speed conditions for the participants' overall cued context recall performance, F (1, 28) = 0.10, p = 0.33. Further analysis revealed that for one of the video segments, there is significant difference in cued context recall performance by video across both speed conditions (M_{Peck} = 3.20, M_{Vollmer} = 2.53, F (1, 28) = 2.36, p = .02). This finding indicates that the "Peck" video segment was more conducive to cued context recall than the "Vollmer" video segment, which leads us to believe that further analysis on the characteristics of the Peck video should be conducted. Nevertheless, the data does not allow us to reject H3. See Table 4.

Table 4
Cued Context Recall by Video Segment

Source	*DF*	*DFDen*	*SS*	*F*	*p*
Speed	1	28	0.03	0.01	.44
Video segments	1	28	6.25	2.36	.02†
Speed*video segments	1	28	1.26	0.47	.17

† *p* is significant at the .05 level (two-tailed).

Presentation speed preference

In a surprisingly strong negative finding, a full 86.67% of students reported preference for the normal speed presentation over the time-compressed presentation. The select few that reported a preference for accelerated presentations did not score significantly higher than those preferring normal speed presentations.

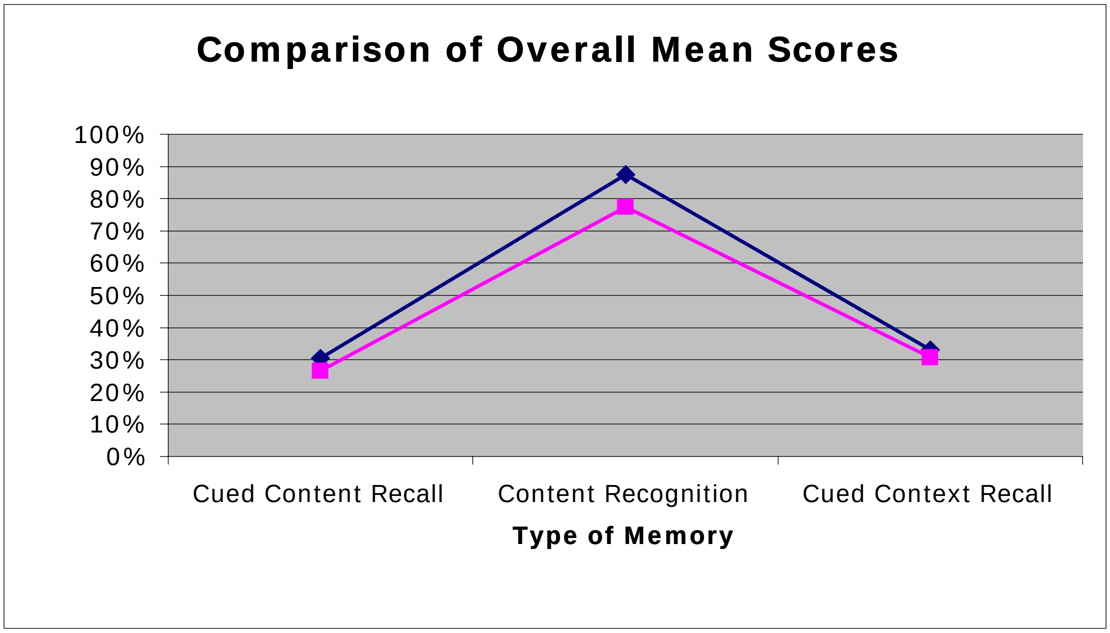
Summary of Key Findings

In summary, our data show a nearly significant difference in the posttest scores for overall content recognition, but we still cannot reject our H2 null hypothesis in favor of the better performance observed for the participants of the normal speed condition. Figure 1 shows the participants' mean performance on the posttests measuring the three types of memory tested across the speed conditions. The data does not support any significant findings for cued content recall or cued context recall that is in favor of either speed condition. There was a significant correlation of the participants' overall performance on the cued content recall and cued context recall.

When looking at the individual segments, speed and the interaction of speed and video segments was not a potential factor influencing the three types of memory performance. However, there was a significant difference in favor of the P video clip for content recognition and context recall, which means that P video clip was more likely to be remembered for those two categories by the participants.

The participants' preference was overwhelmingly in favor of the normal speed condition. In the following discussion, we will further describe the implications of our findings.

Figure 1
Comparison of mean scores by memory type across speed conditions



The difference between the participants' Content Recognition scores is approaching significance.

Discussion

Interpretation of Findings

As Figure 1 shows, the participants in the time-compressed condition did consequently score lower than the normal condition for both of the cued recall measures, however not to a significant degree. The lack of a profound difference between these scores across the two speed conditions is surprising due to the fact that cued recall assessment items are generally considered more challenging due to the deeper levels of processing required. Our recognition data, on the other hand, showed nearly significant differences in relation to speed – that is, the normal speed group outperformed the time-compressed group. Recognition assessment items are usually easier to answer since the participant receives multiple cues as to retrieving the correct answer from memory. The cues in this case were inherent in the multiple-choice question format (i.e. the distractors and the key).

A possible reason for the low overall recall scores may be due in part to test item difficulty. The test items looked for precise details found in the videos (e.g. specific objects or scenes, phrases, contextual details), and such information may not have been effectively encoded by the participants and therefore difficult to retrieve. In scoring, points were not given for similar or near-correct responses, even if the participant indicated a basic understanding of the video presentations' messages. Anecdotally, these "partially correct" answers demonstrated that the participants were able to encode the general themes and concepts (or gist) of the videos, and such gist was not evaluated by the instrument. Assessing the effects of time-compression upon the generality versus the specificity of the participants' recall is one possible avenue for future research.

Uses and Gratification theory may provide one possible explanation for the strong preferences for normal speed over accelerated. Additional factors at play might be traditional expectations of video as a more passive medium. The expectation that video should require less cognitive processing than other forms of communication technologies may have been directly challenged for students in the accelerated condition. Due to the fact that their expectations/desires were violated, students may have reported their preference for normal speed. On the other hand, a more moderate acceleration of perhaps 1.3 times the normal presentation speed would likely have yielded more positive responses for acceleration in a single treatment such as this one. Many of the studies make mention of ear training or an adaptation time frame where such adaptation takes place higher levels of acceleration can be achieved. What was revealing through ad-hoc post treatment debriefing statements was an emerging theme of what “normal speed” is, steadily increases with prolonged exposure to time-compression. Participants in the accelerated group mentioned that the normal clip seemed “to slow” to keep their attention. As mentioned earlier in this text, the ultimate solution may lie in giving users individual and variable control over playback speed. This individualized ability has only very recently been made available in standard industry media players, and its effect has yet to be widely studied.

Practical Implications

A primary motivation for time-compressed speech is for reducing the time needed for a user to listen to a message (Aarons, 1992). An obvious implication and confirmation of previous research was that the comparable performance in recall and recognition between the speed conditions suggests that learners can benefit from the time efficiency afforded by the accelerated speed of time-compressed presentations. Whether just-in-time learning in a corporate training environment, or time management and savings in an academic environment, the compression of materials into shorter time frames without noticeable loss, or the possibly increased learning due to the compression, has merit and needs to be studied further to ascertain what benefits and limitations this may hold for the future of education and presentation of materials. This is not to say that crossover of such future findings could not affect other fields like marketing and advertising or mass communications, only that our admitted bias during this study was for learning outcomes.

When we compared our overall results for the memory performance measures, we see that the performance of the time-compressed group is relatively similar to the normal speed group. This supports the obvious concept that by playing the videos faster students can learn the same amount of material in a shorter timeframe with relatively low loss of memory performance. When looking at the individual video segments, we found that the participants performed better on one of the video segments in terms of content recognition, which lends credence to the need for careful attention to the structure and content of the instructional video materials chosen by instructional designers. Given this minimal difference in performance between the normal and time-compressed presentation speed conditions, two avenues for the utilization of the time savings could be pursued.

First, instructors could choose to push twice as much material upon students. This option may be attractive to high school teachers who face the pressures of accountability measures attached to standardized tests required by state and federal governments. However, this may not be the best use of this time advantage. Our data supports, that a better option may be to repeat the presentation, as suggested by Fairbanks, Guttman, and Miron (1957b). They found that students performed better after hearing time-compressed audio twice than when they heard it at normal speed just once. This suggests that the repeated exposure allowed the students to reorganize their knowledge and more deeply process the messages that they have received.

Limitations

As with all research, this study experienced several limitations, some by design, some by choice, and others that were unforeseen during the design and initial implementation of this study. We had a small sample size of 30 participants, and our findings should be viewed with this in mind. This study could and probably should be considered an exploratory study, and is being utilized as the basis for future studies.

Another concern is the reliability and validity of the assessment instruments. This was the first iteration of this instrument, and there are some areas in need of improvement. Content-based memory tests require a cycle of validation and revision under normal (non-experimental) conditions, and that cycle was truncated by the timeframe imposed for the completion of this study.

Additionally, the participants randomly assigned to the time-compressed condition did not perform as well as we had hoped. One possible reason why participants did not do well in the accelerated condition may be due to a novelty effect and insufficient time to acclimate to the time-compression. Tellis (1997) argues that “when subjects first see novel stimuli, the novelty leads to uncertainty and tension” (p. 6). Due to the recent emergence and still-increasing availability of this technology, it could still be classified as quite novel to the general population.

With regard to comprehension and acclimation time, Voor and Miller (1965) found that comprehension of compressed speech increased significantly over the first eight to ten minutes of listening with little increase after that. Our accelerated group experienced only seven minutes of time-compressed material—which is on the cusp of the six to eight minutes of suggested acclimation time suggested by Voor and Miller. This study’s test instrument also began testing material that was presented less than one minute into the video segments, possibly posing a disadvantage to the time-compressed group.

Numerous variables exist in the research that relates to time-compression and conditioning. Perhaps the most salient of these, is user control of playback speed or Variable Speed Playback (VSP). VSP ability allows users to dynamically accelerate video presentations to speeds they find comfortable for the given topic, prior knowledge, and familiarity with the subject matter. The superiority of user-controlled VSP over fixed-rate acceleration is substantiated by multiple reports (Cohen, 2000; K. Harrigan, 2000; Omoigui et al., 1999; Short, 1977; Zemlin, Daniloff, & Shriner, 1968), but was not within the scope of this study and was intentionally controlled for by removing the user controls from the video playback interface.

Future Research Directions

There was difference observed in the cued context recall and content recognition between the two video segments, where the average score for the Peck (P) video was significantly higher than the Vollmer (V) video. This suggests that the nature and/or the content of the video materials influence the viewers' ability to remember information presented. Future research should explore the characteristics and methods of presentation of video materials that are easily encoded and stored by a general student population.

Our results also provide insight for both online and television video-based advertising. Based on our research, viewers exhibited similar recall performance across both speed conditions. In the advertising industry, where the number of "impressions" of a product image viewed by consumers is positively related to consumer recognition and recall (and ultimately purchase) of a product, the more-plentiful impressions provided by time-compressed could be advantageous to marketers. Since the recall performance of our participants did not differ between the speed conditions, more brand impressions can be created with video that is time-compressed, while the viewers will still be able to recall with equal capability. Further study is needed to explore the potential of the increased impression count that can be provided by time-compressed video.

Future research should also address whether time efficiencies are in fact realized. Informal observations indicate that learners choose to view more content with acceleration, thereby defeating the potential time savings offered by time-compression. In addition, learners may be spend more time replaying specific segments of the videos in an effort to self-regulate their comprehension of the material being presented.

References

Aarons, B. (1992). *Techniques, Perception, and Applications of Time-Compressed Speech: Proceedings of 1992 Conference of the American Voice I/O Society*. Paper presented at the American Voice I/O Society.

Ananova. (2002, November 15, 2002). *US sitcom stars told to speak faster*. Retrieved May 2, 2003, from http://www.ananova.com/entertainment/story/sm_710061.html

Arlen, G. (2003). *For Tech's Sake: Video's Growing Role In Government Services*. Retrieved April 25, 2003, from http://washingtontechnology.com/news/1_1/for_techs_sakes/20605-1.html

Barabasz, A. F. (1968). A study of recall and retention of acceleration lecture presentation. *Journal of Communication, 18,* 283-287.

Beasley, D. S., Bratt, G. W., & Rintelmann, W. F. (1980). Intelligibility of time-compressed sentential stimuli. *Journal of Speech and Hearing Research, 23*, 722-731.

Beasley, D. S., & Maki, J. E. (1976). Time- and Frequency-Altered Speech. In N. J. Lass (Ed.), *Contemporary Issues in Experimental Phonetics* (pp. 419-458). New York: Academic Press.

Cohen, G., Amir, A., Ponceleon, D, Blanchard, B., Petkovic, D., Srinivasan, S. (2000). *Using Audio Time Scale Modification for Video Browsing.* Paper presented at the 33rd Hawaii International Conference on System Sciences.

Daft, R. L., Lengel, R. H., & Trevino, L. K. (1987). Message equivocality, media selection and manager performance: Implications for information systems. *MIS Quarterly, 11*, 355-366.

Dupoux, E., & Green, K. (1997). Perceptual adjustment to highly compressed speech: effects of talker and rate changes. *Journal of Experimental Psychology: Human Perception and Performance., 23*(3), 914-927.

El-Shinnawy, M., & Markus, M. L. (1998). acceptance of communication media in organizations:richness or features. *IEEE Transactions on Professional Communication, 41*(4), 252-253.

Fairbanks, G., Guttman, N., & Miron, M. S. (1957a). Auditory comprehension of repeated high-speed messages. *Journal of Speech and Hearing Disorders, 22*(1), 20-22.

Fairbanks, G., Guttman, N., & Miron, M. S. (1957b). Effects of time compression upon the comprehension of connected speech. *Journal of Speech and Hearing Disorders, 22*(1), 10-19.

Fulford, C. P. (1989). *The relative effectiveness and efficiency of systematically designed instructional text augmented with normal and compressed speech audio tapes.* Unpublished Ph.D. Dissertation, The Florida State University, Tallahassee.

Fulford, C. P. (1993). Can learning be more efficient? Using compressed speech audio tapes to enhance systematically designed text. *Educational Technology, 33*(2), 51-59.

Galbraith, J. (2000). *Using New Internet Technologies to Enhance the Effectiveness of Asynchronous Video-Based Instruction.*, Brigham Young University., Provo, UT.

Galbraith, J., & Spencer, S. (2002). *Variable Speed Playback and Video-Based Instruction: Is Faster Better?* Paper presented at the EdMedia, Denver, CO.

Gutenko, G. (1995). *Speed: "Run"- Time Compressed Video for Learning Improvement and Digital Time Compression Economy.* Retrieved March 24, 2003, from Eric Document, ED384 341.

Harrigan, K. (1995). The SPECIAL system: Self-paced education with compressed interactive audio learning. *Journal of Research on Computing in Education, 27*(3), 361-370.

Harrigan, K. (2000). The SPECIAL system: Searching time-compressed digital video lectures. *Journal of Research on Computing in Education, 33*(1), 77-86.

Heiman, G. W., Leo, R. J., Leighbody, G., & Bowler, K. (1986). Word Intelligibility Decrements and the Comprehension of Time-Compressed Speech. *Perception and Psychophysics, 40*(6), 407-411.

Hsia, H. J. (1971). The information processing capacity of modality and channel performance. *AV Communication Review, 19*(1), 51-75.

King, P. E., & Behnke, R. R. (1989). The Effect of Time-Compressed Speech on Comprehension, Interpretive and Short-Term Listening. *Human Communication Research, 15*(3), 428-443.

LaBarbera, P. A., & MacLachlan, J. (1979). Time-Compressed Speech in Radio Advertising. *Journal of Marketing, 43*, 30-37.

Lang, A. (1995). Defining audio/video redundancy from a limited-capacity information processing perspective. *Communication Research, 22*(1), 86-115.

Lang, A. (2000). The Limited Capacity Model of mediated message processing. *Journal of Communications*, *50*(1), 46-70.

Leigh, J. H. (1991). Information processing differences among braodcast media: review and sugestions for research. *Journal of Adverstising, 20*(2), 71-75.

Mayer, R. E., & Moreno, R. (1998). A split-attention effect in multimedia learning: evidence for dual-procesing systems in working memory. *Journal of educational psychology, 90*(2), 312-320.

Moore, D., Burton, J., & Myers, R. (1996). Multiple channel communication: The theoretical and research foundations of multimedia. In D. H. Jonassen (Ed.), *Handbook of Research for Educational Communications and Technology*. Mahwah, New Jersey: Lawrence Earlbaum.

Olson, J. S. (1985). *A Study of the relative effectiveness of verbal and visual augmentation of rate-modified speech in the presentation of technical material.* Paper presented at the Annual Conference of the Association or Educational Communications and Technology (AECT), Anaheim, Ca.

Omoigui, N., He, L., Gupta, A., Grudin, J., & Sanocki, E. (1999). *Time-Compression: Systems Concerns, Usage, and Benefits.* Paper presented at the CHI 99, 1999, Association for Computing Machinery, Pittsburgh, PA.

Orr, D. B., Friedman, H. L., & Williams, J. C. (1965). Trainability of listening comprehension of speeded discourse. *Journal of Educational Psychology, 56*, 148-156.

Severin, W. J. (1967). Another look at cue summation. *AV communication Review, 15*(4), 233-245.

Short, S. (1977). A Comparison of Variable Time-Compressed Speech and Normal Rate Speech Based on Time Spent and Performance in a Course Taught with Self-Instructional Methods. *British Journal of Educational Technology, 8*(2), 146-157.

Silverstone, D. M. (1974). Compressed speech. *audiovisual instruction, 19*(1), 42-43.

Sticht, T. G. (1969). Comprehension of repeated time-compressed recordings. *The Journal of Experimental Education, 37*(4).

Storck, J., & Sproull, l. (1995). Through a glass darkly: what do people learn in video conferences? *Human Communication Research, 22*, 197-219.

Sundar, S. S., Narayan, S., Obregon, R., & Uppal, C. (1997). *Does web advertising work? Memory for print vs. online media.* Paper presented at the 1997 Association for Education in Journalism and Mass Communication Conference: Communication Technology & Policy Division, Chicago.

Tellis, G. J. (1997). Efective frequency: One exposure or three factors? *Journal of Advertising Research, 37*(4), 75-80.

Voor, J. B., & Miller, J. M. (1965). The effect of practice upon the comprehension of time-compressed speech. *Speech Monographs, 32*, 452-455.

Williams, D. L., Moore, D. M., & Sewell, E. H. (1984). Effects of compressed speech on comprehension of community college students. *Journal of Educational Technology Systems*, *12*(3), 272-285.

Williams, J. R. (1998). *Guidelines for the use of multimedia in instruction.* Paper presented at the Human Factors and Ergonomics Society 42nd Annual Meeting.

Zemlin, W. R., Daniloff, R. G., & Shriner, T. H. (1968). The difficulty of listening to time-compressed speech. *Journal of Speech and Hearing Research, 11*, 875-881.