



## **UNITED STATES AIR FORCE RESEARCH LABORATORY**

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### **THE EFFECT OF VIDEO IMAGE SIZE AND SCREEN REFRESHER RATE ON CONTENT MASTERY AND SOURCE CREDIBILITY IN DISTANCE LEARNING SYSTEMS**

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**May 1998**

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# REPORT DOCUMENTATION PAGE

Form Approved  
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE May 1998	3. REPORT TYPE AND DATES COVERED Final Jan - Jul 97	
4. TITLE AND SUBTITLE The Effect of Video Image Size and Screen Refresher Rate on Content Mastery and Source Credibility in Distance Learning Systems			5. FUNDING NUMBERS  PE -62202F PR -1123 TA -C2 WU -78	
6. AUTHOR(S)  Robert G. Main John F. Long Wendi A. Beane				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)  College of Communication California State University Chico, CA 95927			8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Air Force Research Laboratory Human Effectiveness Directorate Brooks Air Force Base TX 78235-5118			10. SPONSORING/MONITORING AGENCY REPORT NUMBER AFRL-HE-BR-TP-1998-0009	
11. SUPPLEMENTARY NOTES Air Force Research Laboratory Technical Monitor:				
12a. DISTRIBUTION/AVAILABILITY STATEMENT  Approved for public release; distribution unlimited			12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words)  In a laboratory setting, this study examined the effect of image size and refresh rate of those images on the subjects' abilities to recall content, and subjects' perceptions of source credibility. The results suggest that larger images and faster refresh rates do not increase content retention. Further analysis revealed that larger, more realistic televised lectures do not significantly enhance source credibility along the dimensions of attention, confidence, relevance, or satisfaction. This study lends evidence to the notion that Internet based course delivery, using small, slow images may be as effective in terms of learning outcomes and satisfaction, as high bandwidth networks.				
14. SUBJECT TERMS Distance Learning, Multimedia, Video Image Size, Video Refresh Rate			15. NUMBER OF PAGES  21	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT UNCLASSIFIED	18. SECURITY CLASSIFICATION OF THIS PAGE UNCLASSIFIED	19. SECURITY CLASSIFICATION OF ABSTRACT UNCLASSIFIED	20. LIMITATION OF ABSTRACT  UL	

NSN 7540-01-280-5500

Standard Form 298 (Rev.2-89)  
Prescribed by ANSI Std. Z39-18  
298-102

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## **PREFACE**

This report describes the results of a laboratory experiment conducted to evaluate the effects of display image size and refresh rate on subjects' ability to recall subject matter content and their perception of instructor's credibility.

This research was conducted under the United States Air Force Summer Faculty/Graduate Student Research Program. The research was sponsored by the Air Force Office of Scientific Research/AFMC, United States Air Force.

## **SUMMARY**

In a laboratory setting, this study examined the effect of image size and refresh rate, of a transmitted digital video signal displayed on computer monitors, on the subjects' abilities to recall subject matter content, and their perceptions of source credibility. The results suggest that larger images and faster refresh rates do not increase content retention. Further analysis revealed that larger, more realistic televised lectures do not significantly enhance source credibility along the dimensions of attention, confidence, relevance, or satisfaction.

This study lends evidence to the notion that Internet based course delivery, using small, slow images may be as effective in terms of learning outcomes and satisfaction, as high bandwidth networks.

# **THE EFFECT OF VIDEO IMAGE SIZE AND SCREEN REFRESHER RATE ON CONTENT MASTERY AND SOURCE CREDIBILITY IN DISTANCE LEARNING SYSTEMS**

## **I. INTRODUCTION**

The rapid rise of digital telecommunication and the transformation of media from analog to digital formats have opened the door to instructional delivery possibilities that have not been seen before. Distance learning resources and technologies are no longer restricted to a select academic community and they are changing the nature of education and training across a broad spectrum (Capell, 1995). Organizations are beginning to change their question from "Should we be doing distance learning?" to "When are we going to begin distance learning?" The demand will be on improved access, sophisticated interfaces and more interesting and stimulating presentations for an expanded learner base (Main, 1996). Most of the research on distance learning presentations has focused on system capabilities. Transmission rates and methods, media capabilities and interactions (two-way or one-way audio and video, synchronous or asynchronous).

Distance learning has evolved from analog distribution systems whether by conventional broadcast, microwave, fixed site, satellite or cable to digital formats using computer-mediated communication. Desktop video conferencing systems are a reality in some workplaces because of developments in compression method, high bandwidth networks and faster computers (Gale, 1992).

Computer mediated communication using real time video and audio places great demand on network capacities (Kies, 1997). Video frame rate and image size are the two major factors in determining computing power and network speed. Most systems in the United States employ the NTSC standard of 30 frames per second (fps) screen refresh rate. A 2:1 interlace in the presentation produces 60 seams (or fields) per second (Ramachandran and Anstis, 1986). Lower frame rates result in "choppy" video motion which may lead to decreased user satisfaction (Kies, Williges and Rosson, 1996).

Image size for computer mediated communication is commonly a small window where motion video appears. Using contemporary technology to fill the entire screen with information requires much greater computing speed or greatly reduced video quality.

A high proportion of the published research about distance learning are descriptive analyses based on field studies and case studies. Those studies which do attempt quasi-scientific comparisons with traditional delivery modes offer little control over confounding or contaminating variables. This study used a laboratory experiment to investigate some of the basic questions facing distance learning instructional designers and developers.

### **Research Question 1:**

Motion video has become an increasingly common component of distance learning digital workstations. It is axiomatic with satellite or cable based analog systems that the video picture will cover the entire screen. There are exceptions, for example, when special effects switching superimpose a small circular or rectangular video of the instructor as a talking head in a portion of a graphic display. But, these are generally rare. With the advances in digital audio and video and compression technology, desktop computer based distance learning stations linked by local and wide area networks have appeared with regularity. While motion video is available on these digital systems for the instructional designer/developer to use, it is often only a small window in the screen. The first research question for this project is; "What effect does the screen size of the instructor's image have on the learner's perception of source credibility and retention of the message?" The results of the study have implications for decision makers in assessing system capabilities for purchase as well as for instructional designers and developers in designing multimedia presentations.

### **Hypotheses (Research Question 1):**

Two hypotheses were generated by the first research question. The first hypothesis was that learner retention of lecture material, as measured on a ten-question multiple choice exam, varies directly with the image size of the instructor's videotaped lecture. The experiment allowed for three variations of image size.



The second hypothesis was that the learner's perception of the credibility of the instructor has a direct relationship with the image size of the instructor's videotaped lecture. For purposes of this study, credibility is defined as a composite of four sub-variables, in particular, attention, confidence, relevance and satisfaction. This measure was developed from the work of Keller (1983). The independent variable in the experiment was the size of the video image in the computer screen. The video window was manipulated in three sizes--four inch square, six inch square and full 17 inch diagonal screen surface (approximately 12 X 15 inches). The dependent variables (instructor credibility, information retention, and satisfaction with message content and presentation) were measured by questionnaires.

### **Research Question 2:**

Another characteristic of PC-based digital video is that the compression technology permits transmission via telephone networks but the traditional full motion screen refreshment rate of 30 frames per second (fps) is reduced about one-half to 15 fps screen refresh rate. The question to be answered is; "What effect does reduced screen motion capability have on learner retention of content and perception of source credibility?"

### **Hypotheses (Research Question 2):**

The two hypotheses generated by the second research question about video motion speed, parallel those concerning screen size. The first hypothesis is that presentation of an instructor lesson in full motion video increases learner retention compared with 15 fps motion video. The second hypothesis is that instructor credibility is greater when 30 fps video is used for the lesson presentation as compared to 15 fps video. The independent variable in this parallel experiment is the screen refresh rate. Identical lessons were presented with one using a full motion (30 fps) screen refresh rate and one using a 15 fps screen refresh rate. The dependent variables of information retention, instructor credibility and satisfaction with subject matter and presentation are the same as those for the first research question related to screen size and were measured with the same questionnaires.

## **II. EXPERIMENTAL DESIGN**

An experiment was designed in which one 40-minute lesson presentation was manipulated in a two by three experimental model design (see Figure 1). Three treatments of

screen size (4x4 inch, 6x6 inch and full screen) were presented on a PC-based learning station with a 17-inch diagonal monitor. The same 40 minute lesson was presented over all three screen sizes in two speeds (15 and 30 fps refresh rates) and manipulated with the size dependent variable.

	4x4 inch Image	6x6 inch Image	Full Screen Image
15 fps	credibility retention subject satisfaction presentation	credibility retention subject satisfaction presentation	credibility retention subject satisfaction presentation
30 fps	credibility retention subject satisfaction presentation	credibility retention subject satisfaction presentation	credibility retention subject satisfaction presentation

**Figure 1. Research Model**

Four dependent measurements were taken for each of the six treatment conditions (4x4 inch image with 15 fps, 4x4 inch image with 30 fps, 6x6 inch image with 15 fps, 6x6 inch image with 30 fps, full screen with 15 fps and full screen with 30 fps). The dependent variable concerning lecture retention was measured by paper/pencil test covering the learning objectives of the 40-minute lesson. Content mastery was measured immediately after each session, and was also imbedded in the final examination administered three weeks after exposure. The dependent variable of credibility was self-reported from a questionnaire administered with the content examination.

#### **Conduct of the Experiment:**

A laboratory with eight PC-based multimedia learning stations was set up within the Department of Communication Design at California State University, Chico. Each learning station was configured with hardware and software to allow the manipulation for the treatment groups. The learning stations were linked by a local area network to a server. Technical assistance for the project was provided by students in the Department of Communication Design.

A 50-minute class, taken from the lower division course, "Introduction to Broadcasting/Cable", in the Department of Communication Design, was used for the stimulus content. The instructor of the class was assisted by students in the Instructional Technology degree program at the University to design and develop the lesson for delivery via the interactive digital multimedia network. The instructor's presentation was video taped and edited into a 40-minute lesson. The completed lesson was digitized and a master tape was prepared for each of the six treatment modes. The same source video was used for each treatment.

The delivery vehicle for the distance learning lesson was hardware and software developed by SUN Microsystems Incorporated for conducting research in distributed tutored video instruction (DTVI). The system consisted of eight student stations and one instructor station with proprietary software developed by SUN Microsystems, which permitted a segmented screen with nine images displayed simultaneously in a 3x3 matrix. The student workstations and the instructor workstation were isolated from one another and connected through a local area network (LAN). The system was modified for this experiment so that a single display window would appear on the eight student workstations. The size of the display window was set to either, 4x4 inch, 6x6 inch or full screen (17-inch diagonal), depending on the treatment condition. The instructor station controlled the transmission of the prerecorded one-way audiovisual presentation. No two-way audio or video interaction between students or student and instructor was allowed to minimize confounding variables.

Students in an introductory communication survey course were randomly assigned to one of the six treatment groups. The stimulus lesson dealt with the history of radio and was an integral component of the course curriculum. The class had 180 students enrolled and each treatment group had 30 subjects. Since the laboratory system could accommodate only eight subjects for each trial, the groups were randomly assigned to times from six until nine in the evening for six nights over a two-week period. The laboratory was available only on Monday, Tuesday and Wednesday evenings. One Thursday evening session was scheduled to accommodate the last few randomly assigned groups. From the 24 trials, 148 data scores were obtained. The 32 students who failed to show up for their scheduled time gave a number of reasons, the most common being a conflict with a previous commitment. Some admitted they

just forgot and at least one of the students strongly objected to being a part of a military experimental study and was excluded from the analysis of data.

Because of the high rate of no show (almost 25 percent), a chi-square goodness of fit test was conducted between the groups using gender and class level (Freshman, Sophomore, Junior and Senior) as the variables. No systematic bias to the random assignment of subjects appeared.

The students watched the presentation in the image size and screen refresher rate for their particular trial as passive viewers of a linear audio video format. At the completion of the lesson, the students were given a paper and pencil test with ten questions measuring the cognitive content of the presentation. On the back of the paper and pencil test were eight questions measuring the credibility variables.

The credibility measurement instrument was constructed from items developed and validated by John Keller to determine how well presentations hold a learner's attention, is considered relevant, instills confidence and provides satisfaction. Two items for each of the elements were included in the questionnaire.

The ten-item learning measurement instrument was developed by the course instructor and designed to determine achievement of the learning objectives for the class. Information retention over time was measured by performance of the subjects on a delayed measure of the same items administered four weeks after the last trial. A copy of both measurement instruments are included in Appendix A.

### **Design**

The critical independent variables for this study were: (1) image size, and (2) refresh rate of those images. Performance on two primary dependent variables, "content mastery" and "credibility measures" were indexed. The "content mastery" variables consisted of an immediate posttest (0-10) and performance on a delayed measure of the same items (0-10). The "credibility measures" consisted of four attitudinal measures (1-5), attention, confidence, relevance, and satisfaction respectively.

These data were analyzed with repeated measures ANOVA's for each of the six dependent variables. Since the collective impact was not a pertinent question to these hypotheses, MANOVA was not applied.

### III. RESULTS

Descriptive statistics delineated by image size for content mastery variables appear in Table 1.

TABLE 1  
Descriptive Statistics for Content Mastery Delineated by Image Size

Content Mastery					
		Posttest		Delayed Test	
Image Size	n	M	SD	M	SD
Small	43	5.44	1.88	4.74	1.96
Medium	46	5.02	2.03	3.74	1.77
Large	47	5.56	2.20	4.14	1.85

Separate analyses were conducted for each of the dependent measures. The contribution of image size to immediate test performance was found to be non-significant. However, these data did reveal that image size had a significant effect on delayed test retention of lecture material ( $F=3.53$ ,  $p<.05$ ). Interestingly, those in the treatment with the smallest screen size outperformed the other conditions. It is possible that larger screen size may result in passive viewing behavior typical in television use, whereas a smaller screen size may mandate greater cognitive demand in information interpretation. Plausibly, since the lecture was rich in factual information, subjects in that condition were more attentive than the other groups.

The descriptive statistics for image size effect on credibility are displayed in Table 2. The mean scores for the attention, relevance, and satisfaction variables were each higher for the smallest image condition, however, analysis of variance on each of these variables failed to yield significance.

**TABLE 2**  
Descriptive Statistics for Credibility Delineated by Image Size

<b>Credibility Variables</b>									
		<b>Attention</b>		<b>Confidence</b>		<b>Relevance</b>		<b>Satisfaction</b>	
<b>Image Size</b>	<b>n</b>	<b>M</b>	<b>SD</b>	<b>M</b>	<b>SD</b>	<b>M</b>	<b>SD</b>	<b>M</b>	<b>SD</b>
Small	43	4.84	2.11	5.09	2.03	7.35	1.84	5.26	2.18
Medium	46	4.73	1.99	4.93	2.23	6.59	2.21	4.96	2.18
Large	47	4.70	2.18	5.34	2.06	6.79	2.01	5.13	2.13

These data suggested that image size had no significant effect on learning as measured by the immediate posttest, or on the variable concerning the learner's confidence on test performance.

The descriptive statistics in Table 3 and 4 address the main effect of "refresh rate."

**TABLE 3**  
Descriptive Statistics for Content Mastery Delineated by Screen Refresh Rate

<b>Content Mastery</b>					
		<b>Posttest</b>		<b>Delayed Test</b>	
<b>Refresh Rate</b>	<b>n</b>	<b>M</b>	<b>SD</b>	<b>M</b>	<b>SD</b>
15 FPS	70	5.14	2.10	4.07	1.78
30 FPS	66	5.55	1.96	4.36	1.20

**TABLE 4**  
Descriptive Statistics for Credibility Delineated by Screen Refresh Rate

<b>Credibility Variables</b>									
		<b>Attention</b>		<b>Confidence</b>		<b>Relevance</b>		<b>Satisfaction</b>	
<b>Refresh Rate</b>	<b>n</b>	<b>M</b>	<b>SD</b>	<b>M</b>	<b>SD</b>	<b>M</b>	<b>SD</b>	<b>M</b>	<b>SD</b>
15 FPS	70	4.84	2.22	4.94	2.33	6.67	2.14	4.97	2.25
30 FPS	66	4.67	1.93	5.32	1.82	7.14	1.93	5.26	2.05

Mean scores indicated that students receiving the lecture at thirty frames per second performed better on both the posttest, as well as the delayed test. Moreover, this condition indicated greater confidence in test performance, relevance of the subject matter, and satisfaction with the presentation. However, subsequent analysis of variance revealed that none of these differences are significant. Lack of significance is not surprising considering the wide variability of individual scores on both dependent variables as reflected by the large standard deviations. Replication of the study with subjects on a 2x2 design to afford a larger n for each cell might provide significance. Correlation analysis was conducted to examine the inter-relationships of the dependent variables measured in this study.

As Table 5 illustrates, the "content mastery" variables do correlate significantly ( $p < .01$ ), with the "credibility variables", however, the association level is not strong (none above .50).

**TABLE 5**  
Correlation Matrix of Dependent Variables

Correlation Matrix					
Variable	Delayed Test	Attention	Confidence	Relevance	Satisfaction
Posttest #1	.43*	.25*	.45*	.30**	.17
Delayed Test	--	.16	.32*	.21**	.10
Attention		--	.47*	.46*	.60*
Confidence			--	.53*	.51*
Relevance				--	.56*
Satisfaction					--

(\*)  $p < .001$     (\*\*)  $p < .01$

The credibility variables correlate strongly with each other and illustrate universally high levels of significance ( $p < .001$ ). These results suggest that there is considerable cohesiveness in the dependent data structure and depicts a conceptually solid relationship between the two content mastery variables and the four credibility measures.

#### IV. DISCUSSION

The findings in this study suggest that larger image sizes and increased refresher rate do not positively affect content retention or instructor credibility in the sense of attention, satisfaction with the material, relevance of the material or confidence in test performance. In essence, better quality images do not improve cognitive performance or perception of the affective domain of visual images.

These results should be of great interest to those engaged in the development of Internet-based courses and those involved with desktop video conferencing (DVC). The issue of image quality should not be regarded as the driving force behind effective distance learning. Hence, designers of such systems and products can devote greater resources to content development. Moreover, without the need for greater bandwidth and processor speeds for image delivery, more dedicated network bandwidth might be allocated to development of interactive distance learning systems. In fact, most critics of web-based learning resources and DVC claim that it lacks "social presence". Thus, given limited bandwidth, due either to system consideration or cost effectiveness, a portion could be deployed for interactive networking assuming, as this study suggests, that content mastery can be achieved with smaller, slower images as effectively as larger television format images.

Overall, these findings are encouraging to those involved with training and education using limited bandwidth networks. Without question, educational design, not image quality, is the most compelling factor in distance learning applications.

#### Limitations

The results of this study did not support the contentions of the original research hypotheses, and were, arguably, somewhat counterintuitive. It should be noted that this study, by design, was artificially induced, and students were therefore aware of their collective experimental experience. Since this was only a forty-minute presentation, it would be difficult to note any rendering of long term effects. If students were exposed to one of the specific conditions used in this study for an entire semester, it would be reasonable to expect some differences in information retention and credibility. Currently this is a nearly untouched, yet important, area of inquiry. Future experimental designs need to examine image sizes and frame



rate outcomes in more realistic settings. Learning style and other confounding variables should be taken into account in developing a comprehensive model. Finally, more sensitive instruments should be developed to understand the characteristics of attention, confidence, relevance, and satisfaction in the networked learning environment.

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**APPENDIX A**  
**Measurement Instruments**

**Content Mastery Instrument (Page 15)**

**Credibility Instrument (Page 16)**

## Content Mastery Instrument

COM001

### History of Radio

Select single best answer.

1. The legislation that created the Federal Radio Commission was
  - a. the Post Roads Act of 1866.
  - b. the Wireless Ship Act of 1910.
  - c. the Radio Act of 1912.
  - d. the Radio Act of 1927.
2. The network that was formed from the NBC Blue Network was
  - a. CBS.
  - b. ABC.
  - c. RKO.
  - d. Mutual.
3. The person most closely associated with the development of CBS is
  - a. Marconi.
  - b. Weaver.
  - c. Sarnoff.
  - d. Paley.
4. The Federal Radio Commission was under the direction of
  - a. the Navy.
  - b. Department of Commerce.
  - c. Congress.
  - d. Defense Department.
5. The Radio Act of 1912.
  - a. established the FCC.
  - b. established the FRC.
  - c. formed RCA.
  - d. required licenses to use radio frequencies.
6. NBC was originally owned by
  - a. the Red Network.
  - b. AT&T.
  - c. RCA, GE and Westinghouse.
  - d. RCA.
7. The cross-licensing agreements of 1926 prevented which of the following companies from entering the broadcasting business?
  - a. AT&T.
  - b. RCA.
  - c. Westinghouse.
  - d. Mutual.
8. The FCC replaced the FRC in 1934 because
  - a. the FRC was incompetent.
  - b. the FCC would be an agency independent from government.
  - c. the FRC could not oversee television.
  - d. the FRC was under the direction of the Navy.
9. The philosophy of private ownership of electronic communication began with
  - a. the Post Roads act of 1866.
  - b. the Wireless Ship Act of 1910.
  - c. the Communications Act of 1934.
  - d. the Radio Act of 1927.
10. AT&T's chain broadcasting efforts in the 1920's would be characterized today as
  - a. advertising.
  - b. monopolistic.
  - c. networking.
  - d. violations of anti-trust rules.

## Credibility Instrument

Please read the following statements and select the response that most accurately reflects your feelings.

- A = Not true
- B = Slightly true
- C = Moderately true
- D = Mostly true
- E = Very true

1. The instructor made me feel enthusiastic about the subject matter of this course.
2. I feel confident that I did well on the quiz.
3. This presentation had very little in it that captured my attention.
4. The instructor made the subject matter of this course seem important.
5. I do NOT see how the content of this course relates to anything I already know.
6. I enjoyed this presentation.
7. I feel rather disappointed with this presentation.
8. I feel I have received a good foundation in broadcast history.