THE UNIVERSITY OF CALGARY

Visual Simulation and Perception in Urban Planning

by

Bruce Stephen Park

A MASTER'S DEGREE PROJECT SUBMITTED TO THE
FACULTY OF ENVIRONMENTAL DESIGN
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR
THE DEGREE OF:
MASTER OF ENVIRONMENTAL DESIGN
(PLANNING)

FACULTY OF ENVIRONMENTAL DESIGN
CALGARY, ALBERTA
SEPTEMBER, 1996

ISBN 0-612-20336-0

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The undersigned certify that they have read, and recommend to the Faculty of Environmental Design for acceptance, a Master's Degree Project entitled **Visual Simulation and Perception in Urban Planning** submitted by Bruce Stephen Park in partial fulfillment of the requirements for the degree of Master of Environmental Design (Planning).

Dr. Richard Levy, Supervisor
Faculty of Environmental Design

Dr. Alan Miciak, External
Faculty of Management

Professor Lorraine Dearstyne Fowlow, Dean's appointed examiner
Faculty of Environmental Design

Date: October 7, 1996

ABSTRACT

Visual Simulation and Perception in Urban Planning

Bruce Stephen Park

September, 1996

Prepared in partial fulfillment of the requirements of the
Master of Environmental Design degree in
The Faculty of Environmental Design
The University of Calgary

Supervisor: Dr. Richard M. Levy

Recent advances in computer graphics technology have provided urban planners with new tools for creating visual simulations of urban environments. Decreasing hardware costs, faster performance, and the availability of three-dimensional modeling and animation software has brought visual simulation within reach of most planning professionals. To date, research into the effectiveness of dynamic visual simulations in planning remains limited. With advanced virtual reality applications on the horizon, it is important to evaluate the perceptual effectiveness of dynamic visualizations in the form of computer animations. In this research, the perceptual effectiveness of photo-realistic computer animations was investigated. Using 3D Studio, a one-block section in the downtown area of Kirkland, Washington was simulated. One group of respondents evaluated the simulation while another group evaluated actual video footage of the area. Their responses were statistically compared to determine response equivalence. Results indicate that response equivalence was achieved.

Key Words: visual simulation; 3D modeling and animation; computer visualization; 3D Studio

ACKNOWLEDGEMENTS

I would like to thank all of the following individuals for their contributions to this project:

The members of my MDP committee: Dr. Richard Levy, Dr. Alan Miciak, and Professor Loraine Dearstyne Fowlow, for their valuable advice, encouragement and guidance.

Ms. Michele Lynds, for her immeasurable assistance, support and encouragement that made this project possible .

Ms. Donna Delparte, for providing encouragement and much-needed subjects.

Mr. Paul Stewart, Deputy Director, Kirkland Planning Department, for his encouragement.

Mr. Chris Townsend, for his helpfulness in providing computer data.

Dr. Janice Bakal, New Media Center, for funding multimedia support.

Mr. Trevor Doerksen, New Media Center, for enduring repeated video showings.

Mr. Peter C. Wong, Worldesign, for offering an informative insight into the visualization industry.

Finally, my family, for their unending support, patience, and encouragement.

For my mother, Irene, and the memory of my father, Harry.

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"I think things have changed enough nowadays that doing renderings is well within reach of anybody who has almost any kind of computer in the office."

- Gregory Kiss
(Meidinger, 1991, p. 135)

INTRODUCTION

Growth and Change

Very few audiences have not been impressed by the quality of the computer-generated imagery in film and television in recent years. Films such as *Jurassic Park*, which incorporated live action with computer-generated dinosaurs, have brought a new level of realism to the cinema that has never previously been seen. Recent advances in computer graphics technology have brought high-quality, 3D modeling and animation capability to higher-end personal computers. For planners, these new developments offer new tools for creating visual simulations of future urban environments. For the purposes of this study, a *visual simulation* is defined as

> imagery that portrays, in perspective, what a proposal or design would look like if it was to be enacted or built, shown in the context of its surroundings (adapted from Sheppard, 1989).

Advocates of visual simulation in the planning discipline point out that power of visualization lies in its potential for improving the quality of decision-making in the planning process (Sheppard, 1989; Hall, 1993; Bressi, 1995; Lange, 1994; Oh, 1994). Plans, elevations, and descriptions of proposed designs, they point out, are often confusing to the non-professional. By using computers, it is possible to show a visualization of a design proposal in perspective, from an infinite number of viewpoints, in full-colour with the effects of light, shade, and shadows accurately simulated, with realistic materials applied to different objects. With the arrival on the market of software applications such as Autodesk's 3D Studio (Autodesk Inc., Sausalito, CA) it is now possible to create *dynamic* images of a design. While the use of *static* visualization in planning has been demonstrated by a number of authors (Levy, 1995; Hall, 1993; Lange, 1994; Sheppard, 1989), research into their perceptual effectiveness remains limited, at best. *Static visual simulations* refer to images of a proposed design, in perspective, that would be seen by a stationary observer; *dynamic visual simulations* refer to animated images in perspective of a proposed design that would be seen by a moving observer (Lange, 1994). The power of dynamic visualizations, lies in their ability to add a greater experiential quality to the imagery. They have the potential of providing viewers with a sense of place. Despite their potential as useful planning tools, research into the perceptual effectiveness of dynamic visual simulations of urban environments is sparse. Before such techniques can be used effectively in the decision-making process, their response equivalence must be demonstrated:

> ...the audience responses evoked by the simulated settings must be comparable to those that would be evoked in direct encounters with the setting simulated. For example, in using visual simulation in environmental public hearings, the reactions to the proposed project should match or forecast the reactions to the actual setting, if it were ultimately constructed (Appleyard and Craik, 1979).

With virtual reality applications already in use, the need for preliminary research in this field is evident. To this end, this Master's Degree Project will explore visual simulation and its application to the field of urban planning.

OBJECTIVES

The objectives of this study are as follows:

1. To briefly review the history and use of visual simulation in the field of urban planning.
2. To educate planners and non-planners regarding the expanding field of visual simulation technology.
3. To conduct experimental research into the perceptual effectiveness of a dynamic visual simulation of an urban environment in the form of a photo-realistic computer animation in comparison with video imagery of the same area .

RESEARCH QUESTION

This research will attempt to answer the following question:

"Is it possible to evoke equivalent perceptual responses from a video tape and a computer-generated animation of an urban environment?"

Specifically, the following hypothesis will be tested:

Statement of the Null Hypothesis

There are no differences in the mean perceptual responses of semantic differential scores measuring architectural meaning, stimulus measures, site familiarity, image attractiveness, and viewer confidence in the imagery.

Statement of the Alternative Hypothesis

There are differences in the mean perceptual responses of semantic differential scores measuring architectural meaning, stimulus measures, site familiarity, image attractiveness, and viewer confidence in the imagery.

Test Statistic

The test statistic that will be used is F.

RESEARCH METHODOLOGY

The following methodology was employed in this Master's Degree Project:

1. **Literature review**: A survey of the literature on visual simulation in urban planning was conducted. Books, professional journals in planning, landscape architecture, environmental management, psychology, and marketing provided source materials for research. Computer graphics periodicals and newspaper articles were also reviewed to provide an overview of the state of the art in visual simulation.
2. **Experimental Design**: An experiment was designed and conducted to test the perceptual effectiveness of a computer-generated visualization of an urban area in comparison with video imagery of the same area.

Chapter 1 includes a discussion of the history of visual simulation, and the technological advances that have led up to its present form. This is followed by a discussion of the uses of visual simulation in planning practice. Chapter 2 discusses the design of an experiment used to test the perceptual effectiveness of a computer-generated urban environment. Chapter 3 covers the methodology of how the experiment was conducted. Chapter 4 provides a description of the results of the experiment, and finally, Chapter 5 discusses the conclusions of the research, suggestions for future research and outlook.

"Not everyone can read a floor plan, but everybody knows how to watch tv."
- Michael O'Malley
(Meidinger, 1991, p. 136.)

ONE

Visual Simulation

In this chapter, a brief history of visual simulation will be reviewed along with a discussion of the technological advances that have occurred in visualization technology in recent years. This is followed by a review of its application to urban planning in the areas of environmental assessment, mitigation planning, and planning control. Recent planning examples involving the use of visualization will then be discussed. To balance out the discussion, some of the limitations of visual simulation are highlighted. Finally, an overview of visualization research is provided in order to determine which areas require further investigation.

HISTORICAL OVERVIEW

Historically, planners, architects, and engineers have used many different media to represent their designs of buildings and cities. Scale models, plans, diagrams, elevations, and perspectives have been used for centuries to portray visions of the built environment (Figure 1-1). Each media form, however, is not without its limitations: models are time-consuming to build and are problematic due to difficulties in translating their scale to human experience; plans and diagrams are often difficult for the lay-person to understand; elevations and perspectives are necessarily selective and few due to their intensive labor requirement (Hall, 1993).

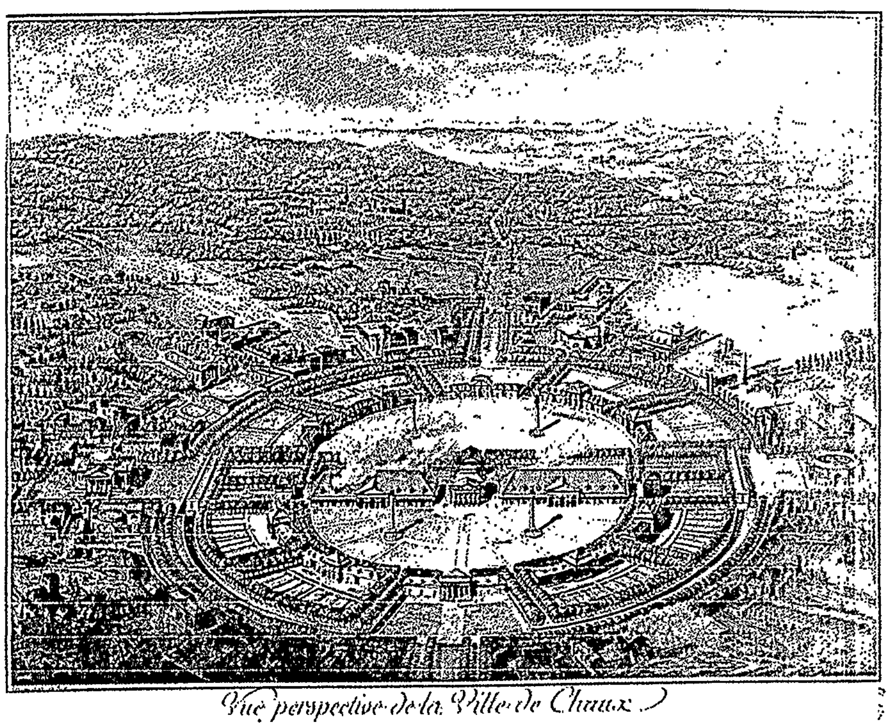


Figure 1-1. Historical perspective sketch of La Ville de Chaux, France.

In the past, the limitations of each of these simulation media were well-known by their creators. In their elaborate and often beautiful representations of buildings and cities, they tried to convey to the viewer what it might be like to experience that space. Medieval views of cities were drawn from the air, and presented in a such a way that they were easily understood by laymen and the masses. In order to provide viewers with a sense of its experiential qualities, San Gallo constructed a scale model of St. Peter's Cathedral that was large enough for a person to walk through (Appleyard and Craik, 1979).

In the modern era, researchers have looked to other methods of simulation, including the utilization of medical optical probes. Originally designed to assist surgeons in viewing the inner workings of the human body, the medical optical probe was originally adapted for use in environmental simulations by the Environmental Simulation Laboratory at the University of California, Berkeley, and later by Swedish researchers in Lund, Sweden (Figure 1-2). By filming detailed scale models with a tiny fiber-optic camera mounted on an adjustable track, it was possible, for the first time, to see an eye-level view of a design (Appleyard and Craik, 1979). Technological advances in other fields, including visual simulators used to train airline pilots, combat simulators used by the military, medical simulators used by doctors, and space simulators used by NASA have contributed much to visualization technology during this same time period. Photo simulations including photomontage, retouched photos, and photo overlays have also been used in landscape simulations primarily for visual impact assessment (Lange, 1994).

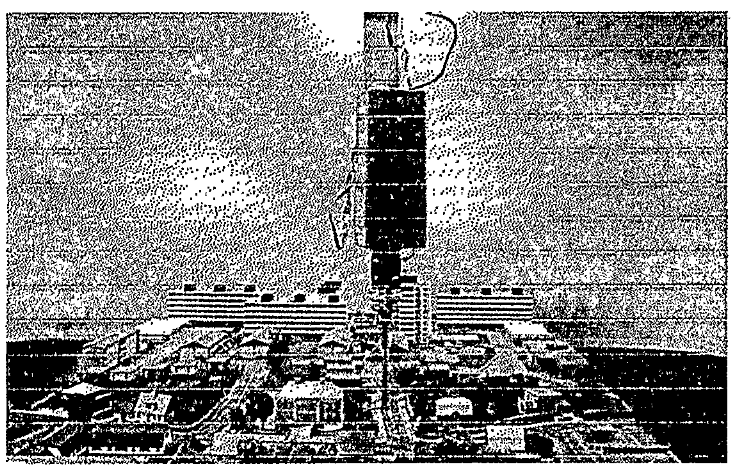


Figure 1-2 The Lund Simulator (from Janssens and Kuller, 1986)

RECENT TRENDS

In the past few years, advances in computer graphics technology have provided new tools for the purposes of visual simulation of urban environments. Planners and architects have begun to use CAD (or Computer-Aided Design) software to model their designs in 2-D, and 3-D electronic space (Levy, 1995). By using these programs, it is possible to create three-dimensional "wire-frame models" of a proposed design. Early versions of CAD software allowed users to "shade in" the wire-frame model, thus providing it with the appearance of a solid object. While not very realistic-looking, it did provide a three-dimensional quality to the image. Since it often took a long time to produce a final image due to high computer-processing requirements (particularly in the case of larger models) initially their use was minimal. Their usefulness and practicality was greatly affected by processor speed (Rahmat, 1996).

Recent advances in computer graphics technology have now reached the point where photo-realism is possible in still images and animations. As readers of computer graphics periodicals are aware, developments in the special effects movie industry has been a strong impetus in advancing visual simulation technology. The realism and believability of the computer-generated dinosaurs in the film *Jurassic Park* provides a good indication of how far this technology has advanced. Although these effects were created on more powerful Silicon Graphics workstations, it is now possible to create 3D models and animations on higher-end PC's and Macintosh computers. The recent availability of faster computers , dramatic decreases in memory prices, and better visualization software applications (Rahmat, 1996) has brought visualization technology within reach of most planning departments and planning consultants.

Along with these recent advances in computer graphics technology has been the development of new simulation media, including photographic-manipulation software, 3D modeling and animation software, and virtual reality applications. Each of these is discussed in turn below.

PHOTOGRAPHIC-MANIPULATION SOFTWARE

After scanning photographic images into a computer, this software allows users to manipulate them electronically. By "cutting and pasting" various elements of the image, and combining them with other photographic images, it is possible to create very realistic-looking simulations. Although this visualization technique has been described in the planning literature for some time (Lewis, 1988), the software has become much more powerful, allowing users to change almost any aspect of the original image. One limitation of this technique, however, lies in the difficulty in preserving accuracy in the final image. Since the objects are not positioned in three-dimensional electronic space, the positional relationship between the objects in the scene is lost as the photograph is altered. Although it is possible to simulate perspective, the image's true perspective is lost. Another limitation of this particular simulation media is that it is a fixed image, and only provides a single view of a subject from one perspective (Decker, 1994).

At this point it would be useful to reiterate the distinction between *static* and *dynamic* visual simulations. Up until now, the discussion has largely centered around static visual simulations. Static visual simulations are simulations that show a proposed project or design as seen from a static (i.e. fixed) observer. Dynamic visual simulations, including computer animations, show a proposed project or design as seen by a moving observer (Lange, 1994).

3D MODELING AND ANIMATION SOFTWARE

As with computer-assisted design (CAD), modeling and animation software allows users to build accurate three-dimensional models of design proposals. While the usefulness of this type of software in urban design has been examined (Levy, 1995; Danahy and Wright, 1988), new generations of more powerful and easier to use 3D modeling and animation software have since reached the market (Maestri, 1996). The flexibility and power of this software (which runs on higher-end personal computers) now provides users with the ability to produce high-quality visual simulations that could only have been done previously on workstation-class computers (Rahmat, 1996). One powerful component of this software is the ability to produce animated walk-throughs and fly-bys of proposed designs. While earlier versions of this type of software allowed only simple solid-colour shading of the wire-frame model, recent versions allow the user to apply photo-realistic materials and textures to it. Another add-on feature is the ability to incorporate a simulated sun into the scene which permits the user to develop shadow studies of a proposed design. Simulated lights and cameras provide realistic lighting effects and camera views of the model. By controlling lighting, camera placement, and textures, it is possible to produce visual simulations with a relatively high degree of realism. The advantage of this type of simulation media lies in its capability in producing highly-detailed perspective views of a proposed design from any viewpoint. Another advantage is the capability of producing fly-bys or walk-throughs of a design (Elliott et al., 1994), giving the viewer an experiential quality that still images lack. Disadvantages of this type of simulation media include a steeper learning curve, increased processing time required to produce an animation, and the inability to move around the rendered model in real-time (Hall, 1993).

Rendering

While three-dimensional modeling and animation programs give users the capability of creating accurate models of proposed designs, it is their powerful rendering capabilities that allow them to produce photo-realistic images. *Computer-based rendering* refers to the process by which a three-dimensional model is created, surface materials are applied, and lights are placed in the scene (Claridge, 1996). Environmental parameters are entered into the program, such as atmosphere, date, or time of day. After this, depending on the speed of the computer used, a rendered image appears of the finished scene some time later. This process can take anywhere from a few minutes, hours, or even days to complete.

Computer-based rendering versus traditional rendering

Traditionally, designs have been rendered in charcoal, pencil, pen, ink, or paint. The result was often a beautifully rendered hand-drawn or hand-painted image of a proposed plan, reflecting the artistic skill of the designer. The attractiveness of using traditional rendering techniques are mired in their long-standing use, and respect for their centuries-old development. Computer-based rendering techniques, on the other hand, have only been available for a few years. Early versions were cumbersome to use and did not provide the user with much flexibility in how the rendered image was produced. Their artistic component became lost in the technology itself (Dawson, 1991). With the advent of sophisticated post-rendering software, however, it is now possible to simulate some of the features that made traditional renderings so attractive:

> With sophisticated paint rendering programs, we can take a rendered image of a building and insert people, cars, and trees to a scene rather than going back and creating geometries for these pieces with the originally rendered model. We can composite rendered models with photographic images. We can selectively smudge, darken, lighten, or re-color parts of our picture. Ironically, we can use sophisticated filters to give our image the appearance of having been rendered with traditional techniques such as pen and ink, pastels, or oil paints. With post-rendering software, there are no limits to the flexibility and control we can have over our images (Claridge, 1996, p. 30).

One clear advantage of computer-based rendering, lies in its flexibility - once a model has been constructed, it is possible to re-render a scene many times from a number of different viewpoints, each time changing lighting, materials, and textures.

With the invention of any new technology, there is reluctance to switch from a traditional means to a non-traditional one. In planning and architecture, traditional rendering techniques will continue to be employed for a long time, since there is a direct human connection to the final product. Increasing awareness and appreciation of the advantages of digital rendering technology, however, will see their increasing usage in these areas.

VIRTUAL REALITY APPLICATIONS

Virtual reality software allows users to experience and interact with three-dimensional computer models of a proposed design in real-time. By manipulating a keyboard, joystick, or special glove, users are able to move around freely and interact with a virtual environment while viewing a computer screen, or on more advanced systems, wearing a special helmet or visor. It is possible to immerse viewers in a virtual environment without the use of a helmet as well; a series of a number of large circular screens has been used in a "virtual reality theater" in such a way that a number of individuals could view the virtual environment at the same time (Saini, 1995). Due to their intensive computing requirements, virtual reality software capable of visually simulating an urban environment have initially been limited to higher-end workstation-class computers. The more detailed and more realistic-looking a model is, the higher its processing requirements become. Since workstation-class computer costs can easily exceed $40,000, their use has been confined largely to firms specializing in computer graphics, universities, and larger visual simulation laboratories. The recent arrival of faster video-processing cards for personal computers has now made the use of virtual reality applications possible on that platform. Advantages of this simulation media include the ability to interact in real-time with the proposed design. Disadvantages include their high computing requirements and relatively high cost. Additionally, their ability to produce photo-realistic simulations is limited to very fast workstation computers, or personal computers with enhanced video processing capabilities; lower-end computers only allow viewing flat-shaded models at real-time speeds.

In planning, the production of dynamic visual simulations (and more recently, virtual reality) has largely been restricted to a small number of specialized environmental simulation labs in Canada and the U.S. (Bressi, 1995). Among these include the Environmental Simulation Laboratory at Berkeley, California, the Environmental Simulation Center in New York, and the Center for Landscape Research at the University of Toronto.

VISUAL SIMULATION IN PLANNING PRACTICE

Visual simulation has been used in a number of different areas in the field of urban planning, including environmental assessment, mitigation planning, planning control, and environmental and perceptual research.

ENVIRONMENTAL ASSESSMENT

One area which is ideally suited for the application of visual simulation is environmental assessment. Visual simulations are potentially useful tools in environmental assessment because 1) they provide data which can be analyzed directly by environmental professionals for aesthetic evaluation and visual impact assessment; and 2) as a presentation device to which audiences can react in surveys to measure attitudes and pubic responses to the project (Sheppard, 1989). Ideally, visualization can be an important tool in environmental impact assessment provided it is integrated early in the planning process. In this way, detrimental effects on the landscape can be foreseen, and steps taken early on to ensure the visual quality of the landscape is maintained. In practice, however, visualizations tend to be done after an environmental impact assessment has already been completed (Lange, 1994).

MITIGATION PLANNING

If it is determined that a project will have an adverse impact on the landscape, it is equally important to determine ways in which this impact can be reduced, or mitigated. Mitigation planning involves the modification of a design such that its negative effects are eliminated, reduced, or offset. The value of visual simulation in mitigation planning is as follows:

> Visual simulations are [again] very helpful to environmental professionals both in designing or developing the mitigations, and in assessing their effectiveness or success. Simulations often form both the medium and the catalyst for integrating the impact assessment with the design process. For example,

analysis may show that a proposed building would create an unattractive, blank, monumental facade in views from nearby residences; simulations could be prepared to show how much vegetation would be needed to screen the worst parts of the building, as a basis for developing a planting plan to enhance views. Simulations can also explain how biological mitigations, for example, might work, or the visual implications of other mitigations such as noise-barrier construction (Sheppard, 1989, p. 20).

PLANNING CONTROL

For planners, architects, members of development review boards, and the public, one of the major problems in discussing a proposed design using traditional simulation media (plans, elevations, and perspectives) lies in the difficulty of the parties involved in visualizing the design and its impact in three-dimensions. Disputes often arise if the plans, elevations, diagrams or perspectives are not well understood by the parties concerned, or if there is confusion over some element of the design. The result is frequent and expensive design appeals. The value of visual simulation lies in its ability to present, in three-dimensions, a view of a design from an infinite number of viewpoints. Hall (1993) investigated the usefulness of visual simulations in a number of planning examples in England, including the redevelopment of a leisure center in Guildford, a planning application for a domestic extension in East Cambridgeshire, and a controversial planning application for a house extension in Danbury. From these examples, he concluded that

> The importance of computer-visualization for planning practice lies in its potential for the improvement of the quality of decision-making by virtue of its ability to avoid misunderstandings in the negotiation of the outward form of development (Hall, 1993, p. 193.).

If all parties concerned are able to view an accurate three-dimensional visual simulation of a proposal, he reasons, they will be able to make better informed planning judgments.

RECENT EXAMPLES

As a part of its successful presentation to the International Olympic Committee for the 1996 summer games, the city of Atlanta used three-dimensional computer modeling software to visualize its proposal (Curtis and Brown, 1992). Following the Los Angeles riots in April 1992, UCLA's Graduate School of Architecture and Planning used Silicon Graphics workstations to build a virtual reality model of the rebuilding designs. This allowed viewers to "fly through" the new neighborhood design model in real time. Since many of the people that lived in the destroyed area were non-English speaking, a presentation medium was needed to display the plans in a way residents could easily understand. The goal of the project was to enable the Spanish and Korean communities to contribute to the rebuilding efforts by participating in community workshops. The use of visualization technology, in this instance, allowed residents to actively participate in the decision-making process (Webster, 1992).

Worldesign, a Seattle-based virtual reality design firm, recently created an interactive model to demonstrate the visual impact of the Port of Seattle's Central Waterfront Project. By using a "virtual reality theater", which consisted of three eight-foot square screens arranged to create a viewer enclosure, a group of viewers were able to fly around in real time and examine a number of alternative layouts of the design (Saini, 1995).

At University of Washington's Human Interface Technology laboratory, researchers have used virtual reality simulations to study redevelopment plans for Seattle Commons, a new district proposed near Seattle's downtown area. A 30 square-block model was constructed which viewers could " walk through" by viewing a computer monitor, or could don virtual reality helmets and "walk around" the southern end of the proposed design (Bressi, 1995).

Recently, the city of Scottsdale, Arizona commissioned the Computer Reality Center, an arm of the Phoenix-based CAD Institute, to produce a computer visualization which illustrated the spread of a major brush fire in 1995 that had burned hundreds of acres and threatened a number of homes in the area. The city's objectives, in commissioning such a study, were to use the graphical information provided in the visualization as a tool for analyzing incident/management procedures and demonstrate to others how new visualization technology could aid in city planning and development processes. In the visualization, an eighteen hour event was compressed into one minute of computer animation, allowing viewers to see, from a variety of viewpoints, how the fire started, and how effective fire-fighting techniques were in combating the blaze. This allowed planners to analyze and modify their incident/management procedures should a similar incident occur in the future (Mahoney, 1996).

ISSUES IN PLANNING PRACTICE

Due to limited resources, the current use of visualization technology by most planning departments tends to be very limited. This is due, in part, to the perception of city officials that visualizations are expensive, time-consuming, and of limited value. While the effective use of this technology in planning has been demonstrated on numerous occasions (Bressi, 1995; Levy, 1995; Hall, 1993), it is still in its infancy.

One difficulty in visualization, as has been the case with the implementation of Geographic Information Systems (GIS), is the problem of limited accessibility to relevant data. To be accurate, visualization requires information that has traditionally been held by other departments, such as engineering and transportation. Departmental barriers often exist that make it difficult to share pertinent information; in some cases planners are not even aware that the information they need to create a visualization is held by another department. Successful implementation of GIS by planning departments, however, will help to reduce these barriers, and provide greater accessibility to information.

Currently, another problem for many planning departments is the availability of adequate hardware and software to produce visual simulations. Since an individual workstation and corresponding software can cost thousands of dollars, it is doubtful that smaller planning departments would be able to afford the technology needed to create their own visualizations. By using planning consultants specializing in visualization, however, planning departments can adopt the technology and expertise without incurring high equipment and software costs. Falling hardware and software prices may see many planning departments doing their own in-house visualizations at some point in the future.

For most planning departments, visualization can be done in a relatively short period of time if the projects are small, and the level of detail is not critical. In presentations to development appeal boards, for example, visualization could be used as an effective tool in resolving disputes. Visualization could also be useful in public participation by providing imagery of a design or redevelopment that can be easily understood by the public. Some planners have taken laptops to design charettes, where they have used visualization to discuss alternate design proposals (Bressi, 1995).

While the use of advanced computer technology in a planning department has often been limited to the realm of a few technically literate individuals, the fact that the software is becoming easier to use may see more and more planners beginning to explore its potential.

LIMITATIONS OF VISUAL SIMULATIONS

While a great deal of literature has been written extolling the virtues of visual simulation technology, a balanced discussion must necessarily include an examination of its limitations. The fundamental difficulty in the use of visual simulation is as follows:

> No matter how sophisticated the technology, there are still significant differences between the way simulation presents the world and the way people experience it - and between a plan that is presented and what is actually built (Bressi, 1995, p. 19.)

This statement, however true, also applies to traditional simulation media. It also raises the question whether reality can, in fact, be simulated. The simple answer is that it can not. No matter how realistic the simulation, it can not represent what is, in essence, an unknown. While visual simulations can not truly represent reality, they can present imagery that informs viewers, and helps them to decide what they wish that reality to be.

Another important limitation in the use of visual simulations in planning practice has been their heavy demand on staff time:

> The high staff-time costs associated with computer visualization (as with other branches of computing) are likely to be the main influence on the nature of its use by planning authorities (Hall, 1993, p. 208).

While the factor of high staff-time costs has been raised as a potential roadblock in the use of visual simulation in planning, this has not precluded the use of other related technologies that also require high demands on staff time, including CAD, and GIS. As the potential benefits of using visual simulation technology become more widely recognized, its use in planning will become more established.

Difficulties in the legitimate use of visual simulations can arise when simulation validity is assumed, rather than objectively measured (Decker, 1994). This is due to the absence of a universal set of simulation standards. Often, audiences do not question the accuracy of visual simulations, including those who make planning decisions on the basis of what is seen. However, rigid enforcement of the codes of professional conduct in the planning and architecture professions would help reduce the possibility of misrepresentation in visual simulations.

As many have pointed out, when visual simulations are done in such areas as dispute resolution, it is often not necessary to produce a photo-realistic simulation (Hall, 1993). High levels of realism can be expensive, owing to the time commitment required to construct them. The level of modeling detail is dependent on a number of factors including time, cost, nature of the planning issue, and characteristics of the intended audience. The experimental validation of computer-generated visual simulation media, particularly dynamic simulations, has yet to be done, suggesting that practitioners must exercise caution in their use.

Critics of the use of visual simulation in design review have argued that people tend to perceive rendered computer images, regardless at which stage in the design process they are shown, as being complete:

> One important area of application of computer graphics is architectural design. Architects use CAD systems to help them design and render images. However, images produced by conventional renderers are typically not appropriate for architects to show their client at an early stage in the design process: Very often architects will trace over the computer output with tracing paper and a pencil to redraw the image by hand because they feel that the computer output appears stale compared to "more alive" presentation of hand-drawn graphics. Furthermore, and perhaps even more important - is the message implicit in conventional computer output: An object being displayed appears "complete", even if it is only a "first-draft". Architects (or planners) have no way of adjusting the rendering of scenes to match their level of confidence in their design, nor does the object reflect the amount of thought which has gone into it so far. Giving a client a photo-realistic image and saying that it represents a preliminary design simply does not have the same effect as giving the client a sketch that is obviously in an early design stage (Strothotte et al., 1994).

To counter this criticism, proponents point to recently developed software applications that simulate real drawing media. By using a stylus, or pen, which is capable of detecting 256 levels of pressure on a small drawing tablet, it is possible to realistically simulate charcoal, pencil, acrylic, water brush, pen, or a variety of other artistic media. By importing a rendered computer image into the program, it can be "touched up" to give it a sketch-like appearance (Claridge, 1996). Add-in programs for 3-D modeling and animation programs that do similar effects have already reached the market, allowing architects and planners to give both their still renderings and animated simulations a "hand-drawn quality".

A key question, then, is: To what extent is a viewer or audience's perceptions influenced by different graphical presentations? To provide answers to these and other questions, the discussion must now turn to visual simulation research.

RESEARCH IN VISUAL SIMULATION

In environmental and perceptual research, visual simulations are used as stimuli to observe and analyze an audience's perceptual responses to proposed environments. By studying how people perceive environments in a controlled experiment, researchers can test general theories about visual simulation. The advantage of visual simulations is that they can be used in experiments to control a set of visual variables of interest for purposes of statistical analysis (Sheppard, 1989).

Despite recent advances in visual simulation technology, research on their effectiveness in the planning discipline remains limited. The increasing usage of photo-manipulation software, three-dimensional modeling and animation software, and virtual reality applications by planning professionals dictates that further research is needed in order to critically appraise their use (Oh, 1991; Zube et al. 1987)

In the past, visual simulation research has largely focused on static simulation methods. A number of early studies focused on determining whether certain types of static simulation media were accurate simulations of environmental scenes. Schomaker (1979) compared audience preferences of landscape modifications in black and white sketches of slides and tinted sketches of slides versus colour slides of the actual site, achieving a correlation of +0.69 and +0.87, respectively. Killeen and Buhyoff (1983) compared an audience's responses to black and white sketches and computer sketches versus responses to slides of the actual site, finding a correlation of +0.71, and +0.43, respectively. Seaton and Collins (1972) examined an audience's ratings of simulated buildings, comparing model views, colour photos, and black and white photos to ratings of the actual site, finding correlations of +0.40, +0.80, and +0.32, respectively (Stamps, 1993).

Stamps (1993) examined an audience's preference for six infill housing construction projects by comparing responses to line drawings of the projects versus post-construction elevation and perspective photographs of the sites, finding substantial agreement in preferences despite differences in simulation media.

A number of previous studies have also examined individual differences in evaluation of the visual landscape (Kaplan and Kaplan, 1989), which can vary with ethnicity, cultural background, and social level. Earlier studies have also tended to use broad measures of evaluative reactions to environments while others have used a more refined response format.

On a more basic level, Wanger et al. (1992) studied the perception of spatial relationships of individual objects (in the form of spheres) in computer-generated images, finding that the perception of computer-generated imagery was influenced by different cues, which in turn affected task performance. For positioning tasks, shadow and perspective were found to provide significant cues. For orienting tasks, perspective, motion, and shadow were significant cues in successful task performance. For scaling tasks, where object location information and object size were relevant to the task, perspective, motion, and shadow were all effective cues. For an audience to perceive spatial relationships accurately, they concluded, it is important to provide appropriate visual cues. This has implications for virtual reality research, whereby viewers are able to interact with a computer-generated environment in real-time. It also suggests that one must be careful when producing visualizations to provide appropriate visual cues to ensure that an audience is perceiving the imagery accurately.

Following an earlier study by Acking and Kuller (1973), Janssens and Kuller (1986) examined the effectiveness of the Lund Simulator, a device consisting of a miniaturized tracking camera used to film a scale model of an urban area, very much like the simulator used at the environmental simulation lab at the University of California, Berkeley. The simulator functions as a dynamic simulator by allowing viewers to "drive through" the model and see it from an eye-level view on a television monitor. In comparing an audience's responses to different representations of an urban neighborhood, including plans, perspective drawings, slides, and a movie of the area (created by the simulator) among the semantic dimensions of Pleasantness, Enclosedness, Complexity, Social Status, and Unity, they found the lowest errors in perception in the dynamic simulation. While the simulator yielded excellent results, Janssens and Kuller noted that not many municipalities in Sweden were willing to invest in its use, citing economic costs, the potential for manipulation by interested parties, and a reluctance to involve non-professionals in the decision process (Janssen and Kuller, 1986).

FOUNDATION FOR THIS RESEARCH

From an examination of past studies, it is evident that research into advanced types of computer simulation media is needed, in particular that of dynamic visual simulations, or specifically, computer-generated animations. Two studies, Appleyard and Craik (1979) and Oh (1994) provided the foundation for this research. If simulations are to be used as a valid decision-making tool, then the reactions people would have in response to seeing a simulation had to be equivalent to the reactions the same person might have after visiting or viewing an actual site (Bosselmann, 1992). In their study, Appleyard and Craik examined the response equivalence between an actual drive-through of an urban area and film footage of a scale model of an urban area, photographed with the use of a medical optical probe (the Berkeley simulator). Oh (1994) examined an audience's perceptual responses to a variety of simulation media at various levels of abstraction (wire-frame, surface model, combination of surface model and scanned images, and image-processing) and also compared the impact of observer characteristics on the results. Each of these studies provided useful information into developing an experimental methodology in this research, which will be discussed in the next chapter.

CHAPTER SUMMARY

Historically, planners, architects, and engineers have used plans, elevations, and perspectives to illustrate their designs. New visual simulation technology is now allowing planners to model their designs in 3-D electronic space, and render them photo-realistically. The advantage of using 3-D modeling and animation lies in its capability to produce static or dynamic perspectives from an infinite number of viewpoints, as well as providing the capability to create fly-bys or walk-thrus of a proposed design. In modern planning practice, visual simulation has applications in environmental assessment, mitigation planning, and planning control. Its importance lies in its potential for improving the quality of the decision-making process. The fundamental difficulty in the use of simulations is that there are still significant differences between the way a simulation presents the world and the way people experience it, and between the way a plan is presented and what later is built. Heavy staff-time requirements, and steep learning curves may hinder its use among planning professionals. In current planning practice, the use of visual simulations is limited, due to its perceived high cost, time commitment, and data issues. Increasing awareness of its value in the planning process should see its increasing usage by planning professionals. To date, research on the effectiveness of visual simulation in planning practice has been limited to static simulations. Research into the effectiveness of dynamic computer-generated visual simulations is needed.

"Simulation allows people to begin to see patterns. If I gave you the data we generated, you'd be lost. But if I gave you a 3-D model, you begin to see where the potential is."

- Michael Kwartler
(Bressi, 1995, p. 16)

TWO

Design of the Experiment

In this chapter, a statement of the research problem, a statement of the null and alternative hypothesis, and a detailed discussion of how the experiment was designed is given.

STATEMENT OF THE RESEARCH PROBLEM

As in any experimental design, it is first necessary to define the research problem, state the null hypothesis, the alternative hypothesis, and the test statistic (Christensen, 1994). In this study, the problem is stated as follows: Is it possible to evoke equivalent perceptual responses from a video tape and a computer-generated animation of an urban environment?

STATEMENT OF THE NULL HYPOTHESIS

There are no differences in the mean perceptual responses of semantic differential scores measuring architectural meaning, stimulus measures, site familiarity, image attractiveness, and viewer confidence in the imagery.

STATEMENT OF THE ALTERNATIVE HYPOTHESIS

There are differences in the mean perceptual responses of semantic differential scores measuring architectural meaning, stimulus measures, site familiarity, image attractiveness, and viewer confidence in the imagery.

TEST STATISTIC

The test statistic that will be used is F.

DETERMINATION OF AN EXPERIMENTAL DESIGN

In designing the experiment to test the perceptual effectiveness of a dynamic computer-simulation of an urban area, two previous studies (Appleyard and Craik, 1979; Oh, 1994) provided useful methodological approaches. In their pioneering study on the effectiveness of visual simulation in environmental planning, Donald Appleyard and Kenneth Craik (1979) compared audience responses of film footage shot by a fiber-optic camera of a detailed model of an area in Marin County, California to audience responses of another group that were taken on a twenty-five minute auto tour of the same area. In their study, 187 people made the auto tour, while 192 viewed the film simulation. Respondents were given a list of three hundred adjectives of common terms used to describe environments, from which they checked off their overall impressions of specific localities in the tour area. Despite the potential for large simulation effects (errors introduced due to the influence of the simulation on the viewer), a remarkable degree of correlation between each group's responses (+.97) was achieved over sixty-seven evaluative statements. Some simulation effects, due to the lack of human and vehicular movement and the limitation of the model in simulating the road, sidewalk, grass, and shrubbery, were observed.

While Appleyard and Craik's study provides a foundation for studying dynamic visual simulations, it is problematic in that it used an extremely broad measure of perceptual response: preference. Other studies have shown that there is great individual variation in evaluation of the landscape (Nohl and Neuman, 1986, as reported by Lange, 1994; Kaplan and Kaplan, 1989). What was needed, therefore, was a tighter, more objective measure of perceptual response.

The answer to this problem was solved by referring to a recent visualization study conducted by Kyushik Oh (1994) at the University of California, Berkeley. In his study, Oh examined the perceptual effectiveness of a variety of simulation media, including wire-frame models, surface models, combination of surface model and scanned images, and image-processing. In his study, he compared the perceptual responses of these visualization media to that of a slide of the actual site, using a set of semantic differentials. This set of semantic differentials were useful in that they had been used in previous studies to assess the meaning of architectural environments, as discussed by Hershburger (1972). Since their validity and reliability had previously been demonstrated, they were selected for use in this study. A more detailed discussion of this is provided in the next chapter.

DESIGN OF THE EXPERIMENTAL METHODOLOGY

Using methodological elements from both studies, an experimental design for this study was devised as follows: A short 4-5 minute video tape of an urban area was produced to serve as a control. A computer-generated dynamic visualization (in the form of a computer animation) of the same urban environment was also produced, with similar views, lighting, and content. The computer model, in order to achieve the highest level of response equivalence, was built with a high degree of realism (as limited by the computer resources available). The end result was two videos, one depicting real video footage of the area, and the other depicting a simulation. One problem that has always existed in perceptual research is whether representations of actual environments (such as pictures, slides, or movies) provide similar responses to actually being there. In reality, humans perceive environments with all senses - sight, sound, smell, and touch. If this is the case, can representations provide comparable responses? As one researcher points out,

> The quick and straightforward answer to these questions is that people's responses to the two-dimensional representation are surprisingly similar to what they are in the setting itself. A number of studies have focused on these issues because these are basic questions that needed to be resolved. Though the similarity in responses to pictures and to real settings may seem surprising to those who focus on research methods, it is much less surprising if considered in terms of daily human experience. Much of the information that we consider all the time reaches us by means of two-dimensional representations of three-dimensional settings. When watching television or seeing pictures in a book or a painting on the wall people are not likely to say that the representation is deceiving (Kaplan and Kaplan, 1989, p. 17).

To continue, subjects were selected from a group of students, fifty in number (as determined by sampling theory). The respondents were randomly divided into two groups of twenty-five participants. A classroom served as the testing area. A coin toss determined which group would view the video and which group would view the computer animation. Prior to testing, each group was given informed consent forms to read and sign. The first group was shown one of the videos on a twenty-eight inch television monitor, supported on a stand for viewing efficiency. The room lights were turned off for clarity. Once the video was over, the room lights were turned back on, and the respondents completed the questionnaire. Once done, the first group left the room, and the second group was ushered in shortly thereafter, to reduce interaction amongst the two groups. The procedure was then be repeated. The same experimenter was used on both occasions to keep the experimenter effect constant. Once the experiment was complete, in order to test the null hypothesis, the data was analyzed by using one-way ANOVA (comparison of two means).

CHAPTER SUMMARY

An experiment was devised to test the response equivalence between a dynamic visual simulation of an urban environment with actual video imagery. Two previous visualization studies, Appleyard and Craik (1979) and Oh (1994) were useful in designing an appropriate experimental methodology to answer the question, "Is it possible to evoke equivalent perceptual responses between video imagery, and a computer-generated animation of an urban environment?". In the experiment, the perceptual responses of two groups, one viewing video imagery, and the other the computer animation, would be tested, and the results analyzed statistically to answer this question.

"The world is moving so fast these days that the man who says it can't be done is generally interrupted by somebody doing it."
- Elbert Hubbard

THREE

Methodology of the Experiment

The following chapter details the procedures and methodology by which the visual simulation and the video imagery of an urban environment was produced. This is followed by a discussion of the design of the questionnaire used in the experiment. Finally, a brief description is given into how the experiment was conducted.

MODEL CONSTRUCTION

SITE SELECTION

In this research, a small, one block area in the central business district of Kirkland, Washington was simulated (Plate 1). Kirkland is a small attractive community located in close proximity to Seattle, Washington. It is bounded to the west by Lake Washington, to the north by the city of Bothell, to the east by the city of Redmond, and to the south by the city of Bellevue (Fig. 3-1). Kirkland has won numerous urban design awards for its well-planned downtown and treatment of its long shoreline, which has an extensive lakefront park system . The city has a unique character and sense of place, and has been successful in merging the design of its buildings and places with the natural environment. It is very pedestrian-oriented with wide sidewalks and pathways, and has strong linkages between its downtown and Lake Washington (City of Kirkland, 1995).

This site was selected as a simulation subject for a number of reasons: 1) A distant site would minimize pre-existing bias in the respondents, since few would have intimate knowledge of it; 2) it is richly detailed in terms of storefronts, street furniture and fixtures, architectural detail, landscaping, and artwork (Plate 2); and 3) it successfully merges its downtown with its lakefront park (Plates 3 and 4), thus offering a variety of environments to simulate.

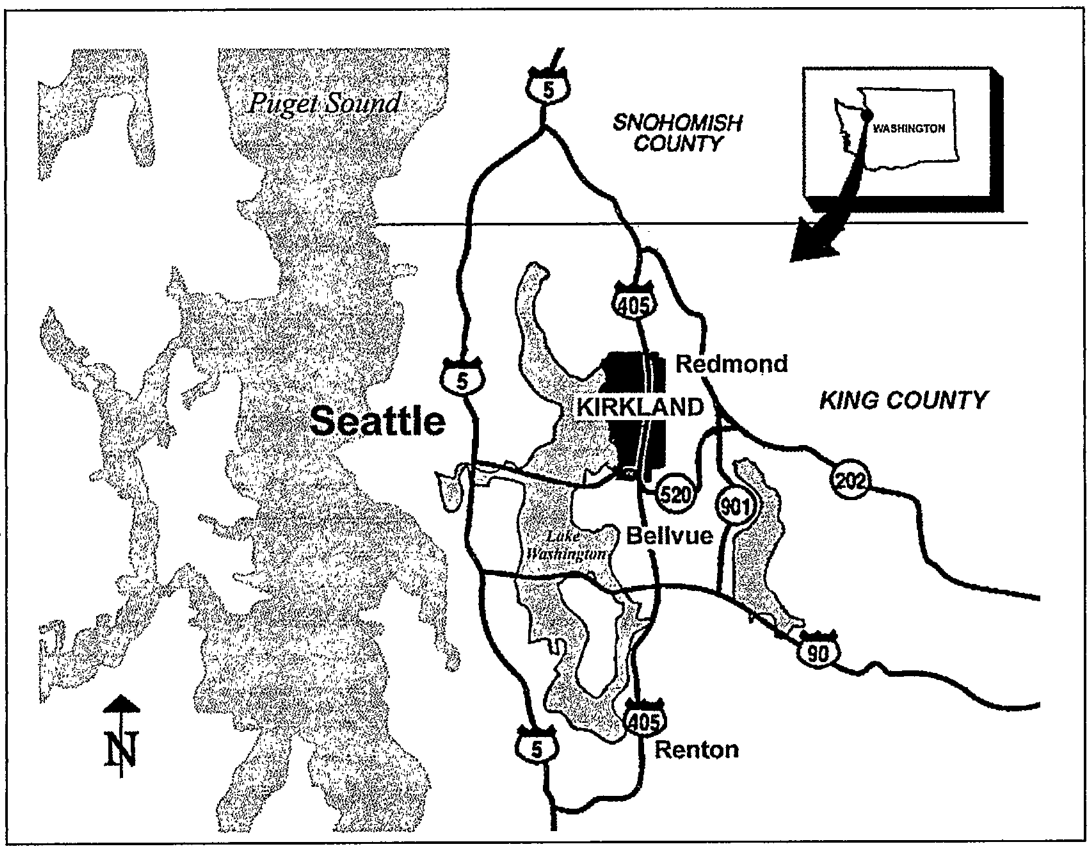


Figure 3-1. Location map of Kirkland, Washington.

SITE DESCRIPTION

The site simulated consists of a one block area, bounded by Lake Washington to the west, Central Way to the north, Lake Street to the east, and finally by Kirkland Avenue (Fig. 3-2) to the south.. The site contains an assortment of shops, restaurants, and small businesses which are located along Kirkland Avenue, Lake Street, and Central Way (Plate 5). The back of the shops open out to a small pedestrian sidewalk, which is directly adjacent to a large well-landscaped public parking lot. Beside the parking lot, a small waterfront park is present, with numerous park benches, a small sandy beach, a gazebo, and a small dock, to which a large number of small motorboats and sailboats are often moored.

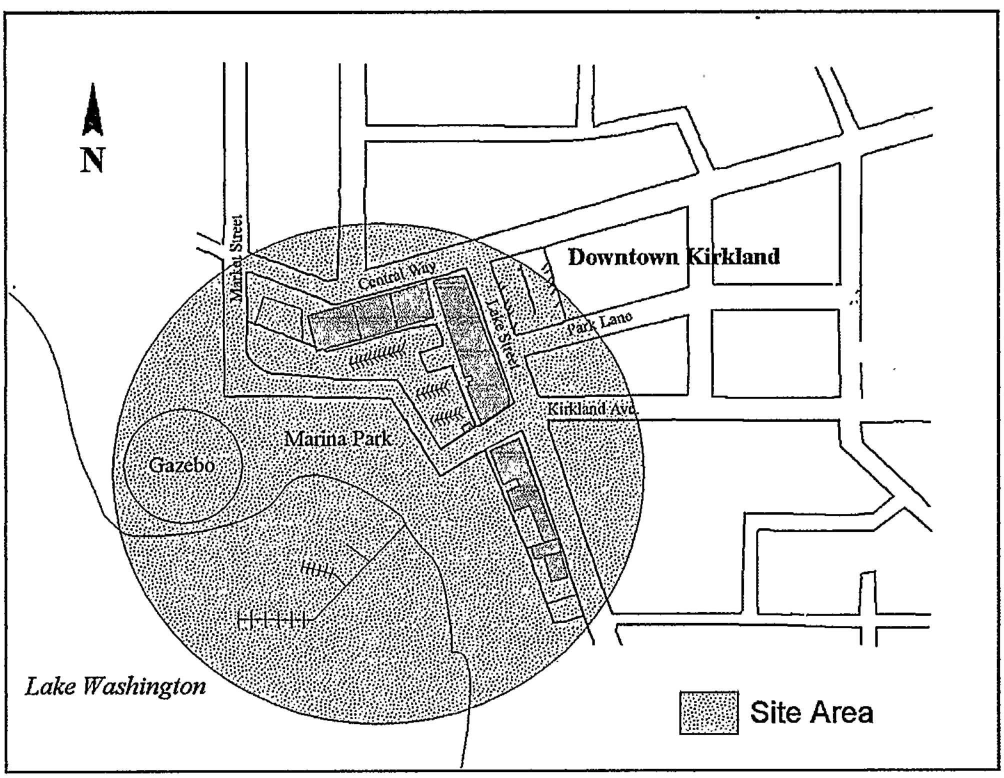


Figure 3-2. Site location map.

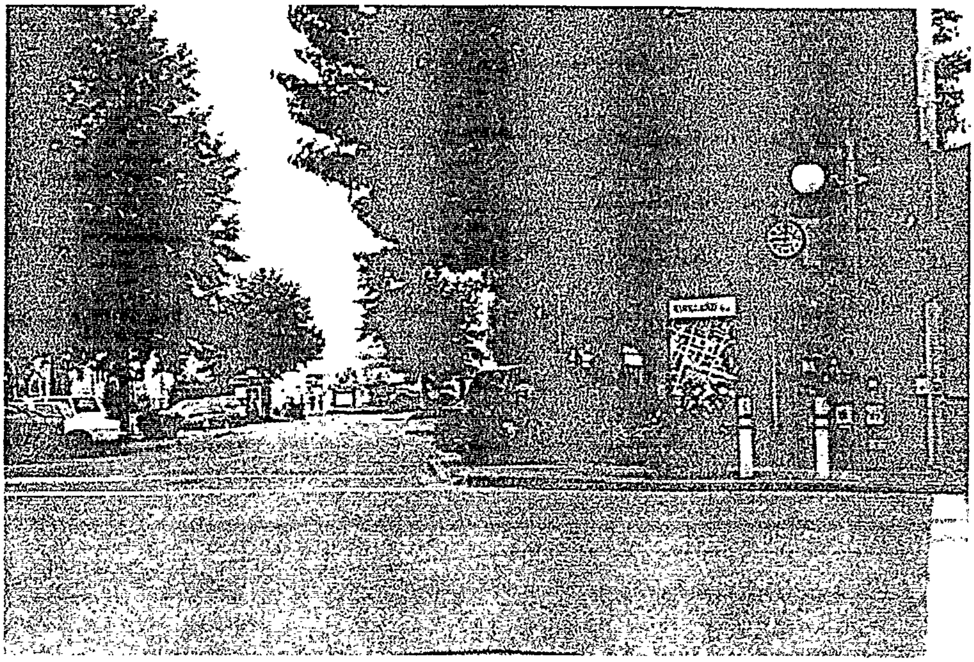


Plate 1. Photograph of study area looking down Kirkland Avenue towards Marina Park.

Plate 2. Photograph of study area, showing artwork, plantings and shops.

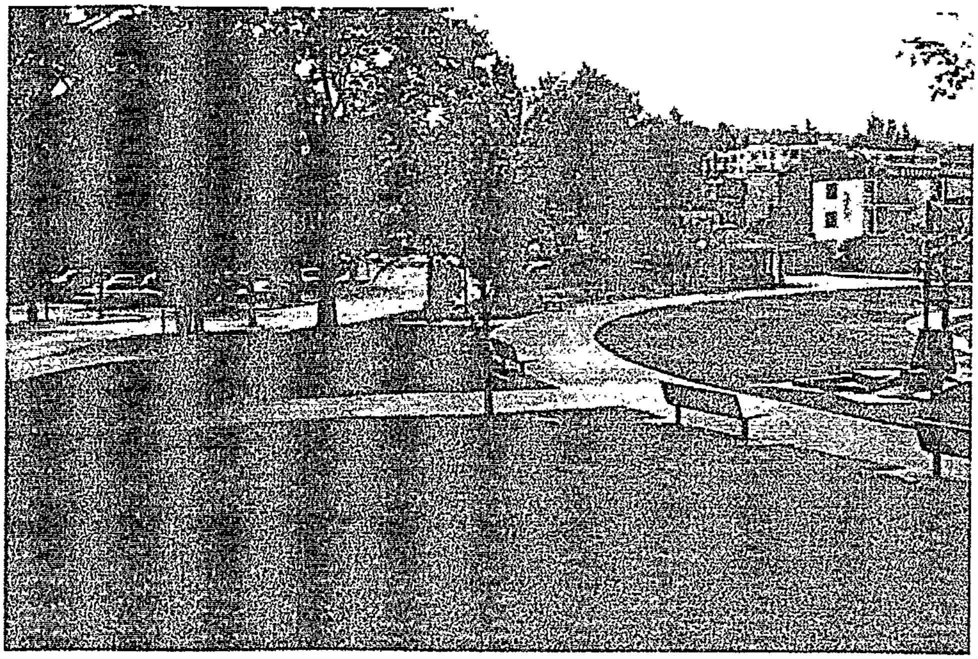


Plate 3. Photograph of Marina Park.

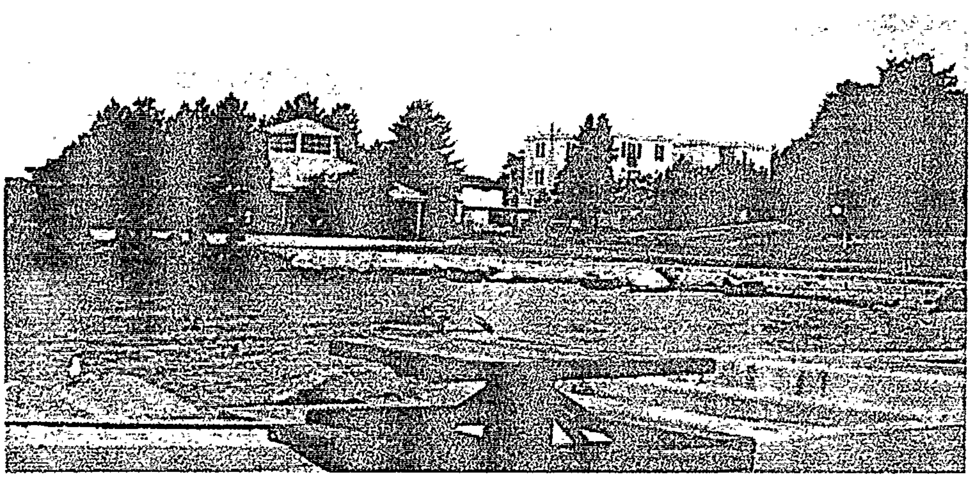


Plate 4. Photograph of Marina Park beach and gazebo.

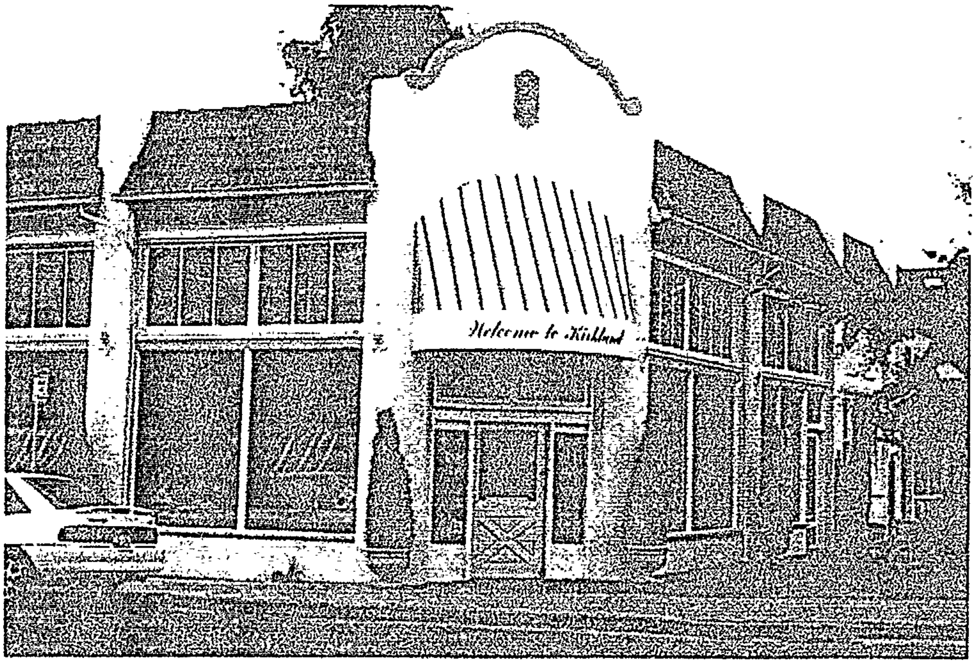


Plate 5. Example of building in the study area.

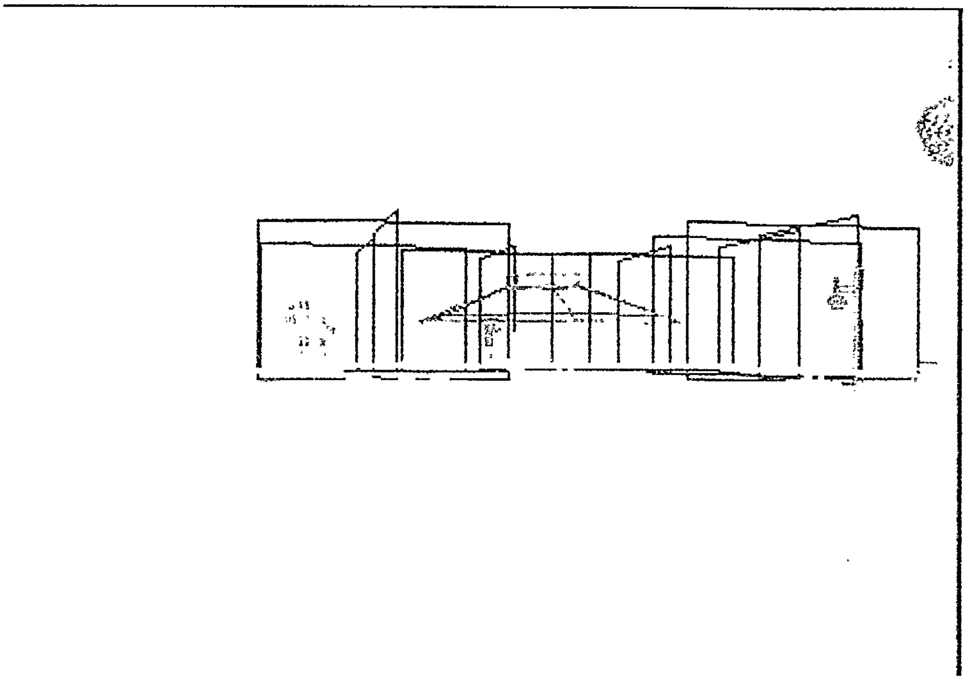


Plate 6. Wire-frame model of gazebo.

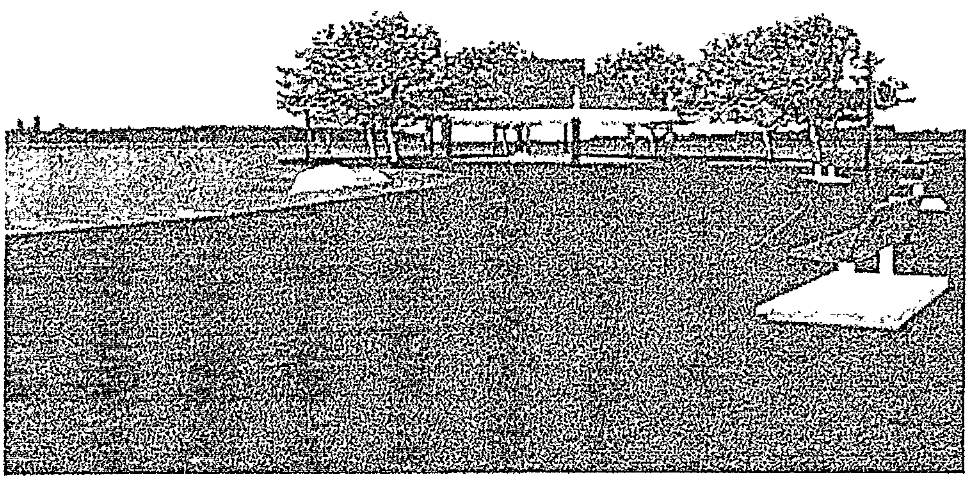
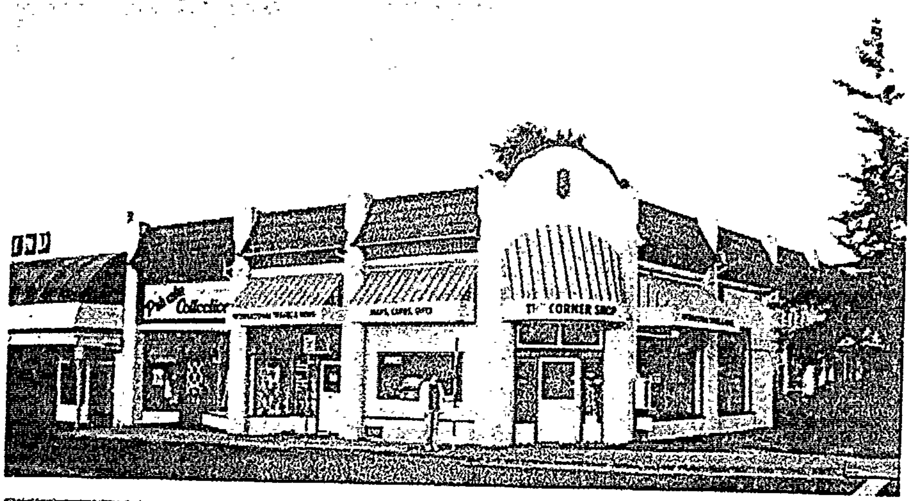
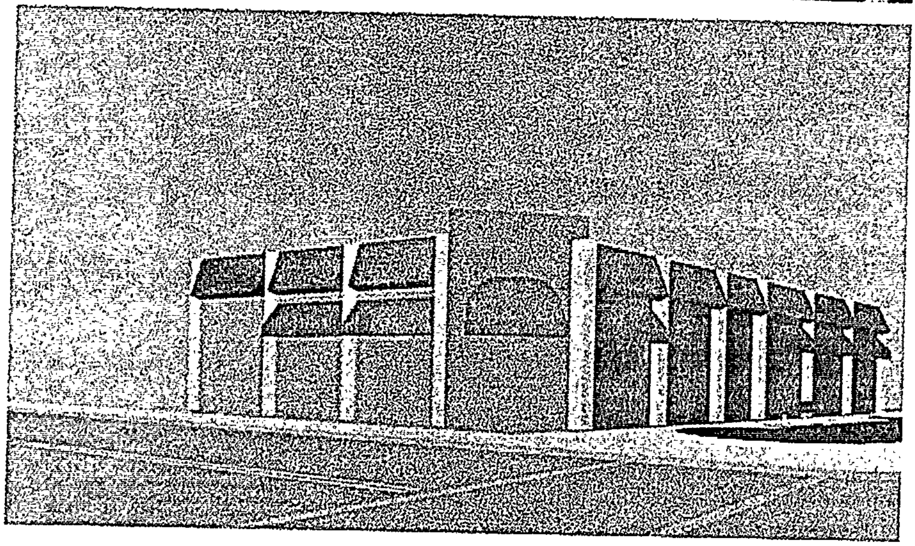


Plate 7. Photo-realistic rendering of gazebo.

8a.



8b.



8c.

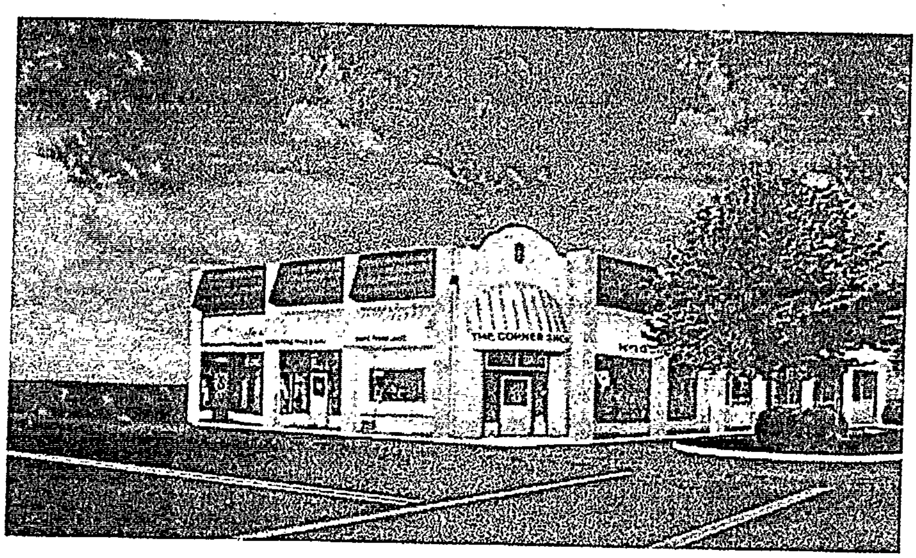


Plate 8. Photograph of actual site (8a), flat-shaded model (8b), and photo-realistic rendering of sample building (8c).

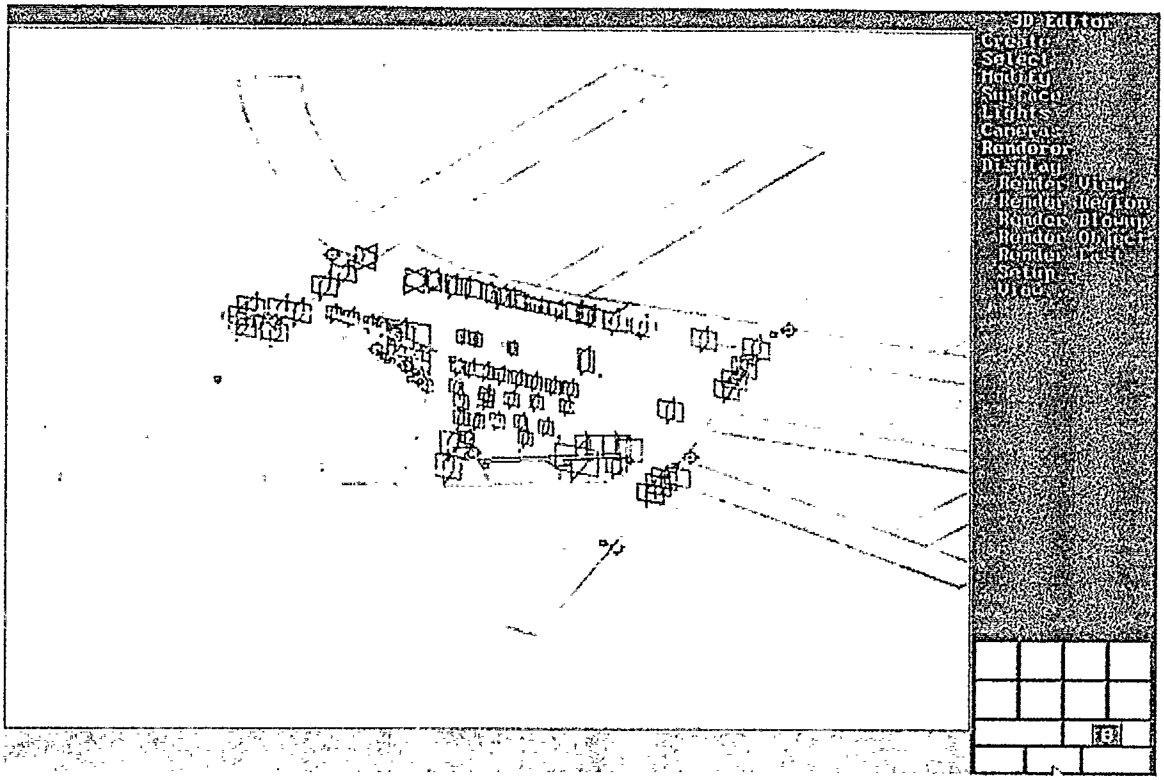


Plate 9. 3-D Studio screen-capture of aerial view of complete wire-frame model.

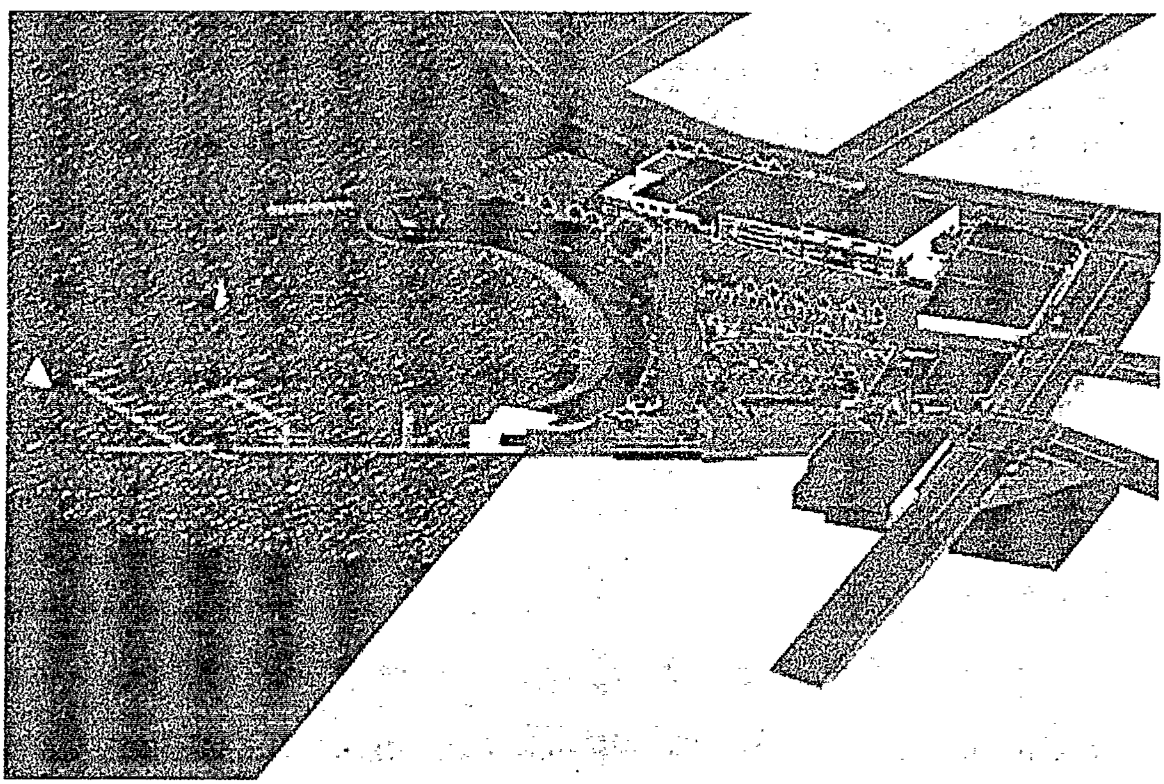
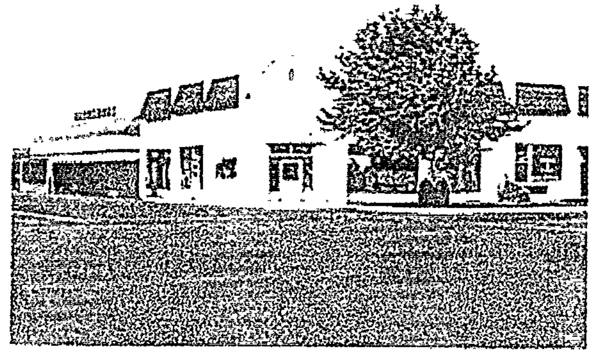


Plate 10. Photo-realistic rendering of complete model.

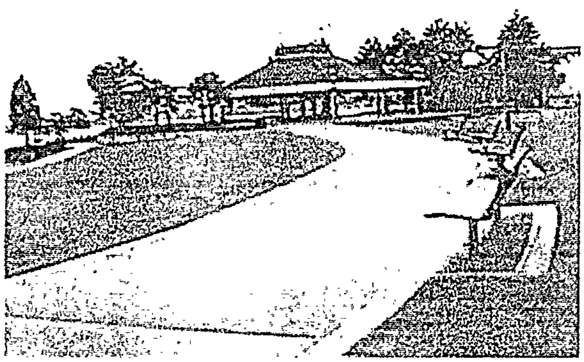
11a



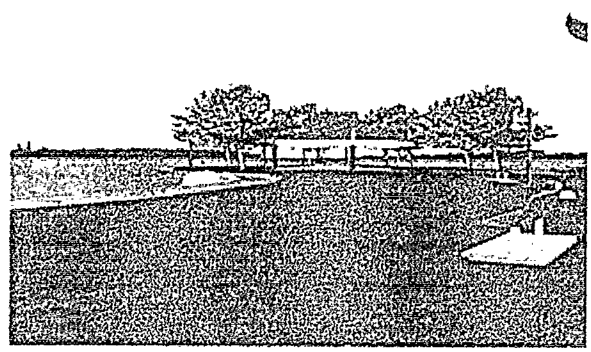
11e

11b

11f

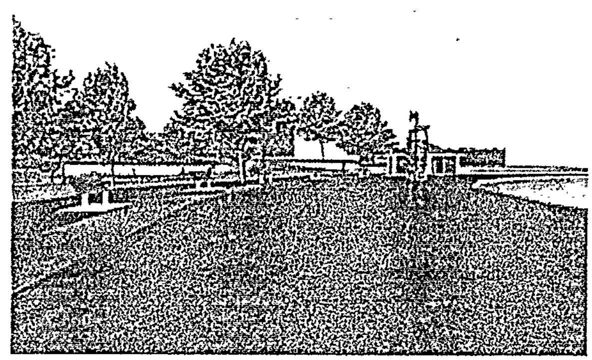


11c



11g

11d



11h

Plate 11. Comparison of video images (a,b,c,d) and corresponding model views (e,f,g,h).

SIMULATION METHOD USED IN THIS RESEARCH

To date, research into dynamic visual simulations in the planning discipline has been limited to assessing the image performance of films of scale models of urban areas in comparison with film footage (Appleyard and Craik, 1979). Recent studies have been concerned with static visual simulations, such as retouched photographs, or rendered scenes of computer models from a stationary viewpoint (Oh, 1994).

In this experiment, in order to achieve the highest response equivalence with video footage of the site, a detailed three-dimensional computer model was constructed. A recent study has already examined image performance of a number of different types of static visual simulations, including wire-frame, flat-shaded, and image-processing at different levels of abstraction (Oh, 1994). It was found that the lack of detail in these simulation types resulted in their poorer perceptual effectiveness.

In this research, the highest quality dynamic visual simulation technique available on a personal computer, which involves applying photographic-quality textures to a three-dimensional wire-frame model, was used. This technique yields the highest level of detail, and is the most realistic in comparison to the other simulation techniques.

Since the computer visualization would be measured against actual video footage, it had to be a very good visual simulation. While legal guidelines for simulation construction and use have yet to be formulated, Sheppard (1989) lists five important criteria by which a simulation can be assessed. These include:

1) Representativeness - a simulation should show important and typical views of a project.
2) Accuracy - how close in appearance the simulation looks in comparison to the project, should it be built.
3) Visual clarity - the level to which the detail and overall content of the simulation can be clearly recognized.

4) Interest - the level to which the simulation captures the attention of the viewer.
5) Legitimacy - the extent to which the accuracy of a simulation can be defended by the person or agency who created it.

In producing the simulation, careful attention was paid to each of these criteria as follows:

Representativeness

Since the animation was a dynamic simulation, it would show views that a moving observer might see while traversing the site. In this way, a large number of different perspectives could be seen in a relatively short period of time. To help ensure that representative views were included, a variety of camera positions would be used.

Accuracy

In order to achieve a relatively high degree of accuracy, AutoCAD files containing street and topography data obtained from the local planning department would be used as a base for the model. Information from aerial photographs and Kroll maps would also be used to supplement this data. A pogo stick marked off in feet would be used to obtain vertical dimensions of building facades.

Visual Clarity

To increase visual clarity, the model would be constructed using texture maps of the actual site buildings. In addition, texture maps would be created from site photographs of other site objects, including signs, artwork, and street furniture.

Legitimacy

By comparing identical views of photographs of the actual site with still images generated by the computer, it would be possible to demonstrate simulation accuracy. By keeping copies of the computer files involved in producing a simulation, it would be possible to demonstrate the procedures by which the model was constructed.

HARDWARE AND SOFTWARE USED IN CREATING SIMULATIONS

Traditionally, due to their intensive graphics processing requirements, visual simulations have largely been done by on workstation-class computer systems. However, with the recent arrival of Pentium-class microcomputers, it is now possible to produce detailed visual simulations on business desktop computers. For this research, a 100 Mhz Pentium computer was used. Other equipment included a flatbed scanner, which was used to scan photographic images into the computer for use as textures, and a graphics tablet, which was used to make photographic image editing easier. The animation images were transferred to video tape in Adobe Premiere under support of the University of Calgary New Media Center. The software used in this project included Autodesk 3-D Studio, AutoCAD (Autodesk Inc., Sausalito, CA) and Adobe Photoshop (Adobe Systems, Inc., Mountain View, CA).

VIDEO PRODUCTION

In order to provide a basis for comparison, an 8mm video camcorder was used to shoot footage of various representative views of the site, including a complete drive-through, a number of short pans of the area along Lake Street and Central Way, and a still shot in Marina Park. The footage was later edited and transferred to VHS format, and was used as a template on which the computer animation was based.

MODEL CREATION

Computer files containing the streets and topography in AutoCAD (Autodesk Inc., Saucilito, CA) were provided by the Kirkland Planning Department which served as a useful starting point for model construction. Kroll maps of the site were obtained, which assisted in the accurate placement of building footprints in the computer model. Aerial photographs of the area provided updated information concerning newer buildings, trees, and other objects. Each building on the site was photographed using a 35mm camera with a normal 50mm lens, with camera placement adjusted to minimize distortion. To assist in model accuracy, a pogo stick marked out in feet was included to determine building height. All of the photographs were later scanned into the computer and edited for use as material maps which would be later applied to the wire-frame model. A wide variety of street fixtures, including benches, garbage cans, planters, light standards, and newspaper stands were also photographed to provide detailed texture maps for the corresponding wire-fame objects used in the model. Other objects were photographed as needed to provide further detail. These included bushes, trees, grass, wood textures, sidewalk block textures, asphalt, flowers, and signs.

Once all of the photographs had been scanned into the computer and edited, model construction of the buildings could begin. This consisted of creating a three-dimensional "wire-frame" model of the site, to which the scanned in images could later be attached (Plate 6 and 7). This was done by extruding a two-dimensional plan of the site into three-dimensions, through a process referred to as "lofting" (Elliott et al., 1994). After the wire-frame had been completed, the facades were applied to all the buildings through a process referred to as "box-mapping", which allowed different images to be applied to different faces of the wire-frame box. In this way the facade and roof textures could be applied relatively easily (Plate 8). Any further details such as extruding roofs, building supports, or canopies were added by constructing wire-frame models of these objects and applying appropriate textures to them. After the streets, sidewalks, and buildings were completed, other details were filled in, including plantings, street fixtures, water, pedestrians, cars, and sculptures. To complete the model, a sky, some pedestrians, and a number of cars were added. Plate 10 shows a view of the entire model in wire-frame, and in rendered form.

Once the model was finished, a light was placed in the scene in order to accurately simulate the sun. This was done through the use of a commercial add-on software application in 3D-Studio, known as Imagine Sun (4D Vision Inc., Denver, CO). After the user enters in the parameters of latitude, longitude, date, and time of day, the program creates a simulated sun and places it in the scene, allowing accurate shadow casting to be done. A number of simulated cameras were placed in the scene to match the camera angles used in the video footage. A gradient background was added to simulate the cloudy conditions observed.

Animation paths for each camera were then constructed and previewed to match closely the views seen in the video. The animation was then rendered frame by frame, producing a series of still computer image files in targa (.tga) format. The series of images were later transferred to video tape in sequence by importing them onto a Macintosh equipped with special video compression hardware and recording the animation on VHS video tape as it played back, thus creating an animated "movie" of the area (Plate 11).

ORGANIZATION OF THE QUESTIONNAIRE

SEMANTIC DIFFERENTIALS

In order to evaluate environmental simulations, some measure of appraisal of that environment is needed. Bipolar descriptive evaluative dimensions, in the form of semantic differentials, appear to be the most useful for evaluating environments (Sheppard, 1982; Bosselmann and Craik, 1987). As Hershburger (1972) points out,

> Architects, if they are to serve mankind well, must improve their abilities to predict (accurately and consistently) how people will comprehend and use the buildings which they design - before they are constructed. The semantic differential and other semantic scaling devices appear to offer possibilities in this regard. Why? They correspond to the verbal mode by which occupants of buildings most often express their perceptions, thoughts, feelings, attitudes,

> and behaviors to architects concerning the physical environment. They are easy to administer, score, and analyze. Their validity and reliability in predicting behavior has been demonstrated in general by Osgood, and a beginning has been made for architectural subject matter by Collins.

Several semantic differential approaches have been utilized (Vielhauer, 1965; Craik, 1968; Collins and Seaton, 1970; Hershberger, 1972; Hesselgren, 1975) but many of these have lengthy response formats that are difficult to administer. Since semantic differentials are easy to administer and analyze, and because their reliability and validity has been demonstrated in similar research (Oh, 1994), 15 pairs of bipolar adjectives, based largely on those of Hershberger (1972) were used in this experiment. In his work "Toward a Set of Semantic Scales to Measure the Meaning of Architectural Environments", Hershburger (1972) proposed 20 semantic scales which could be used to measure the meaning of architectural environments. For this research, it was necessary to select those bipolar adjectives which most closely related to the site. The following 15 pairs of semantic differentials were selected:

Unique-Common,
Friendly-Hostile
Ordered-Chaotic
Loose-Compact
Spacious-Confined
Ornate-Plain
Colourful-Subdued
Clean-Dirty
Bright-Dim
Public-Private
Quiet-Noisy
Formal-Casual
Old-New
Warm-Cool
Planted-Barren

All of these semantic differentials were recorded using a five-point descriptive scale (Very X, Somewhat X, Neutral, Somewhat Y, Very Y), with a two extreme values, two intermediate values, and a midpoint.

EVALUATIVE QUESTIONS

In this section, specific questions were asked concerning site familiarity, visual attractiveness, and the participants' confidence in the imagery. The site familiarity question utilized a three-point scale (very familiar, slightly familiar, unfamiliar), while the questions addressing visual attractiveness and participant's confidence utilized a five-point scale (attractive-unattractive and not confident-very confident endpoints, respectively).

STIMULUS MEASURES

Apart from comparing the subject matter of the video imagery versus the animation, it would also be useful to compare measures of the strength of the stimulus itself, since a large variation in stimulus strength can influence responses . Semantic scales which have been used in marketing studies (Bruner, 1994) that have been designed to measure a stimulus's complexity, potency, and interest were used in this research to assess how dynamic, how strong, and how interesting the video and animation was perceived to be by the respondents. All of these measures utilized a 7 point semantic differential scale with the following endpoints: Simple-Complex (Complexity); Quiet-Loud (Potency); Interesting-Uninteresting, Emotional-Unemotional (Interest). Similar measures have been used in other simulation research (Acking and Kuller, 1973).

Complexity has been studied extensively in the past by psychologists interested in aesthetic research. Using artificially-generated stimulus patterns, researchers discovered that people prefer patterns that are not at extreme ends on the complexity spectrum (Vitz, 1966; Day, 1967). In this study and other studies, complexity is defined by the variety and number of visual elements in a scene; how intricate it is; its richness. It is a useful factor to study, since it is closely related to interest. By controlling complexity, it is possible to engage the viewer and thus elicit viewer attention:

> [Complexity] thus reflects how much is going on in a particular scene, how much there is to look at - issues that call upon the picture plane, as opposed to

depth cues. Clearly, exploration is enhanced when there is more variety in the scene, when there is the suggestion that there are more different things available. It could be argued that Complexity provides content, or things to think about (Kaplan and Kaplan, 1989, pp. 53-54.)

OPEN-ENDED QUESTION

An open-ended question was included to allow participants to provide general comments on the video imagery they had seen. This would allow respondents to provide a qualitative assessment of the video and animation imagery, which has proved insightful in similar research (Oh, 1994).

PARTICIPANT'S BACKGROUND

A number of questions in this section addressed the personal characteristics of the respondents. Specifically, the information gathered included age, gender, background in design-related studies, and occupation. Information concerning age, gender, and occupation was obtained in order to determine similarity between the two groups tested. Information on the presence or lack of a design education was also obtained in order to determine whether or not perceptual responses were influenced by this factor.

HOW THE EXPERIMENT WAS CONDUCTED

PARTICIPANTS

Fifty students at the Southern Alberta Institute of Technology (SAIT) participated in this experiment. Half of the students were attending an introductory course in Geographic Information Systems while the rest were attending Continuing Education courses in the Spring/Summer semester 1996. The GIS students were selected since they would likely have strong technical backgrounds in computer technology and design; the rest of the students not specializing in computer technology or design would provide responses which could then be compared to assess the influence of design education on perception.

PRESENTATION FORMAT

The fifty participants were originally from a mixture of two classes, which were arbitrarily divided into two groups, with 25 participants in each group. Each group in turn was led to a classroom where a brief introduction was given, and informed consent forms were distributed (see Appendix 1). A coin toss determined which group would see the video of the actual area and which group would view the computer-generated animation. After viewing a short 4-5 minute video, each group was asked to record their impressions of the video or animation by filling out a short questionnaire. Each group was instructed not to discuss the imagery with the other group until the experiment was completed.

PRESENTATION MEDIA

For presenting video imagery to the public, the use of a large television monitor and videocassette tape player are commonly used. In this research, a 28 inch television monitor and standard VHS videocassette recorder were used. The monitor was elevated approximately five feet on a supporting stand, which provided a good viewing angle to all respondents. Seats were arranged in rows centered in front of the television monitor to allow an unobstructed view, with enough separation between seats to prevent copying. The image-to-viewer distance was approximately 5-8 feet, to allow respondents to have an adequate view of the screen. The room lights were turned off during the presentation for clarity.

CHAPTER SUMMARY

In this chapter, the methodology for creating the video and computer animation was discussed, along with a discussion of the design of the questionnaire, and how the experiment was conducted. For modeling, a site in Kirkland, Washington was selected. In building the model, the following criteria for creating good simulations (Sheppard, 1989) was used: Representativeness; Accuracy; Visual clarity; Interest; and Legitimacy. Using 3-D Studio, a three-dimensional wire-frame model of the site was constructed, to which photo-realistic textures were later applied. A questionnaire utilizing semantic differentials was devised for testing people's responses of the simulation and video.

"The great tragedy of science - the slaying of a beautiful hypothesis by an ugly fact."
- Thomas Henry Huxley

FOUR

Experimental Results

RESPONDENT CHARACTERISTICS

The characteristics of the 50 respondents are summarized below.

Characteristics	Video Group	Animation Group
Average age	35.2 years	31.6 years
Age range	25-47 years	19-43 years
Gender	11 males, 14 females	10 males, 15 females
Educational background	Design-related: 9 Not design-related: 16	Design-related: 13 Not design-related: 12
Occupation	Professional: 10 Non-Professional: 6 Other: 9	Professional: 8 Non-professional: 12 Other: 5

Table 4-1. Summary of respondent characteristics

COMPARISON OF MEAN SCORES FOR 15 SEMANTIC DIFFERENTIALS

As a method of measuring the response equivalence between the video group and the animation group, the responses to the 15 semantic differential scales were analyzed. Figure 4-1 shows a comparison of the mean scores for each of these 15 paired-adjectives between the video group and animation group.

One-way ANOVA was computed for all 15 semantic differentials (Appendix A), with the result that 13 paired-adjectives showed no significant difference between the video and animation groups (at $\alpha = 0.05$). However, the two semantic differentials for Neatness (Clean-Dirty semantic scale) and Colour (Warm-Cool semantic scale) did show significant differences in mean scores (at $\alpha = 0.05$).

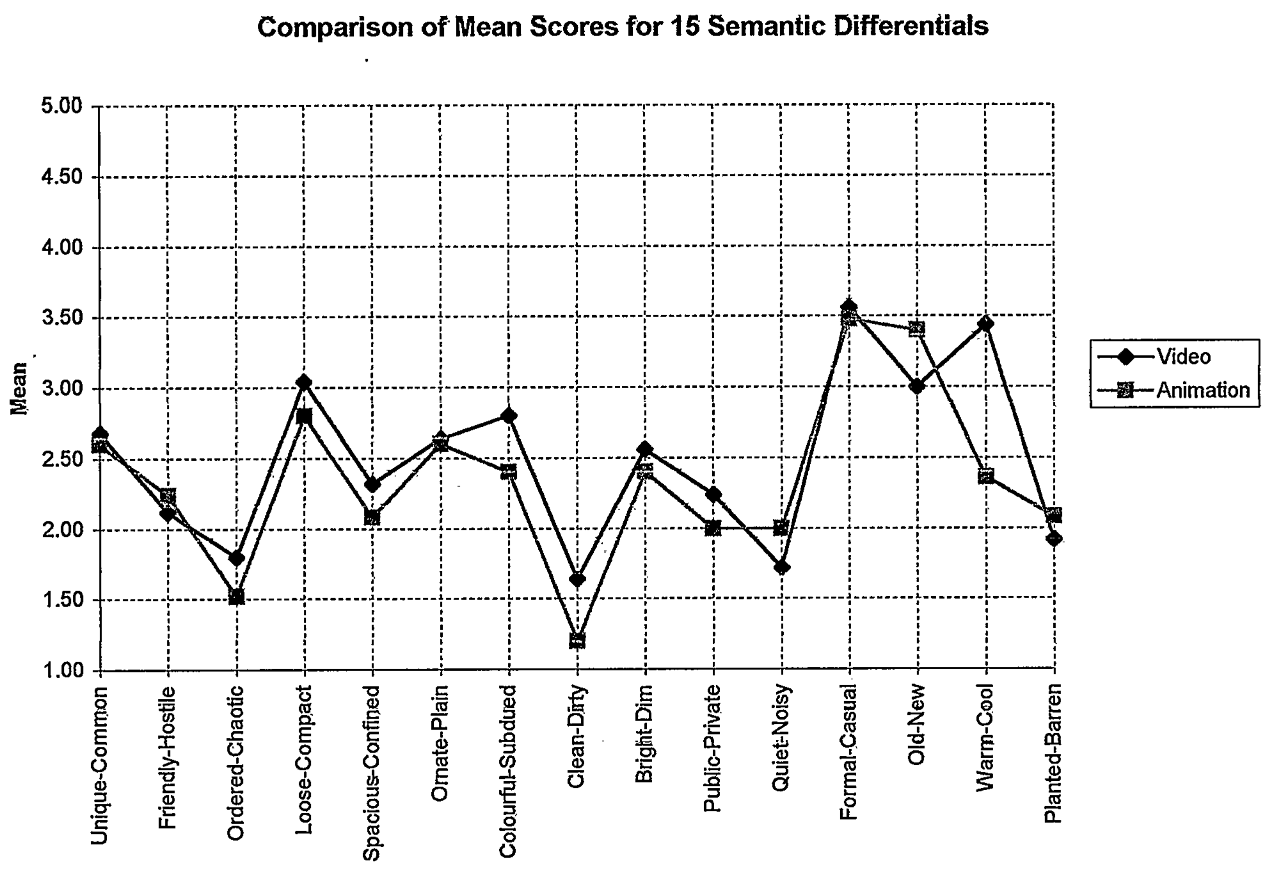
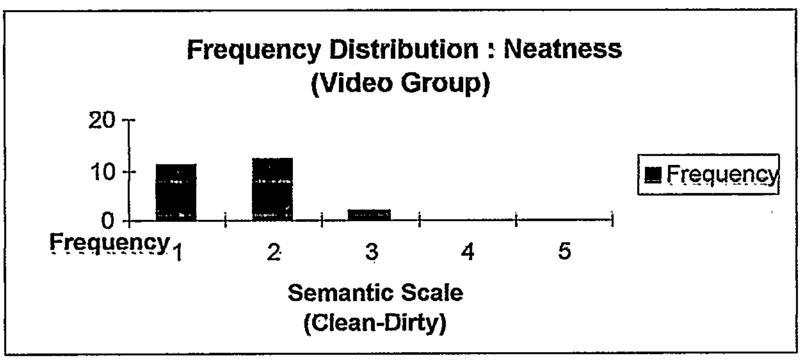


Figure 4-1. Mean scores of 15 semantic differentials.

CLEAN-DIRTY (NEATNESS)

An examination of frequency distribution histograms (Figure 4-2) of this paired-adjective revealed that the group viewing the animation rated it as being much cleaner (20 out of 25 respondents gave it a score of 1 on the Clean-Dirty semantic scale) than did the video group, who were split between scores of 1 and 2. This is likely the result of computer-generated imagery that audiences commonly perceive as being "too clean". The relative absence of dirt, grime, clutter, wear and tear, or erosion, in comparison to the amounts observed in real life are detected immediately by audiences. In addition, details such as the absence of traffic lights, telephone wires, and limited amounts of vehicular and pedestrian traffic contribute to this sense of neatness.



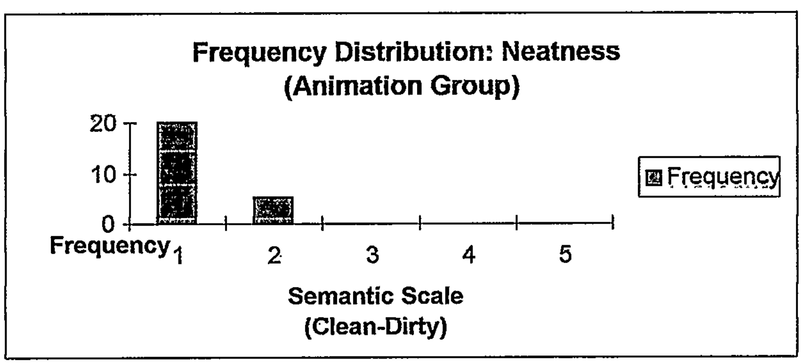
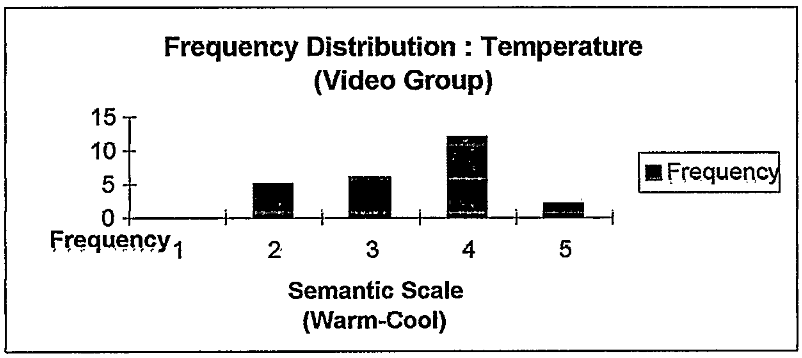


Figure 4-2. Frequency distribution histogram comparison of Neatness (Clean-Dirty semantic scale)

WARM-COOL (COLOUR)

The frequency distribution histograms (Figure 4-3) for this paired adjective show that the group viewing the animation perceived it as having a greater colour warmth (12 respondents gave it a score of 2 on the Warm-Cool semantic scale) than did the video group (12 respondents gave it a score of 4). The audience perceived cooler colours in the video because of the bluish-grey colour cast as a result of the prevailing atmospheric conditions (it was raining lightly). Due to software limitations, this atmospheric hue was difficult to simulate accurately in the animation, with the result that the colours appeared warmer.



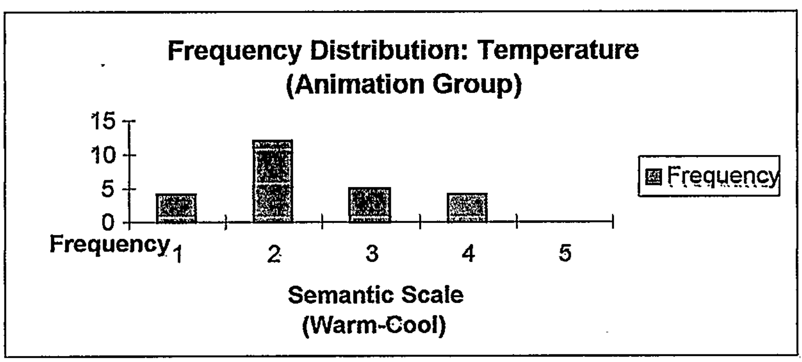
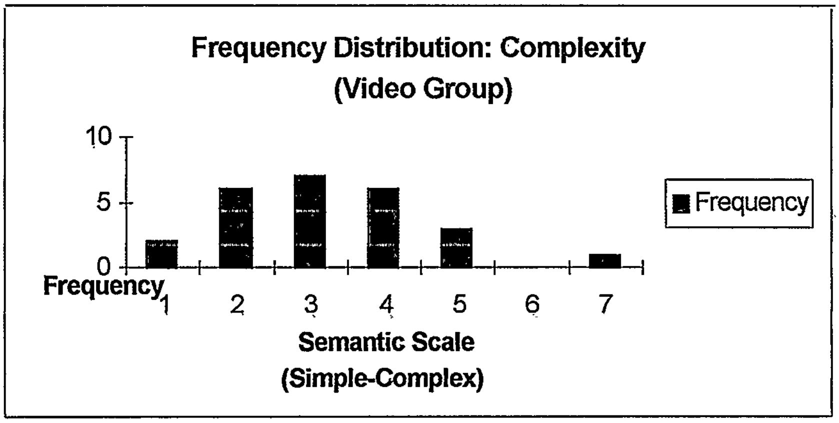


Figure 4-3. Frequency distribution histogram comparison of Colour temperature (Warm-Cool semantic scale)

STIMULUS MEASURES

COMPLEXITY

One-way ANOVA comparing the video versus the animation groups responses show that there was a significant difference ($P<0.05$) in the mean responses between the two groups. The frequency distribution histograms (Figure 4-4) reveal that, on average, the video group rated the complexity of their stimulus at 3 (7-point semantic scale, with Simple-Complex endpoints), while the animation group rated theirs at 5. The frequency histogram for the group viewing the animation revealed a much tighter cluster of responses near the "Complex" end of the scale, suggesting that they perceived the animation as having a higher degree of complexity than the group viewing the video. The apparent disparity between the two groups might be explained as follows: Audiences are used to seeing video images in presentations and are generally comfortable with them. Computer animations are not as common in presentations, and the technology behind them are generally not as well understood. Differences in perceived complexity could also be a result of the viewers having to consciously or unconsciously translate the computer animation into a "live picture", which is more in tune with their real-world experience. Visual simulations are still imperfect; they do not capture all the subtle visual nuances that exist in reality such as age, weathering, or changing atmospheric conditions. This gap between reality and simulation may require some suspension of belief by audiences in order for them to make judgments about a simulated environment.



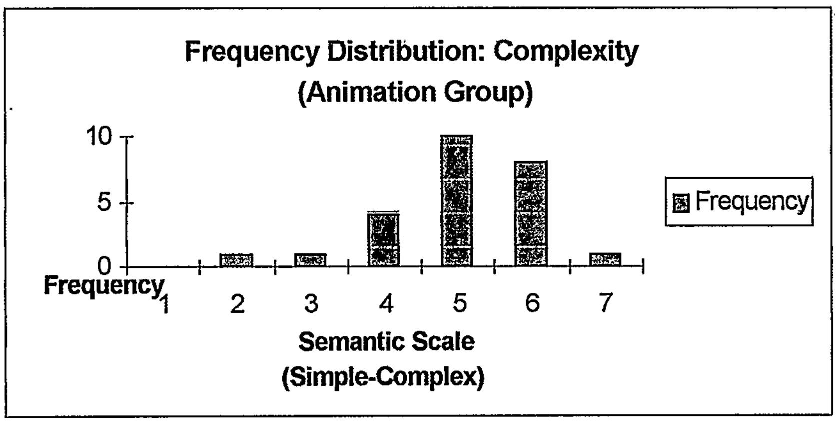


Figure 4-4. Frequency Distribution Histograms comparing Complexity. (Simple-Complex semantic scale)

POTENCY

One-way ANOVA comparing the mean scores between the video and animation groups indicate that there was no significant difference in perceived potency. The video and animation groups scored means of 2.76 and 3.12, respectively, suggesting that they perceived each stimulus as being in the visually quiet range of the scale.

INTEREST

One-way ANOVA analysis comparing the mean scores between the video and animation groups suggest that there was no significant difference in perceived interest. An examination of the frequency distribution histograms (Figure 4-5), however, reveals slight differences in responses between the two groups. The video group showed a wider range of responses than the animation group, which showed a tighter clustering of responses near the "Interesting" end of the semantic scale. This is likely due to the infrequent use of computer animations in presentations and may be indicating some measure of its novelty. This effect, however, appears limited.

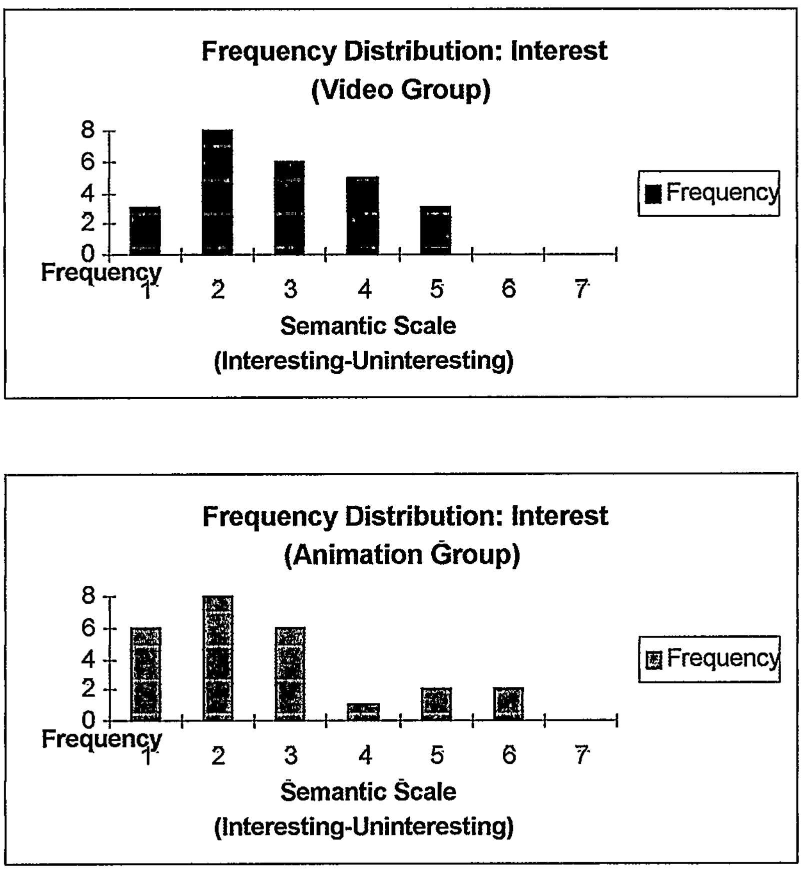


Figure 4-5. Frequency distribution histograms comparing Interest (Interesting-Uninteresting semantic scale)

EMOTION

As a second measure of stimulus interest, a seven-point semantic scale with Emotional-Unemotional endpoints was also used. One-way ANOVA analysis of the mean scores between the video and animation group suggest that there was no significant difference between the perceived emotional impact of either stimulus. The mean score of both groups was 4.4, indicating a neutral emotional response.

ATTRACTIVENESS, CONFIDENCE, AND FAMILIARITY

VISUAL ATTRACTIVENESS VERSUS MEDIA TYPE

As a comparative measure, visual attractiveness of the imagery was examined between the video and animation groups. A five-point semantic differential with Unattractive-Attractive bipolar adjective dimensions was used. One-way ANOVA analysis revealed that there was no significant difference in perceived attractiveness between the video and computer animation. The video and animation imagery was rated a mean score of 3.96, and 4.0, respectively, indicating a high degrèe of visual attractiveness was perceived by both audiences.

CONFIDENCE VERSUS MEDIA TYPE

A five-point semantic differential scale with Not confident-Very confident endpoints was used to assess each group's level of confidence in the presented imagery. One-way ANOVA analysis of the two group's responses revealed there was no significant difference in either groups perceived confidence in the presented imagery.

FAMILIARITY VERSUS MEDIA TYPE

A three-point semantic differential scale with Very familiar-Slightly familiar-Very familiar endpoints was used to assess the respondents familiarity with the site. One-way ANOVA revealed no significant difference in site familiarity between the video and animation groups ($P<0.05$).

ATTRACTIVENESS VERSUS DESIGN EDUCATION

There was no significant difference ($P<0.05$) in perceived visual attractiveness between people with design education and those without. This was true for both the animation and video groups.

CONFIDENCE VERSUS DESIGN EDUCATION

One way ANOVA for the video group revealed that there were unequal variances and unequal group sizes between the Design and Non-Design categories with respect to viewer confidence (Appendix 2). To account for this, a paired t-test was calculated, which assumed unequal variances. The results of this calculation are shown below:

t-Test: Two-Sample Assuming Unequal Variances (P<0.05) (Video Group)

	Design	*Non-Design*
Mean	3.4	4.06666667
Variance	1.1555556	0.4952381
Observations	10	15
Hypothesized Mean Difference	0	
df	14	
t Stat	-1.7295817	
P(T<=t) one-tail	0.05284	
t Critical one-tail	1.7613092	
P(T<=t) two-tail	0.1056801	
t Critical two-tail	2.1447886	

The following hypothesis test was conducted:

Null hypothesis H_0: $\mu_1 = \mu_2$

Alternative hypothesis H_A: both μ's are not equal.

Test statistic: t

Reject H_0 if $t^*>2.1445$ or if $t^*< -2.1445$ (Two-tailed test)

From the table above, $t^* = -1.7295$.

Since t* does not fall within the rejection region, we FTR H_0.

Based on the sample data, there is insufficient evidence to conclude that the means in confidence level are different between the design educated and non-design educated people in the video group.

One way ANOVA was also calculated for the animation group (Appendix 2) with the result that no significant difference ($P<0.05$) was observed in level of confidence in the imagery between people possessing design education versus those without.

QUALITATIVE EVALUATION OF PRESENTED IMAGERY

The open-ended question asking the respondents to comment on the imagery seen revealed a number of interesting statements .

ANIMATION

One respondent felt that the animation was somewhat jerky in places, owing to the 15 frame per second display rate (video imagery utilizes a 30 frame per second display rate). A few respondents felt that the animation moved too quickly, and would liked to have seen a pedestrian-speed survey of the area, "like someone was actually searching for a familiar shop." One respondent noted that they would have liked to have seen more variation in camera angles and zooms. Some respondents commented that the scenes appeared somewhat sterile and lifeless to them. In fact, there were a few people portrayed in the computer animation, including a figure walking in the park, but they were not numerous due to the increased rendering times that would have been incurred. Some people commented that they liked the realism of the trees and buildings. Overall, most respondents stated that they were very impressed with the quality of the computer-generated imagery.

VIDEO

Most comments on the video reflected people's attraction to the site. They generally expressed characteristics about the area that they liked, including cleanliness, quietness, neatness, and peacefulness, noting that it was "a nice place that I would like to visit" or "a nice place to go on an afternoon".

SOUND

Despite their recognition that the experiment dealt with a visual assessment of presented imagery, several respondents in both the video and the animation groups pointed out that it would have been desirable to include sound or background music. They felt that music would have enhanced the overall experience by setting a tone and evoking a more emotional response.

LIMITATIONS OF THE RESEARCH

While the perceptual effectiveness of a computer simulation of an urban environment was tested in this study, research was not conducted into the effectiveness of the imagery at various levels of abstraction. In many cases, creating simple wire-frame or flat-shaded imagery will suffice, depending on the nature of the planning problem considered. For instance, in planning control issues such as shadow studies, constructing a photo-realistic model is not necessary . The level of detail required really depends on the nature of the planning problem that is to be addressed. It is hoped that future studies will examine dynamic simulations at various levels of abstraction to determine their role and usefulness in planning practice.

In more general terms, the results of this study must be interpreted in light of its limitations, including issues of causality, experimental control, sources of potential errors (including sampling errors, subject error, the experimenter effect), and internal and external validity.

CAUSALITY

In experimental research, it can never be proven that X is a cause of Y. From a scientific standpoint, it can only be inferred that a relationship exists between X and Y on the basis of observed data. In this experiment, data was collected to test the hypothesis that equivalent perceptual responses could be obtained by a video and computer animation of an urban area. The experimental design used in this research was a Between-Subjects-After-Only Design. In this design, subjects are randomly assigned to experimental and control groups. Ideally, if enough subjects are included to allow randomization to work, theoretically all possible extraneous variables are controlled, with the exception of such things as experimenter expectancies (Christensen, 1994, p. 306). The advantage of this design is that the experimental variable can be studied under different conditions.

This experimental design, however, is not without its difficulties. It is very sensitive to problems of selection bias and experimental mortality. The equality of the groups is assumed because of the random assignment of subjects to each group. If the groups are not equal, difficulties can arise. If a subject drops out or refuses to cooperate in one of the groups, the equality between the two groups no longer exists, and thus destroys the assumption that the two groups are equal save for the impact of the experimental stimulus. In this experiment, random assignment of subjects to the experimental and control groups was done through the use of a coin toss, which should have allowed some degree of randomization to be present. Experimental mortality was not observed in this experiment, since all students present participated. It is not clear, however, if any students were excluded due to their absence because of illness or some other reason.

CONTROL

The issue of control in experimental research is an important one, since it can have a large impact on a study's results and the interpretation of those results. The goal of any researcher is to attain internal validity, or the extent to which it can be stated with certainty that the independent variable produced the observed effect (Christensen, 1994, p. 213). If the observed effect is caused *only* by the independent variable, then internal validity has been achieved. Errors arise when other variables aside from the independent variable exert their influence.

POSSIBLE SOURCES OF ERROR

Sampling error

In research, sampling and non-sampling errors are the basic types of errors that are encountered. Sampling error is the difference between observed values of a variable, and the long-run average of observed values in repeated measurements of that variable (Churchill, 1995, p. 652). While sampling errors can be reduced by increasing sample size, there are other factors which may limit using a large sample size, including cost and subject availability. In this experiment, fifty subjects were tested, with twenty-five being randomly assigned to the treatment and control groups. Sampling theory suggests that inferences can be made about the larger student population on the basis of this sample size. When breaking down the subject groups into smaller divisions (those with design education and those without, for example) the sample size becomes smaller and the likelihood of small sample error increases.

Non-sampling errors are any other errors that can arise in an experiment. These include non-observation errors and observation errors. Non-observation errors occur when there is a failure to collect data from parts of the sample population selected. In this experiment, while all students present in both classes participated, those students who missed class on that day did not. While it was not determined how many students were missing, the number was likely to be very small.

Observation errors are errors that can occur in an experiment as a result of obtaining inaccurate information from the sample elements or as a result of errors in processing the data or in reporting the findings. In this experiment, care was taken to minimize recording errors; two people compiled the data which was checked more than once for transcription errors.

Subject effect

In experimental research, errors can occur as a result of the subject effect, or errors induced as a result of the characteristics and motivations of the subjects themselves. In a laboratory setting, subjects are asked to perform a task that is asked of them. It has been noted that subjects respond to an experimental task as they perceive it (Christensen, 1994, p. 224). Superimposed on the desire of the subjects to complete the task required of them is a desire to make a positive self-presentation (Christensen, 1981). This means that subjects are not only concerned with completing the task, but doing so in such a way that places them in the most positive light. In this experiment, subjects were asked to perform a task by evaluating video or computer-generated imagery on the basis of a series of semantic scores. Only in cases where subjects believe that others view their behavior as being determined by some external source not under their control, is this effect absent (Christensen, 1984, p. 226). In this experiment, this was not the case, so it must be inferred that some degree of the subject effect exists.

Subject Sophistication

It has been shown that subjects that are familiar with the subject matter and methods of experimental psychology can have a confounding effect on the results. However, due to the nature of this experiment (no deception was involved), and because the subjects were probably not trained in psychological research, this effect was likely minimal.

Experimenter effect

The presence of the experimenter can influence an experiments results as well. In some cases, the experimenters desires and expectancies can be communicated to the subjects by subtle cues and thus influence their performance (Christensen, 1994, p. 229). Experimenter effects can be divided into experimenter attributes and experimenter expectancies. Experimenter attributes include physical characteristics of the experimenter such as age, gender, or race, and psychological characteristics of the experimenter, such as anxiety level, authoritarianism, dominance, intelligence, and social behavior. In this experiment, an effort was made to keep the experimenter effect as constant as possible: a single experimenter was used, subject groups were tested minutes apart, and subjects were approached and instructions given in a similar manner.

Experimenter expectancies can also be a source of error; experimenters are motivated to see their hypotheses confirmed. These unintentional influences can affect the experimenter by altering his or her behavior and thus influence subjects as well. It has also been shown that experimenter expectancies can affect results (Christensen, 1994, p. 233). In this experiment, it was perceived by the researcher that the information provided from either acceptance or rejection of the hypothesis would provide useful information about the visualization. The researcher was aware of the phenomena of experimenter expectancy, and its potential as a source of bias. Despite this, and due to the difficulty in measuring this effect, it can be assumed that it existed in some amount.

INTERNAL AND EXTERNAL VALIDITY

Internal validity refers to the researchers ability to attribute the effect that was observed to the experimental variable and not to other factors present (Churchill, 1995, p. 202). By controlling as many extraneous factors as possible, it is possible to isolate a particular effect of interest. In this experiment, care was taken to control a number of factors: the same classroom, equipment, lighting conditions, experimenter, and instructions to subjects were used for both the experimental and control groups. Testing of each group occurred within a short time of each other to control for temporal effects. While it is impossible to control for all possible extraneous effects, conducting an experiment in a laboratory setting provides one of the best conditions for achieving internal validity. There is an inverse relationship, however, between internal and external validity - or the extent to which the results of an experiment can be generalized across different persons, settings, and times (Christensen, 1994, p. 468). High internal validity usually means low external validity, and vice versa.

Normally, in order generalize the results of a study, inferences are made from testing a target population that is representative of the population the experimenter is interested in. However, due to a number of factors (time, cost, subject availability) most studies do not randomly sample the specified population. Instead, an experimentally accessible population is sampled from which a generalization is made to the target population. External validity can be threatened by a number of factors, including lack of ecological validity, lack of population validity, and lack of time validity.

Ecological validity

Ecological validity refers to generalize the results of a study across particular settings or environmental conditions (Christensen, 1994, p. 474). Factors including the Hawthorne effect (changes in a subject's behavior as a result of the knowledge that he or she is being tested), any potential influence of the experimenter on the subjects, or conducting the experiment over a single session can impact ecological validity. In this research, the experiment was conducted in a classroom setting by an experimenter on subjects who knew they were being tested. While the magnitude of these effects is not known, it is likely that they did influence the results to some degree.

Population validity

Population validity refers to the ability to generalize from the experimental subject sample to the larger population from which the sample was drawn. To achieve population validity, experimental subjects must be selected at random. Whether results can be generalized from the experimental subject sample depends on a consideration of whether or not the treatment interaction would be affected by subject, setting, or time characteristics. In this research, subjects were tested on their perceptual responses to a broad range of semantic scores. The meaning of the adjectives used in these measures has not changed significantly over time.

In many studies, research has been restricted to younger undergraduate students. In this study, students were older, in many cases already possessing a degree, and most had a few years of practical work experience, characteristics that would assist in promoting population validity.

Temporal validity

Temporal validity refers to the influence of time on an experiment's results. If the results of an experiment vary with the passage of time, then the influence of the treatment condition can only be generalized to that point in time that the experiment was conducted. Characteristics of individuals vary over time as well, which can affect temporal validity.
In this study, the technology being examined is in a constant state of flux. New generations of computer graphics in film and television are emerging every day, as are advances in visual simulation technology. It is likely then, that people's perceptions of video and computer-generated animations will change over time, as their expectations change. As they have in the past, Hollywood special effects will have a large impact on audience expectations of computer-generated imagery in the future.

SUMMARY

Historically, planners, architects, and engineers have used plans, elevations, and perspectives to illustrate their designs. New visual simulation technology is now allowing planners to model their designs in 3-D electronic space, and render them photo-realistically. The advantage of using 3-D modeling and animation lies in its capability to produce static or dynamic perspectives from an infinite number of viewpoints, as well as providing the capability to create fly-bys or walk-throughs of a proposed design. In modern planning practice, visual simulation has applications in environmental assessment, mitigation planning, and planning control. Its importance lies in its potential for improving the quality of the decision-making process. The fundamental difficulty in the use of simulations is that there are still significant differences between the way a simulation presents the world and the way people experience it, and between the way a plan is presented and what later is built. Heavy staff-time requirements, and steep learning curves may hinder its use among planning professionals. In current planning practice, the use of visual simulations is limited, due to its perceived high cost, time commitment, and data issues. Increasing awareness of its value in the planning process should see its increasing usage by planning professionals. To date, research on the effectiveness of visual simulation in planning practice has been limited to static simulations. Research into the effectiveness of dynamic computer-generated visual simulations is needed.

An experiment was devised to test the response equivalence between a dynamic visual simulation of an urban environment with actual video imagery. Two previous visualization studies, Appleyard and Craik (1979) and Oh (1994) were useful in designing an appropriate experimental methodology to answer the question, "Is it possible to evoke equivalent perceptual responses between video imagery, and a computer-generated animation of an urban environment?". In the experiment, the perceptual responses of two groups, one viewing video imagery, and the other the computer animation, would be tested, and the results analyzed statistically to answer this question.

For modeling, a site in Kirkland, Washington was selected. In building the model, the following criteria for creating good simulations (Sheppard, 1989) was used: Representativeness; Accuracy; Visual clarity; Interest; and Legitimacy. Using 3-D Studio, a three-dimensional wire-frame model of the site was constructed, to which photo-realistic textures were later applied. A questionnaire utilizing semantic differentials was devised for testing people's responses of the simulation and video.

The results from this research indicate a high level of agreement in perceptual responses was observed between the two groups, one viewing a dynamic photo-realistic simulation of an urban environment (the experimental group), and the other viewing video imagery of the actual environment (the control group). For thirteen out of fifteen semantic differentials measured, there was no significant difference in the mean responses observed between the two groups tested. For two of the differentials in which a significant difference was observed, including Neatness (Clean-Dirty) and Colour (Warm-Cool), the disparity in responses may be a result of simulation effects. A significant difference in perceived complexity was observed between the two groups. No significant difference in perceived potency, interest, or emotion was observed. No significant difference in perceived visual attractiveness, confidence in the media type, or familiarity with the site was observed. No significant difference between perceived attractiveness by those with design education and those without a design education, although the frequency distribution histogram did reveal some variation in responses. Finally, no significant difference in image confidence by those with and those without a design education was observed.

These results, however must be viewed in terms of the limitations of the study. Issues of causality, experimental control, potential sources of error (including sampling errors, subject error, the experimenter effect) must all be considered in determining the internal and external validity of the experiment.

"..computer simulations may be so pervasive (and so realistic) that life itself will require some sort of authenticity. Reality, in other words, may one day come with an asterisk."

- Mark Slouka
(Slouka, 1995, p. 23.)

FIVE

Conclusion

This research has demonstrated that response equivalence was observed between a dynamic visual simulation and video imagery of an urban environment. For thirteen out of a possible fifteen semantic differentials used to measure meaning of architectural environments, no statistical difference was observed between the experimental and control groups. Although video imagery contains much more detail than is efficient to model using current visual simulation methods, equivalent responses were obtained of a moderately detailed photo-realistic animation. Some perceptual differences among some semantic differentials were observed possibly as a result of simulation effects, including Neatness, and Colour. The image performance of the dynamic simulation, as measured by its visual attractiveness, and confidence in the imagery was equitable between the two media types. A difference was observed in perceived complexity between the two groups, possibly a result of simulation effects. A comparison of the stimulus measures of Potency, Interest, and Emotion revealed no significant difference in responses between the animation and the video groups. Concerning the factor of design education, no significant difference was observed in image attractiveness (Appendix 2, p. 109). This is in agreement with Oh's (1994) finding and in contrast with Appleyard's (1979) contention that people with design education understood the environment differently from lay people. No difference was observed in image confidence among those with and without design education in either the animation or the video groups, suggesting that for the two groups tested, possession of design education did not significantly alter their level of confidence in the imagery.

Any generalizations concerning the results of this experiment must be made with caution. While every attempt has been made to control extraneous variables and other sources of potential error including sampling error, subject effects, and experimenter effects, no experiment is totally free of bias in some measure. Due to the complex nature of the phenomena being studied, in this case perceptual responses to computer-generated imagery, and due to the potential effects of ecological, population, and temporal validity, it would be difficult to generalize the results to a broader population. However, the results are encouraging, suggesting that we are moving in the right direction.

Another important caveat to note, is that due to the rapidly changing nature of visualization technology in conjunction with evolving audience sophistication, it is possible that perceptual responses will change as expectations change. Temporal validity, therefore, may be an important factor to consider in the future use of this technology.

While the use of visual simulations in such areas as environmental assessment, mitigation planning, and planning control has been advocated by many planning professionals because they have the potential to strengthen the quality of the decision-making process, at present they are rarely done. They are often perceived as being too expensive, too time-consuming, or unnecessary. However, as recent examples of visualization use in planning attest, its importance and value in the planning process is becoming more widely recognized. Its potential as a communication tool in the planning process should not be underestimated, including such cases where there is disagreement or controversy concerning the outward appearance of a design. Visual simulations can often far outweigh their costs by providing valuable information on the visual impact of proposed designs before they are constructed, helping planners, government agencies, and the public in making better-informed planning decisions. Dynamic visual simulations can assist in this regard by providing an experiential quality to a proposed design that static images cannot.

There is an inherent responsibility by those utilizing visualization technology to ensure that standards of accuracy, representativeness, visual clarity, interest, and legitimacy are adhered to in order to ensure greater acceptance of this technology in modern planning practice.

The basic roadblock to any newly-emerging technology lies in adherence to traditional techniques. This should not prevent the exploration and discovery of alternative techniques, which may offer some advantages that existing methods do not. A desirable outcome would see a merging of the two techniques while mutually recognizing their value:

> We all know how to draw with a pencil. When we look at a detailed drawing done by hand with pen and ink, we are very aware of the tremendous effort, skill, and patience that brought about the finished art. Computer graphics still suffer from the misconception that you "press a button, and the computer does it." Perhaps, as computer-based tools become a more common part of our experience, we will develop a new appreciation for and sensitivity to the subtleties intrinsic to digital rendering, animation, and imaging (Claridge, 1996, p. 30).

RECOMMENDATIONS

For planners, visual simulation technology can be a useful tool in everyday practice, provided that it is used responsibly and in the proper context. Not all planning applications lend themselves to visual simulation use; the size and nature of the project will dictate what type of simulation, if any, would be beneficial. It has been found that in projects where there is controversy over the outward appearance of a design, the use of visual simulations can minimize costly and repetitive development appeals. In small projects such as housing extensions, simulations have been found to assist greatly in resolving disputes over shadowing and obstruction of neighbor's views. The communication of complex plans or designs can be enhanced considerably by visualizations, particularly in cases where input from the public is desired.

In cases where it is determined that some form of visualization would be beneficial, a decision must be made whether a static or dynamic visualization would best suit the purpose at hand. Dynamic simulations take longer to produce, but provide much more visual information than singular static views. Another issue to consider is the level of detail required. Often, a simple solid-shaded model will suffice, particularly in the case of shadow or massing studies. In this case, due to their simplicity, they may be constructed in a relatively short period of time; animations may then be produced fairly quickly due to short rendering times. Models displaying higher levels of realism take longer to produce, but are accepted more readily by audiences because the level of abstraction is much lower, and the imagery can be understood more quickly and evaluated.

Although the cost of equipment required to create dynamic visual simulations is steadily decreasing, the costs of doing in-house visualizations can be high, particularly for small planning departments with limited budgets. Adequate hardware and software , and staff expertise is needed to produce animations or still images which may require upgrading of existing equipment. Getting funding approval for such upgrades from upper management may be difficult, particularly in cases where there is limited recognition of the potential benefits in increased staff productivity by using faster machines.

A more cost-effective alternative to doing in-house visualizations would be to contract out work to well-qualified visualization consultants, who have the expertise, equipment, and experience to complete the work in a timely fashion. As with any new technology, its benefits must be demonstrated and proven in a number of examples before it will gain wider acceptance in general practice. Visual simulations are still a relatively new phenomena in planning; managers are reluctant to utilize the technology because they perceive it as being risky, and unproven. However, as shown in its successful use by many municipalities in North America and abroad, its acceptance as a legitimate planning tool is growing quickly. Once a department is comfortable with its use, and its benefits realized, then it can consider the long-term advantages of doing its own in-house visualizations.

FUTURE RESEARCH

While this study does shed some light on the perceptual effectiveness of dynamic photo-realistic simulations, its scope is somewhat limited. A broader investigation into a wide range of simulation media is needed, including an examination of the perceptual effectiveness of dynamic simulation media at various levels of abstraction (wire-frame, flat shaded, photo-realistic, etc.). The development of quantifiable and definitive guidelines for the creation and use of visual simulations are needed to ensure its legitimate application in all professions, including planning. Investigation into the image performance of virtual reality applications is needed to assess its usefulness in planning design and review. To date, the perceptual effectiveness of sound in dynamic simulations has not been examined. Also helpful would be an examination of the effectiveness of visual simulation techniques in actual planning practice, using a case-study approach. While such a study has been done in the past (Sheppard, 1989), further investigation is required into this emerging, and rapidly advancing technology..

OUTLOOK

Visual simulation technology continues to advance at an extremely rapid rate. The trend of increasing processing speeds, decreasing costs, and the development of better visualization applications shows no sign of slowing down in the foreseeable future. In the future, a merging of visualization and GIS technology will see database information connected to visual elements, allowing planners to ask the question "What if...." in ways that have not previously been done. Adequate research into the use of this technology must be pursued in order to ensure that simulations are used appropriately, effectively and confidently by planners in everyday practice.

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GLOSSARY

Box-mapping. A feature of 3D-Studio that allows the user to apply a different texture map to six sides of a three-dimensional wire-frame box.

CAD. Acronym for Computer-Assisted Design

Dynamic visual simulation. Imagery of a proposed design, in perspective, that would be seen by a moving observer.

Elevation. Two-dimensional representation of a side view of a design.

Flat-shading. Another term used to describe the solid-shading of a wire-frame model.

Perspectives. Drawings representing a three-dimensional view of a design, with a vanishing point occurring at some distance from the observer.

Plans. Two-dimensional representations of an aerial view of a design, often diagrammatic.

Real time. The ability to interact with a simulation as fast as would occur in reality.

Rendering, Computer. The computational process by which a computer generates a final image of a model.

Response equivalence. An audience's responses evoked by the simulated settings are comparable to those that would be evoked in direct encounters with the setting simulated.

Scale models. A physical expression of a design, usually made of wood, plastic, glass, or metal, built to scale.

Semantic differential. A numerical scale measure with bipolar adjective descriptors used to measure an audience's perception of the physical environment.

Simulation media (or medium). The type of technique used to create a visual simulation, usually described by the materials and tools used to create it.

Static visual simulation. Images of a proposed design, in perspective, that would be seen by a fixed observer.

Texture mapping. The process by which images are draped on wire-frame models.

Wire-frame. A term used to describe the simplest expression of a three-dimensional computer model, which consists of a series lines that connects points in space.

Virtual reality. A term used to describe a three-dimensional computer-generated environment that a person can interact with in real-time.

Visual simulation. Imagery that portrays, in perspective, what a proposal or design would look like if it was to be enacted or built, shown in the context of its surroundings.

APPENDIX 1

SAMPLE QUESTIONNAIRE

QUESTIONNAIRE

Please answer all of the questions below to the best of your ability. The answers you provide will be helpful in advancing environmental design research. All responses will be strictly anonymous.

1. After viewing the short video, please record your impressions of the **urban area** for each category below by circling the appropriate number.

Use the following for reference:

		1	2	3	4	5	
		very X	somewhat X	neutral	somewhat Y	very Y	
a) Aesthetics	**Unique**	1	2	3	4	5	**Common**
b) Friendliness	**Friendly**	1	2	3	4	5	**Hostile**
c) Organization	**Ordered**	1	2	3	4	5	**Chaotic**
d) Space	**Loose**	1	2	3	4	5	**Compact**
e) Space	**Spacious**	1	2	3	4	5	**Confined**
f) Ornate	**Ornate**	1	2	3	4	5	**Plain**

g) Colouring	Colourful	1	2	3	4	5 Subdued
h) Neatness	Clean	1	2	3	4	5 Dirty
i) Lighting	Bright	1	2	3	4	5 Dim
j) Privacy	Public	1	2	3	4	5 Private
k) Visual Noise	Quiet	1	2	3	4	5 Noisy
l) Formal	Formal	1	2	3	4	5 Casual
m) Time	Old	1	2	3	4	5 New
n) Colour Temperature	Warm	1	2	3	4	5 Cool
o) Plantings	Planted	1	2	3	4	5 Barren

2. How familiar to you is the site?

1	2	3
very familiar	**slightly familiar**	**not familiar**

3. How visually attractive do you consider the imagery as a whole?

	1	2	3	4	5	
unattractive						**attractive**

4. How confident are you that the images shown present a truthful representation of the area?

	1	2	3	4	5	
not confident						**very confident**

5. For the following scales, evaluate the **video** itself.

		1	2	3	4	5	6	7	
a) Complexity	**simple**								**complex**
b) Potency	**quiet**								**loud**
c) Interest	**interesting**								**uninteresting**
	emotional								**unemotional**

6. Any general comments you might have on the quality of the presented images:

____
____
____
____
____

7. What is your age? ________

8. Gender: Male ____ Female ____

9. Does your educational background include any design related studies (architecture, environmental design, planning, or urban geography)?

☐ Yes   If 'Yes", specify which ________________

☐ No

10. Please enter your occupation (include any part-time work): _______________

____

CONGRATULATIONS! YOU ARE NOW DONE. PLEASE TURN IN YOUR COMPLETED QUESTIONNAIRE.

THANK YOU FOR YOUR PARTICIPATION.

UNIVERSITY OF CALGARY
CONSENT FORM

Research Project:	Visual Simulation and Perception in Urban Planning
Investigator:	B. Park
Funding Agency:	Faculty of Environmental Design, University of Calgary

This consent form, a copy of which has been given to you, is only part of the process of informed consent. It should give you the basic idea of what the research is about and what your participation will involve. If you would like more detail about something mentioned here, or information not included here, please ask. Please take the time to read this form carefully and to understand any accompanying information.

The purpose of this study is to investigate and compare people's visual perceptions of a video tape of an urban area versus a computer-generated animation of that same area. This study will help to assess the effectiveness and usefulness of computer animations in the field of urban planning.

The study consists of viewing either a short (4-5 minute) video or computer animation on a television screen, and answering a short questionnaire on the imagery seen. Most of the questions will involve rating the imagery on a scale from 1 to 5 on some descriptive measure (e.g. Light-Dark). Other questions will ask general information on your personal background (gender, age, level of education, etc.) and whether you have had any experience in a design-related field or with computer visualizations. Any information provided by you will be kept strictly confidential and will be stored as such for a period of one year. All information obtained in this study is dealt with as group data: forms are coded and names are removed to hide personal identities. Also, any information published as a result of this study will pertain to group data, and will not reveal any individual identity.

Participation in this study will not directly benefit you, but will help further visualization research in the field of urban planning. I do not foresee any possibility of harm coming to you as a result of your participation in this experiment

The study will take about 10 minutes of your time. Once you have completed the questionnaire, your participation in this study is concluded.

Your signature on this form indicates that you have understood to your satisfaction the information regarding participation in the research project and agree to participate as a subject. In no way does this waive your legal rights nor release the investigators, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw from the study at any time. Your continued participation should be as informed as your initial consent, so you should feel free to ask for clarification or new information throughout your participation. If you have further questions concerning matters related to this research, please contact:

Bruce Park
Telephone: (403) 288-4557

If you have any questions concerning your participation in this project, you may also contact the Office of the Vice-President (Research) and ask for Karen McDermid, (403) 220-3381.

______________________________ ______________________________

Participant Date

______________________________ ______________________________

Investigator/Witness (optional) Date

A copy of this consent form has been given to you to keep for your records and reference.

APPENDIX 2

STATISTICAL TABLES OF RESULTS

The following appendix contains summary statistics of the questionnaire results. They are organized as follows:

Summary of Respondent Characteristics

Summary statistics for 15 semantic differential scales

- Unique-Common
- Friendly-Hostile
- Ordered-Chaotic
- Loose-Compact
- Spacious-Confined
- Ornate-Plain
- Colourful-Subdued
- Clean-Dirty
- Bright-Dim
- Public-Private
- Quiet-Noisy
- Formal-Casual
- Old-New
- Warm-Cool
- Planted-Barren

ANOVA analysis

- Familiarity vs. Media Type
- Confidence vs. Media Type
- Attractiveness vs. Media Type
- Attractiveness vs. Design Education
- Confidence vs. Design Education

Stimulus measures

- Complexity
- Potency
- Interest

Summary of Respondent Characteristics

Age

Video Group	Anim. Group
Age (Years)	Age (Years)
41	31
25	32
47	35
36	36
33	44
37	23
37	37
34	32
29	19
30	35
46	29
31	35
27	25
34	37
43	19
34	23
33	26
32	29
35	32
39	37
36	43
45	31
28	34
32	30
36	35
35.2	**31.56**	Average
25-47	19-43	Range

Gender

	Video	Animation	Total
Male	11	10	21
Female	14	15	29

Educational Background (Design-related)

	Video	Animation	Total
Yes	9	13	22
No	16	12	28

Occupation	Video	Animation	Total
Professional	10	8	18
Non-Professional	6	12	18
Unemployed	9	5	14

Aesthetics : Unique-Common Semantic Differential Scale

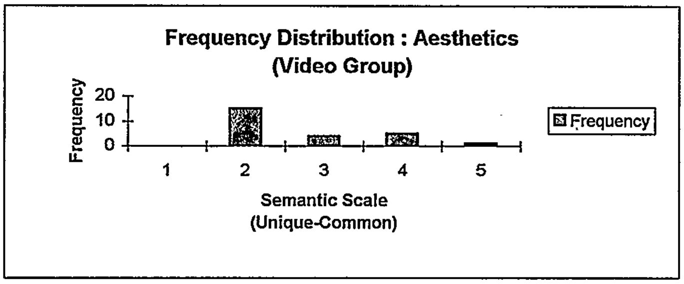
Data Values (Semantic Scores)	
Video	Animation
2	4
3	2
2	3
2	5
3	1
2	1
5	2
4	3
2	2
2	4
2	4
2	4
4	2
2	2
4	3
3	2
2	4
2	2
2	4
4	1
2	3
2	2
2	2
4	1
3	2
2.68	**2.60**	Mean
25	25	N

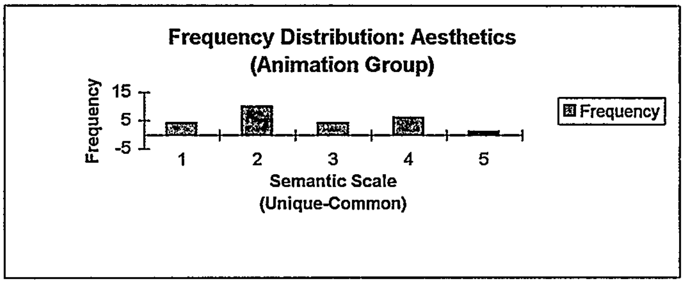
Video

Bin	*Freq.*
1	0
2	15
3	4
4	5
5	1

Animation

Bin	*Freq.*
1	4
2	10
3	4
4	6
5	1





Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Video	25	67	2.68	0.89333333
Animation	25	65	2.6	1.33333333

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.08	1	0.08	0.07185629	0.78980159	4.04264711
Within Groups	53.44	48	1.11333			
Total	53.52	49				

$\alpha = 0.05$

Hypothesis Testing

$H_0 : \mu_1 = \mu_2$

H_A : both μ's are not equal

Test statistic: F

Reject H_0 if $F^* > F_{0.05,1,48} = 4.043$

From the table above, $F^* = 0.072$.

Since 0.072 is not greater than 4.043, we FTR H_0.

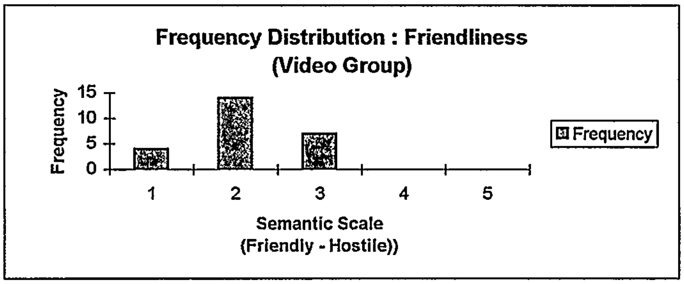
Based on the sample data, there is insufficient evidence to conclude that the means between the video and animation groups are not the same.

Friendliness : Friendly-Hostile Semantic Differential Scale

Data Values (Semantic Scores)	
Video	Animation
2	1
2	4
3	2
2	1
1	3
2	4
2	2
3	2
2	3
2	3
3	1
2	1
3	2
2	2
2	2
2	2
1	3
2	3
3	1
1	2
1	3
3	2
2	2
2	3
3	2
2.12	**2.24**	Mean
25	25	N

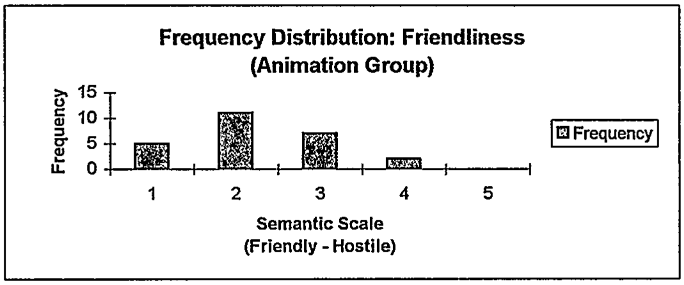
Video

Bin	*Freq.*
1	4
2	14
3	7
4	0
5	0



Animation

Bin	*Freq.*
1	5
2	11
3	7
4	2
5	0



Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Video	25	53	2.12	0.44333333
Animation	25	56	2.24	0.77333333

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.18	1	0.18	0.29589041	0.5889882	4.04264711
Within Groups	29.2	48	0.60833			
Total	29.38	49				

$\alpha = 0.05$

Hypothesis Testing

$H_0 : \mu_1 = \mu_2$

H_A : both μ's are not equal

Test statistic: F

Reject H_0 if $F^* > F_{0.05,1,48} = 4.043$

From the table above, $F^* = 0.296$

Since 0.296 is not greater than 4.043, we FTR H_0.

Based on the sample data, there is insufficient evidence to conclude that the means between the video and animation groups are not the same.

Organization: Ordered-Chaotic Semantic Differential Scale

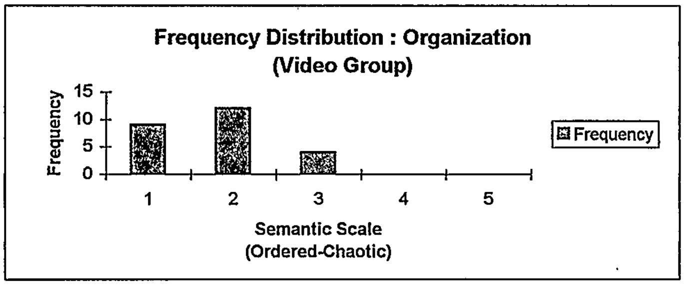
Data Values (Semantic Scores)	
Video	Animation
3	2
1	1
2	1
3	2
2	1
1	1
2	1
2	1
2	2
2	1
1	1
3	2
2	3
2	2
2	3
1	1
1	1
2	1
3	2
1	2
1	1
1	1
2	2
2	2
1	1
1.80	**1.52**	Mean
25	25	N

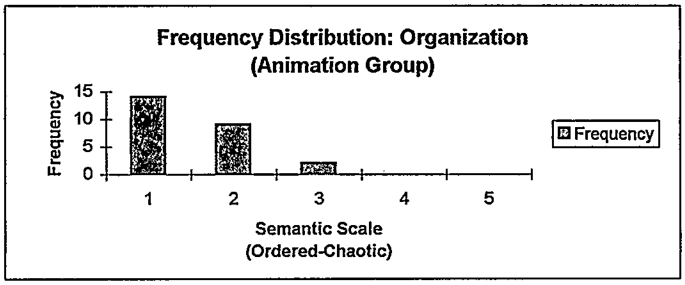
Video

Bin	*Freq.*
1	9
2	12
3	4
4	0
5	0

Animation

Bin	*Freq.*
1	14
2	9
3	2
4	0
5	0





Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Video	25	45	1.8	0.5
Animation	25	38	1.52	0.42666667

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.98	1	0.98	2.11510791	0.15235999	4.04264711
Within Groups	22.24	48	0.46333			
Total	23.22	49				

$\alpha = 0.05$

Hypothesis Testing

$H_0 : \mu_1 = \mu_2$

H_A : both μ's are not equal

Test statistic: F

Reject H_0 if $F^* > F_{0.05,1,48} = 4.043$

From the table above, $F^* = 2.12$

Since 2.12 is not greater than 4.043, we FTR H_0.

Based on the sample data, there is insufficient evidence to conclude that the means between the video and animation groups are not the same.

Space: Loose-Compact Semantic Differential Scale

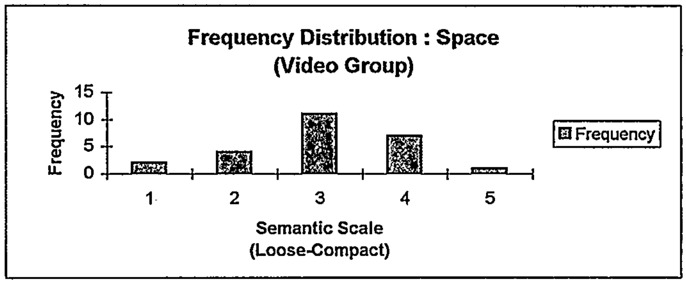
Data Values (Semantic Scores)	
Video	Animation
4	1
2	1
4	1
4	4
4	2
1	3
5	3
4	3
3	3
3	2
4	4
3	4
4	4
3	3
3	3
2	3
1	3
3	2
3	1
3	3
3	5
2	3
2	3
3	4
3	2
3.04	**2.80**	Mean
25	25	N

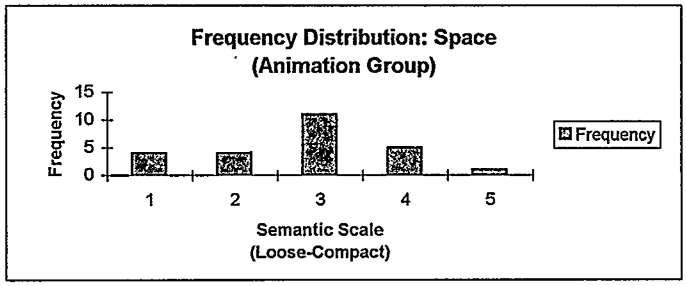
Video

Bin	*Freq.*
1	2
2	4
3	11
4	7
5	1

Animation

Bin	*Freq.*
1	4
2	4
3	11
4	5
5	1





Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Video	25	76	3.04	0.95666667
Animation	25	70	2.8	1.16666667

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.72	1	0.72	0.67817896	0.41428753	4.04264711
Within Groups	50.96	48	1.06167			
Total	51.68	49				

$\alpha = 0.05$

Hypothesis Testing

$H_0 : \mu_1 = \mu_2$

H_A : both μ's are not equal

Test statistic: F

Reject H_0 if $F^* > F_{0.05,1,48} = 4.043$

From the table above, $F^* = 0.678$

Since 0.678 is not greater than 4.043, we FTR H_0.

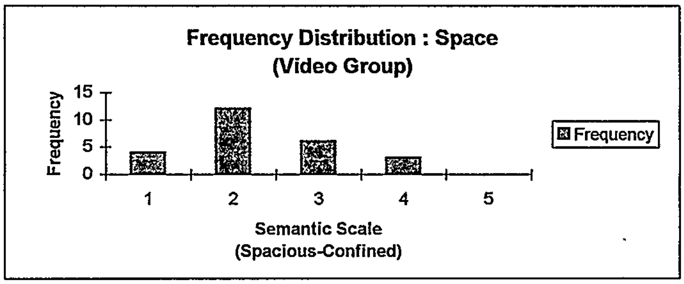
Based on the sample data, there is insufficient evidence to conclude that the means between the video and animation groups are not the same.

Space: Spacious-Confined Semantic Differential Scale

Data Values (Semantic Scores)	
Video	Animation
2	2
2	1
3	1
3	2
4	2
2	2
3	3
3	2
2	2
4	2
4	3
2	3
3	4
2	1
2	3
2	1
1	2
2	3
3	1
1	3
1	3
2	1
2	2
2	1
1	2
2.32	**2.08**	Mean
25	25	N

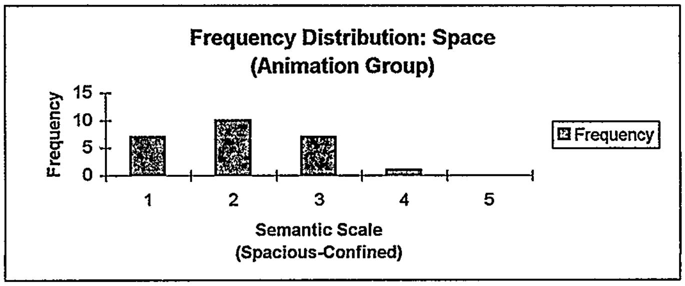
Video

Bin	*Freq.*
1	4
2	12
3	6
4	3
5	0



Animation

Bin	*Freq.*
1	7
2	10
3	7
4	1
5	0



Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Video	25	58	2.32	0.81
Animation	25	52	2.08	0.74333333

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.72	1	0.72	0.92703863	0.34045928	4.04264711
Within Groups	37.28	48	0.77667			
Total	38	49				

$\alpha = 0.05$

Hypothesis Testing

$H_0 : \mu_1 = \mu_2$

H_A : both μ's are not equal

Test statistic: F

Reject H_0 if $F^* > F_{0.05,1,48} = 4.043$

From the table above, $F^* = 0.927$

Since 0.927 is not greater than 4.043, we FTR H_0.

Based on the sample data, there is insufficient evidence to conclude that the means between the video and animation groups are not the same.

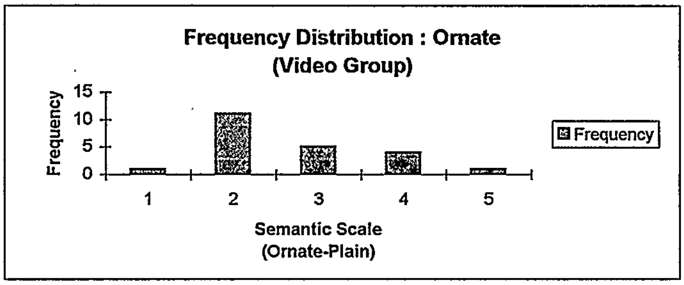
Ornate: Ornate-Plain Semantic Differential Scale

Data Values (Semantic Scores)	
Video	Animation
2	3
2	4
2	2
3	2
4	3
2	1
4	2
3	3
2	4
4	4
2	2
2	3
2	4
3	1
3	3
2	2
5	3
2	2
3	2
1	2
4	3
2	4
2	2
3	2
2	2
2.64	**2.60**
25	25

Mean
N

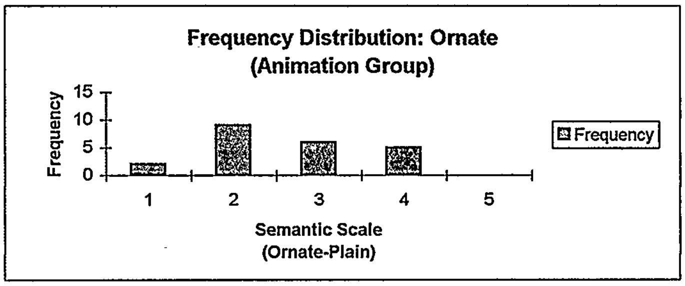
Video

Bin	*Freq.*
1	1
2	11
3	5
4	4
5	1



Animation

Bin	*Freq.*
1	2
2	9
3	6
4	5
5	0



Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Video	25	66	2.64	0.90666667
Animation	25	65	2.6	0.83333333

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.02	1	0.02	0.02298851	0.88012243	4.04264711
Within Groups	41.76	48	0.87			
Total	41.78	49				

$\alpha = 0.05$

Hypothesis Testing

$H_0 : \mu_1 = \mu_2$

H_A : both μ's are not equal

Test statistic: F

Reject H_0 if $F^* > F_{0.05,1,48} = 4.043$

From the table above, $F^* = 0.023$

Since 0.023 is not greater than 4.043, we FTR H_0.

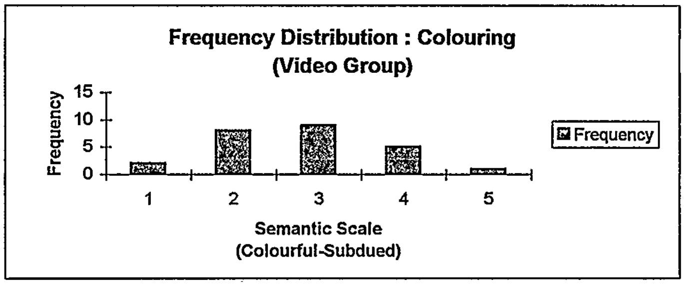
Based on the sample data, there is insufficient evidence to conclude that the means between the video and animation groups are not the same.

Colouring: Colourful-Subdued Semantic Differential Scale

Data Values (Semantic Scores)	
Video	Animation
3	3
1	2
2	2
3	2
3	2
2	4
3	2
4	2
4	4
4	3
4	3
2	3
2	3
3	2
2	2
2	2
5	1
3	2
3	2
1	2
2	2
4	3
3	2
3	3
2	2
2.80	**2.40**	Mean
25	25	N

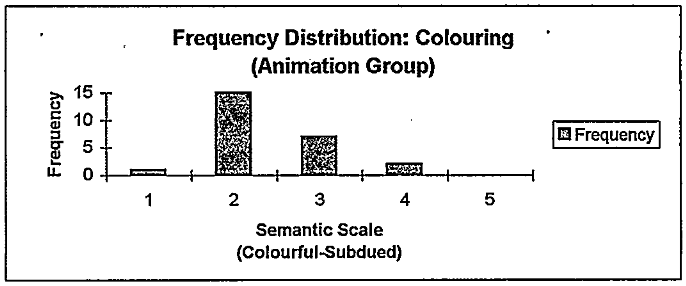
Video

Bin	*Freq.*
1	2
2	8
3	9
4	5
5	1



Animation

Bin	*Freq.*
1	1
2	15
3	7
4	2
5	0



Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Video	25	70	2.8	1
Animation	25	60	2.4	0.5

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	2	1	2	2.6666667	0.109014	4.0426471
Within Groups	36	48	0.75			
Total	38	49				

$\alpha = 0.05$

<u>Hypothesis Testing</u>

$H_0 : \mu_1 = \mu_2$

H_A : both μ's are not equal

Test statistic: F

Reject H_0 if $F^* > F_{0.05,1,48} = 4.043$

From the table above, F* = 2.66.
Since 2.66 is not greater than 4.043, we FTR H_0.
Based on the sample data, there is insufficient evidence to conclude that the means between the video and animation groups are not the same.

Neatness: Clean-Dirty Semantic Differential Scale

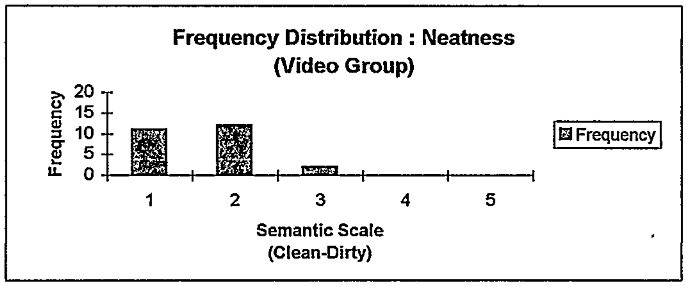
Data Values (Semantic Scores)	
Video	Animation
2	2
1	1
2	1
2	1
2	1
1	2
2	1
2	1
1	2
3	1
1	2
3	1
2	1
2	1
1	1
2	1
1	1
2	1
1	1
1	1
1	1
1	1
1	1
2	2
2	1
1.64	**1.20**	Mean
25	25	N

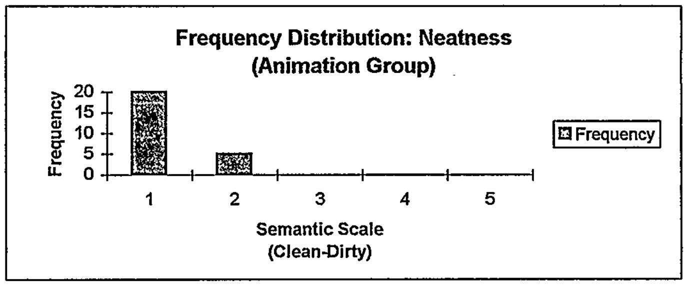
Video

Bin	Freq.
1	11
2	12
3	2
4	0
5	0

Animation

Bin	Freq.
1	20
2	5
3	0
4	0
5	0





Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Video	25	41	1.64	0.40666667
Animation	25	30	1.2	0.16666667

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	2.42	1	2.42	8.44186047	0.00553127	4.04264711
Within Groups	13.76	48	0.28667			
Total	16.18	49				

$\alpha = 0.05$

Hypothesis Testing

$H_0 : \mu_1 = \mu_2$

H_A : both μ's are not equal

Test statistic: F

Reject H_0 if $F^* > F_{0.05,1,48} = 4.043$

From the table above, $F^* = 8.442$

Since 8.442 is greater than 4.043, we reject H_0.

Based on the sample data, there is sufficient evidence to conclude that the means between the video and animation groups are not the same.

Lighting: Bright-Dim Semantic Differential Scale

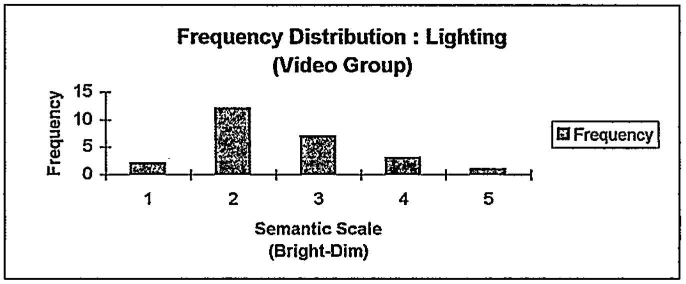
Data Values (Semantic Scores)	
Video	Animation
2	2
3	2
3	3
3	2
2	3
2	5
4	3
3	2
2	2
4	1
5	1
3	2
3	2
2	3
2	2
2	3
1	3
2	2
2	2
2	4
1	3
4	2
2	2
3	3
2	1
2.56	**2.40**	Mean
25	25	N

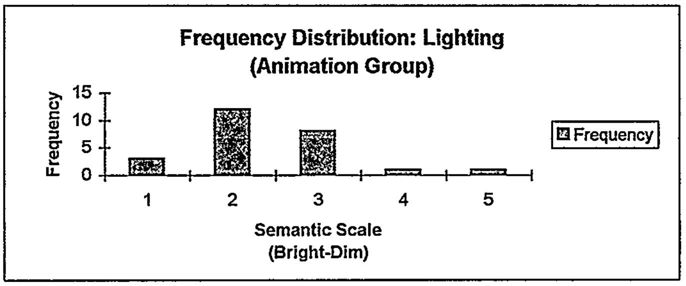
Video

Bin	*Freq.*
1	2
2	12
3	7
4	3
5	1

Animation

Bin	*Freq.*
1	3
2	12
3	8
4	1
5	1





Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Video	25	64	2.56	0.92333333
Animation	25	60	2.4	0.83333333

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.32	1	0.32	0.36432638	0.54895519	4.04264711
Within Groups	42.16	48	0.87833			
Total	42.48	49				

$\alpha = 0.05$

Hypothesis Testing

$H_0 : \mu_1 = \mu_2$

H_A : both μ's are not equal

Test statistic: F

Reject H_0 if $F^* > F_{0.05,1,48} = 4.043$

From the table above, $F^* = 0.364$

Since 0.364 is not greater than 4.043, we FTR H_0.

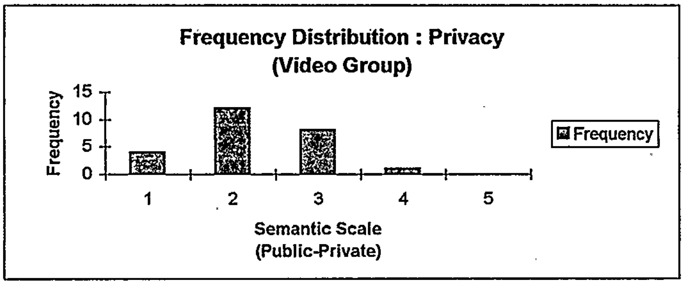
Based on the sample data, there is insufficient evidence to conclude that the means between the video and animation groups are not the same.

Privacy: Public-Private Semantic Differential Scale

Data Values (Semantic Scores)	
Video	Animation
2	2
2	2
3	2
3	3
2	1
1	2
2	4
2	2
2	1
2	2
1	3
3	3
2	3
2	3
4	2
3	3
1	1
3	1
2	1
1	2
3	1
2	1
2	2
3	1
3	2
2.24	**2.00**	Mean
25	25	N

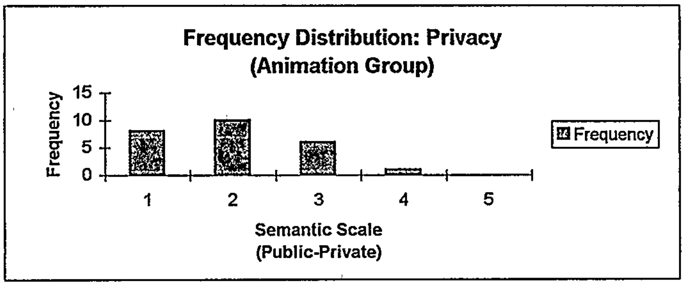
Video

Bin	*Freq.*
1	4
2	12
3	8
4	1
5	0



Animation

Bin	*Freq.*
1	8
2	10
3	6
4	1
5	0



Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Video	25	56	2.24	0.60666667
Animation	25	50	2	0.75

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.72	1	0.72	1.06142506	0.30805392	4.04264711
Within Groups	32.56	48	0.67833			
Total	33.28	49				

$\alpha = 0.05$

Hypothesis Testing

$H_0 : \mu_1 = \mu_2$

H_A : both μ's are not equal

Test statistic: F

Reject H_0 if $F^* > F_{0.05,1,48} = 4.043$

From the table above, $F^* = 1.06$

Since 1.06 is not greater than 4.043, we FTR H_0.

Based on the sample data, there is insufficient evidence to conclude that the means between the video and animation groups are not the same.

Noise: Quiet-Noisy Semantic Differential Scale

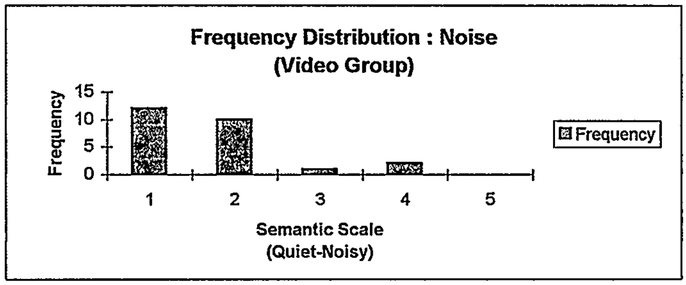
Data Values (Semantic Scores)	
Video	Animation
1	4
1	1
1	2
1	1
2	2
2	1
3	3
2	1
1	2
4	2
4	2
2	2
2	1
1	3
1	2
1	4
1	4
1	1
2	3
2	1
2	1
2	2
1	2
2	2
1	1
1.72	**2.00**	Mean
25	25	N

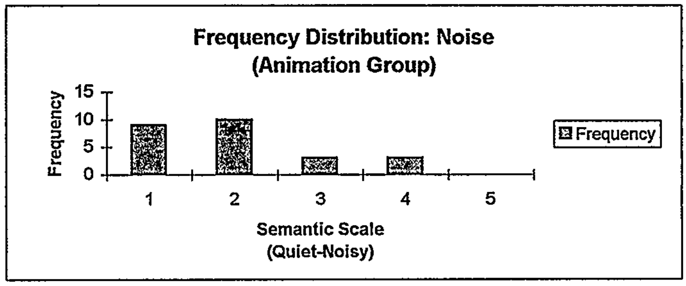
Video

Bin	*Freq.*
1	12
2	10
3	1
4	2
5	0

Animation

Bin	*Freq.*
1	9
2	10
3	3
4	3
5	0





Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Video	25	43	1.72	0.79333333
Animation	25	50	2	1

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.98	1	0.98	1.0929368	0.30105774	4.04264711
Within Groups	43.04	48	0.89667			
Total	44.02	49				

$\alpha = 0.05$

Hypothesis Testing

$H_0 : \mu_1 = \mu_2$

H_A : both μ's are not equal

Test statistic: F

Reject H_0 if $F^* > F_{0.05,1,48} = 4.043$

From the table above, $F^* = 1.09$

Since 1.09 is not greater than 4.043, we FTR H_0.

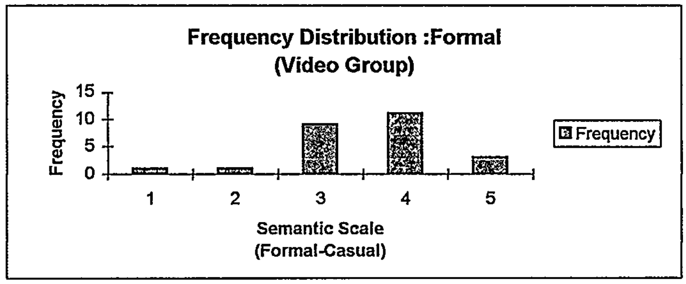
Based on the sample data, there is insufficient evidence to conclude that the means between the video and animation groups are not the same.

Formal: Formal-Casual Semantic Differential Scale

Data Values (Semantic Scores)	
Video	Animation
3	2
5	4
1	4
3	2
4	3
5	4
4	3
4	4
4	4
3	2
4	3
3	5
3	4
2	2
3	5
4	3
3	5
4	3
3	3
4	4
4	5
4	4
4	4
3	4
5	1
3.56	**3.48**	Mean
25	25	N

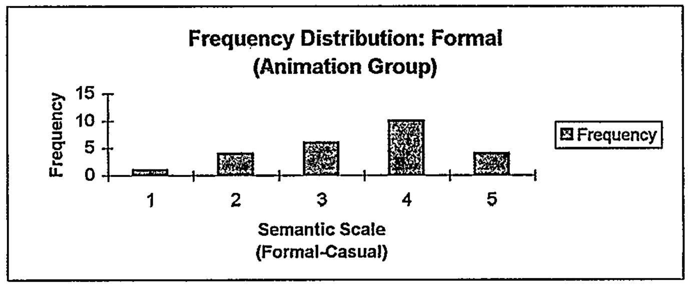
Video

Bin	*Freq.*
1	1
2	1
3	9
4	11
5	3



Animation

Bin	*Freq.*
1	1
2	4
3	6
4	10
5	4



Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Video	25	89	3.56	0.84
Animation	25	87	3.48	1.17666667

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.08	1	0.08	0.07933884	0.77940622	4.04264711
Within Groups	48.4	48	1.00833			
Total	48.48	49				

$\alpha = 0.05$

Hypothesis Testing

$H_0 : \mu_1 = \mu_2$

H_A : both μ's are not equal

Test statistic: F

Reject H_0 if $F^* > F_{0.05,1,48} = 4.043$

From the table above, $F^* = 0.079$

Since 0.079 is not greater than 4.043, we FTR H_0.

Based on the sample data, there is insufficient evidence to conclude that the means between the video and animation groups are not the same.

Time: Old-New Semantic Differential Scale

Data Values (Semantic Scores)	
Video	Animation
2	4
5	4
1	3
3	4
3	4
5	3
2	4
4	4
2	4
4	5
2	3
2	2
3	3
2	2
4	3
4	4
2	3
2	2
3	4
4	4
2	4
4	3
1	1
4	3
5	5
3.00	**3.40**
25	25

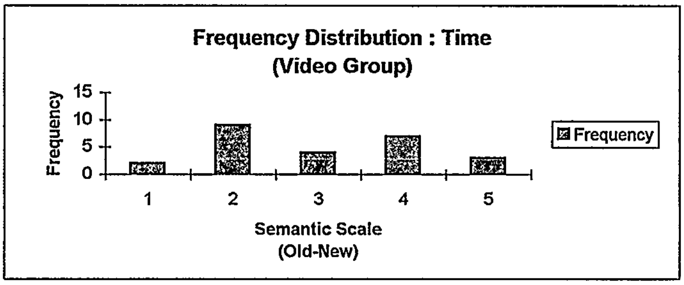
Mean
N

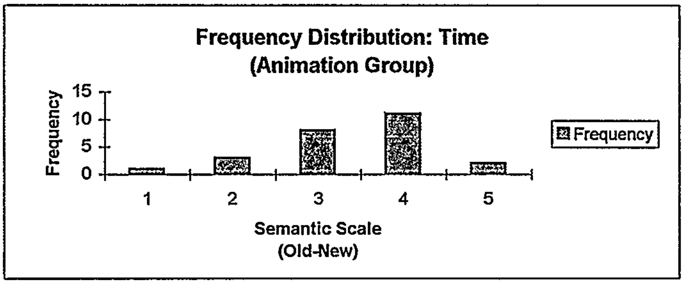
Video

Bin	*Freq.*
1	2
2	9
3	4
4	7
5	3

Animation

Bin	*Freq.*
1	1
2	3
3	8
4	11
5	2





Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Video	25	75	3	1.5
Animation	25	85	3.4	0.91666667

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	2	1	2	1.65517241	0.20442704	4.04264711
Within Groups	58	48	1.20833			
Total	60	49				

$\alpha = 0.05$

<u>Hypothesis Testing</u>

$H_0 : \mu_1 = \mu_2$

H_A : both μ's are not equal

Test statistic: F

Reject H_0 if $F^* > F_{0.05,1,48} = 4.043$

From the table above, $F^* = 1.66$.
Since 1.66 is not greater than 4.043, we FTR H_0.
Based on the sample data, there is insufficient evidence to conclude that the means between the video and animation groups are not the same.

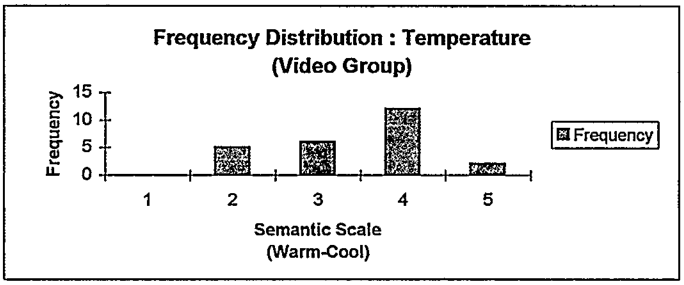
Temperature: Warm-Cool Semantic Differential Scale

Data Values (Semantic Scores)	
Video	Animation
3	2
4	4
2	2
3	1
4	4
3	2
2	2
4	3
2	4
4	2
3	2
5	2
4	3
4	4
5	1
4	2
2	2
2	1
4	3
4	3
3	1
4	2
3	2
4	3
4	2
3.44	**2.36**
25	25

Mean
N

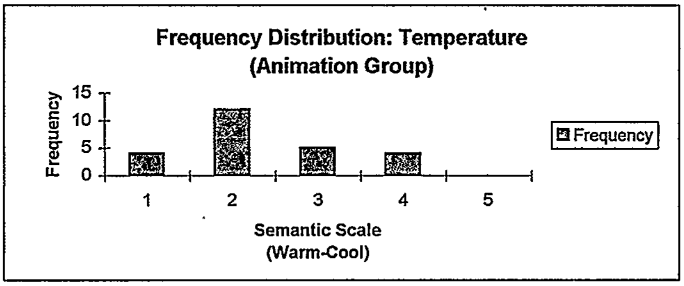
Video

Bin	*Freq.*
1	0
2	5
3	6
4	12
5	2



Animation

Bin	*Freq.*
1	4
2	12
3	5
4	4
5	0



Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Video	25	86	3.44	0.84
Animation	25	59	2.36	0.90666667

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	14.58	1	14.58	16.6946565	0.00016593	4.04264711
Within Groups	41.92	48	0.87333			
Total	56.5	49				

$\alpha = 0.05$

Hypothesis Testing

$H_0 : \mu_1 = \mu_2$

H_A : both μ's are not equal

Test statistic: F

Reject H_0 if $F^* > F_{0.05,1,48} = 4.043$

From the table above, $F^* = 16.69$

Since 16.69 is greater than 4.043, we reject H_0.

Based on the sample data, there is sufficient evidence to conclude that the means between the video and animation groups are not the same.

Plantings: Planted-Barren Semantic Differential Scale

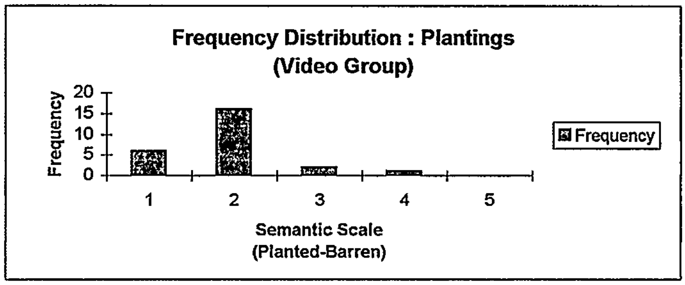
Data Values (Semantic Scores)	
Video	Animation
1	2
2	1
2	1
2	1
2	1
4	1
2	1
1	3
1	3
2	4
2	1
1	3
2	3
2	3
2	3
3	2
2	2
2	2
2	1
2	3
1	1
2	2
2	2
1	4
3	2
1.92	**2.08**	Mean
25	25	N

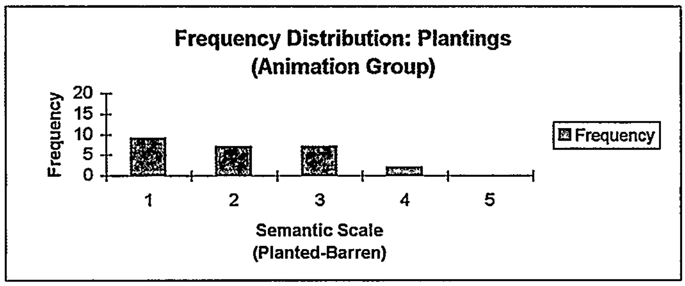
Video

Bin	*Freq.*
1	6
2	16
3	2
4	1
5	0

Animation

Bin	*Freq.*
1	9
2	7
3	7
4	2
5	0





Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Video	25	48	1.92	0.49333333
Animation	25	52	2.08	0.99333333

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.32	1	0.32	0.43049327	0.51488006	4.04264711
Within Groups	35.68	48	0.74333			
Total	36	49				

$\alpha = 0.05$

Hypothesis Testing

$H_0 : \mu_1 = \mu_2$

H_A : both μ's are not equal

Test statistic: F

Reject H_0 if $F^* > F_{0.05,1,48} = 4.043$

From the table above, $F^* = 0.43$.

Since 0.43 is not greater than 4.043, we FTR H_0.

Based on the sample data, there is insufficient evidence to conclude that the means between the video and animation groups are not the same.

Complexity : Simple-Complex Semantic Differential Scale

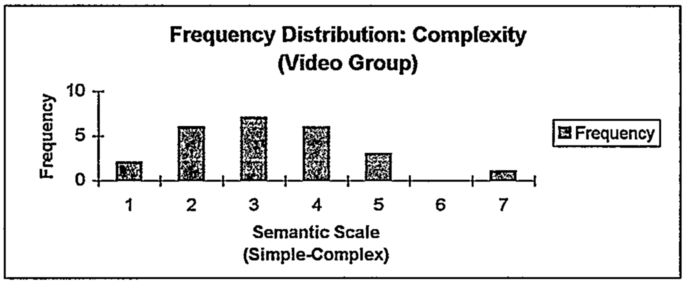
Data Values (Semantic Scores)	
Video	Animation
2	5
3	7
5	6
3	6
3	6
5	6
5	5
2	4
3	2
4	5
1	5
3	4
4	6
7	5
4	3
1	5
4	4
2	5
3	6
2	5
4	5
2	6
2	5
4	6
3	4
3.24	**5.04**	Mean
25	25	N

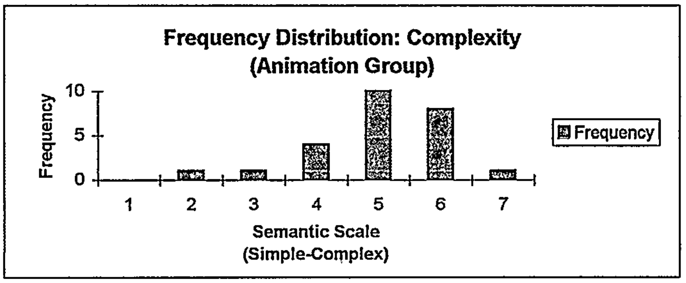
Video

Bin	*Freq.*
1	2
2	6
3	7
4	6
5	3
6	0
7	1

Animation

Bin	*Freq.*
1	0
2	1
3	1
4	4
5	10
6	8
7	1





Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Video	25	81	3.24	1.94
Animation	25	126	5.04	1.20666667

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	40.5	1	40.5	25.7415254	6.2711E-06	4.04264711
Within Groups	75.52	48	1.57333			
Total	116.02	49				

$\alpha = 0.05$

Hypothesis Testing

$H_0 : \mu_1 = \mu_2$

H_A : both μ's are not equal

Test statistic: F

Reject H_0 if $F^* > F_{0.05,1,48} = 4.043$

From the table above, $F^* = 25.74$

Since 25.74 is greater than 4.043, we reject H_0.

Based on the sample data, there is sufficient evidence to conclude that the means between the video and animation groups are not the same.

Potency : Quiet-Loud Semantic Differential Scale

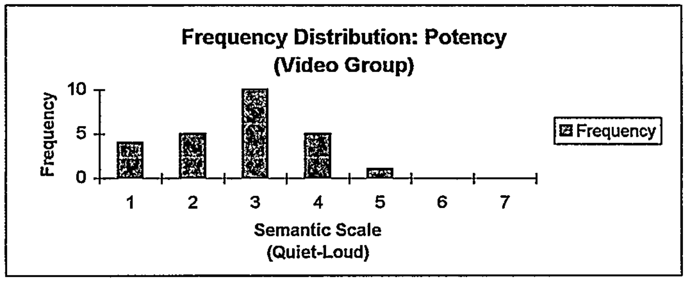
Data Values (Semantic Scores)	
Video	Animation
3	2
4	4
1	5
1	4
3	4
3	5
1	5
2	3
2	1
4	2
2	4
1	3
4	3
3	2
3	3
3	2
3	5
2	1
3	1
5	5
4	3
3	2
3	3
2	3
4	3
2.76	**3.12**	Mean
25	25	N

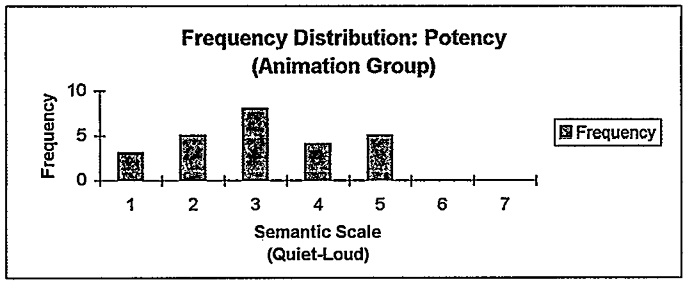
Video

Bin	Freq.
1	4
2	5
3	10
4	5
5	1
6	0
7	0

Animation

Bin	Freq.
1	3
2	5
3	8
4	4
5	5
6	0
7	0





Anova: Single Factor

SUMMARY

Groups	Count	Sum	Average	Variance
Video	25	69	2.76	1.19
Animation	25	78	3.12	1.69333333

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.62	1	1.62	1.12369942	0.29442836	4.04264711
Within Groups	69.2	48	1.44167			
Total	70.82	49				

$\alpha = 0.05$

Hypothesis Testing

$H_0 : \mu_1 = \mu_2$

H_A : both μ's are not equal

Test statistic: F

Reject H_0 if $F^* > F_{0.05,1,48} = 4.043$

From the table above, $F^* = 1.12$

Since 1.12 is not greater than 4.043, we FTR H_0.

Based on the sample data, there is insufficient evidence to conclude that the means between the video and animation groups are not the same.

Interest: Interesting-Uninteresting Semantic Differential Scale

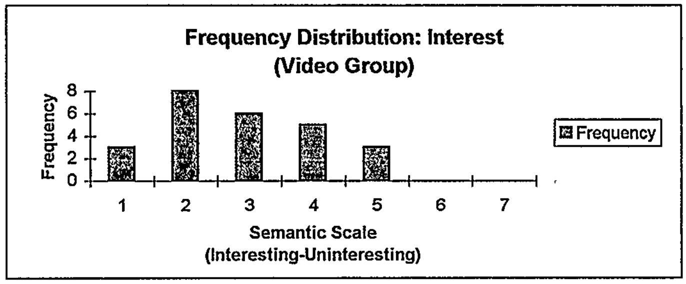
Data Values (Semantic Scores)		
Video	Animation	
2	3	
5	5	
2	2	
5	1	
2	1	
3	6	
2	2	
1	2	
1	2	
4	3	
4	4	
4	5	
1	1	
3	1	
4	2	
3	2	
2	3	
3	1	
4	1	
5	6	
3	3	
2	3	
2	2	
2	3	
3	2	
2.88	**2.64**	Mean
25	25	N

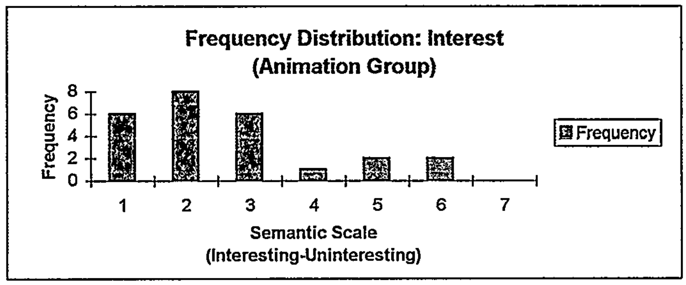
Video

Bin	*Freq.*
1	3
2	8
3	6
4	5
5	3
6	0
7	0

Animation

Bin	*Freq.*
1	6
2	8
3	6
4	1
5	2
6	2
7	0





Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Video	25	72	2.88	1.52666667
Animation	25	66	2.64	2.32333333

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.72	1	0.72	0.37402597	0.5437038	4.04264711
Within Groups	92.4	48	1.925			
Total	93.12	49				

$\alpha = 0.05$

Hypothesis Testing

$H_0 : \mu_1 = \mu_2$

H_A : both μ's are not equal

Test statistic: F

Reject H_0 if F* > $F_{0.05,1,48}$ = 4.043

From the table above, F* = 0.374

Since 0.374 is not greater than 4.043, we FTR H_0.

Based on the sample data, there is insufficient evidence to conclude that the means between the video and animation groups are not the same.

Interest: Emotional-Unemotional Semantic Differential Scale

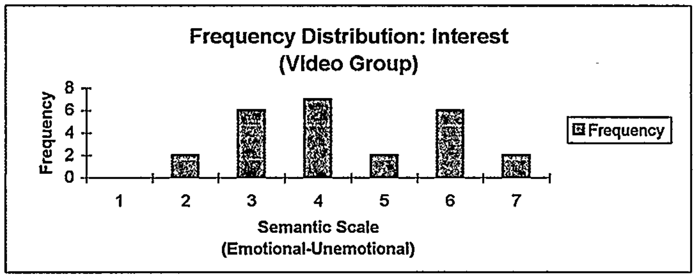
Data Values (Semantic Scores)	
Video	Animation
6	5
6	7
3	3
4	2
5	3
4	7
7	4
3	4
4	4
6	6
4	6
6	4
4	4
3	1
2	1
3	7
3	5
6	4
6	5
7	6
5	7
2	5
4	4
4	5
3	3
4.40	**4.48**	Mean
25	25	N

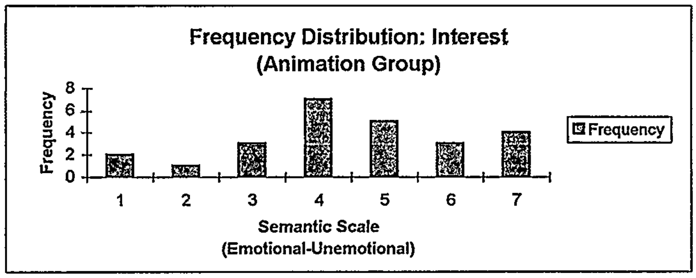
Video

Bin	*Freq.*
1	0
2	2
3	6
4	7
5	2
6	6
7	2

Animation

Bin	*Freq.*
1	2
2	1
3	3
4	7
5	5
6	3
7	4





Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Video	25	110	4.4	2.25
Animation	25	112	4.48	3.01

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.08	1	0.08	0.03041825	0.86227815	4.04264711
Within Groups	126.24	48	2.63			
Total	126.32	49				

$\alpha = 0.05$

<u>Hypothesis Testing</u>

$H_0 : \mu_1 = \mu_2$

H_A : both μ's are not equal

Test statistic: F

Reject H_0 if $F^* > F_{0.05,1,48} = 4.043$

From the table above, $F^* = 0.304$

Since 0.304 is not greater than 4.043, we FTR H_0.

Based on the sample data, there is insufficient evidence to conclude that the means between the video and animation groups are not the same.

Familiarity vs. Media Type

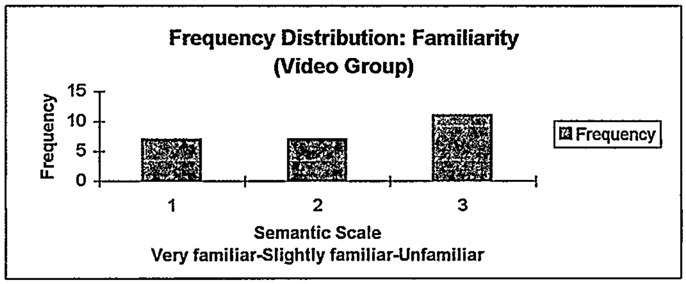
Data Values (Semantic Scores)	
Video	Animation
2	3
1	3
3	3
1	2
2	1
3	2
3	2
1	2
3	3
3	3
2	3
3	2
3	3
1	3
1	2
1	3
3	2
2	3
2	1
3	2
3	2
1	1
2	1
2	3
3	2
2.16	**2.28**	Mean
25	25	N

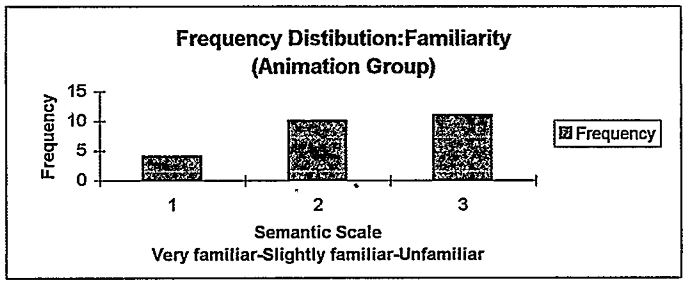
Video

Bin	Freq.
1	7
2	7
3	11

Animation

Bin	Freq.
1	4
2	10
3	11





Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Video	25	54	2.16	0.72333333
Animation	25	57	2.28	0.54333333

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.18	1	0.18	0.28421053	0.59641454	4.04264711
Within Groups	30.4	48	0.63333			
Total	30.58	49				

$\alpha = 0.05$

Hypothesis Testing

$H_0 : \mu_1 = \mu_2$

H_A : both μ's are not equal

Test statistic: F

Reject H_0 if $F^* > F_{0.05,1,48} = 4.043$

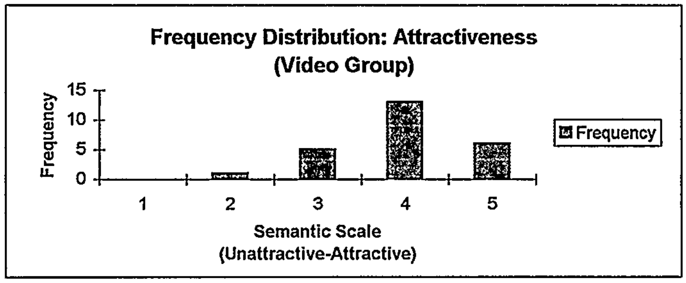
From the table above, $F^* = 0.284$.
Since 0.284 is not greater than 4.043, we FTR H_0
Based on the sample data, there is insufficient evidence to conclude that the means between the video and animation groups are not the same.

Attractiveness vs. Media Type

Data Values (Semantic Scores)	
Video	Animation
5	2
4	3
4	5
4	4
4	5
4	3
2	5
3	4
5	5
4	4
4	3
5	4
4	4
4	5
5	4
3	3
5	4
3	5
4	5
3	4
4	3
4	4
4	5
3	3
5	4
3.96	**4.00**	Mean
25	25	N

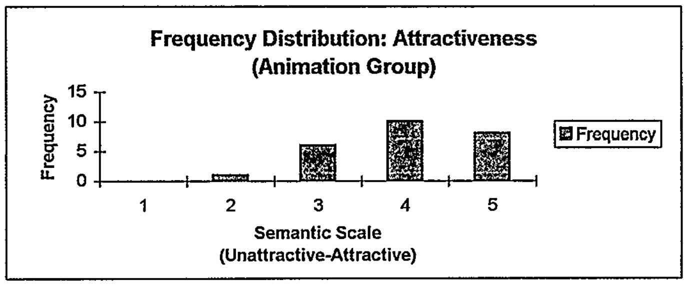
Video

Bin	*Freq.*
1	0
2	1
3	5
4	13
5	6



Animation

Bin	*Freq.*
1	0
2	1
3	6
4	10
5	8



Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Video	25	99	3.96	0.62333333
Animation	25	100	4	0.75

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.02	1	0.02	0.02912621	0.86520531	4.04264711
Within Groups	32.96	48	0.68667			
Total	32.98	49				

$\alpha = 0.05$

<u>Hypothesis Testing</u>

$H_0 : \mu_1 = \mu_2$

H_A : both μ's are not equal

Test statistic: F

Reject H_0 if $F^* > F_{0.05,1,48} = 4.043$

From the table above, $F^* = 0.029$.

Since 0.029 is not greater than 4.043, we FTR H_0.

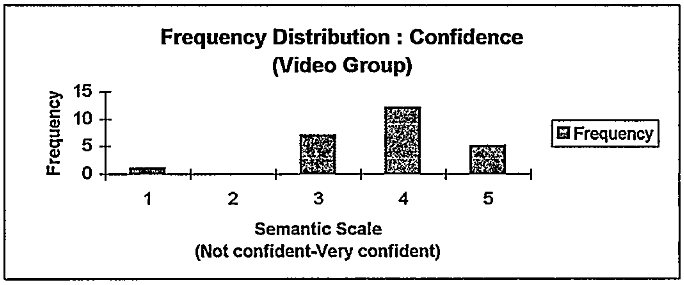
Based on the sample data, there is insufficient evidence to conclude that the means between the video and animation groups are not the same.

Confidence vs. Media Type

Data Values (Semantic Scores)	
Video	Animation
4	4
1	5
3	4
3	4
3	4
5	2
4	1
4	4
4	3
5	3
3	5
4	4
5	4
4	4
5	2
3	3
4	1
3	5
5	2
4	2
4	4
4	3
4	3
4	4
3	3
3.80	**3.32**	Mean
25	25	N

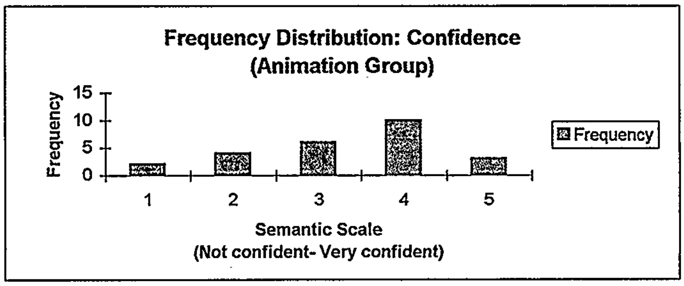
Video

Bin	*Freq.*
1	1
2	0
3	7
4	12
5	5



Animation

Bin	*Freq.*
1	2
2	4
3	6
4	10
5	3



Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Video	25	95	3.8	0.83333333
Animation	25	83	3.32	1.31

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	2.88	1	2.88	2.6874028	0.10768329	4.04264711
Within Groups	51.44	48	1.07167			
Total	54.32	49				

$\alpha = 0.05$

Hypothesis Testing

$H_0 : \mu_1 = \mu_2$

H_A : both μ's are not equal

Test statistic: F

Reject H_0 if $F^* > F_{0.05,1,48} = 4.043$

From the table above, $F^* = 2.69$.

Since 2.69 is not greater than 4.043, we FTR H_0.

Based on the sample data, there is insufficient evidence to conclude that the means between the video and animation groups are not the same.

Attractiveness versus Education

Video	
Design	Non-Design
5	4
4	5
4	3
3	4
5	4
3	4
4	4
5	4
3	4
4	4
	5
	2
	3
	4
	5

Anova: Single Factor: Video (P<0.05)

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Design	10	40	4	0.66666667
Non-Design	15	59	3.933333333	0.63809524

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.026667	1	0.026666667	0.04107143	0.841182	4.279343102
Within Groups	14.93333	23	0.649275362			
Total	14.96	24				

Hypothesis Testing: Video (P<0.05)

$H_0 : \mu_1 = \mu_2$

H_A : both μ's are not equal

Test statistic: F

Reject H_0 if $F^* > F_{0.05,1,23} = 4.2793$

From the table above, F* = 0.04107.

Since 0.04107 is not greater than 4.2793, we FTR H_0.

Based on the sample data, there is insufficient evidence to conclude that the means between the design and non-design groups are different.

Animation	
Design	Non-Design
3	5
5	5
2	4
3	4
4	5
3	4
5	4
3	5
5	4
3	4
4	4
5	3
4	

Anova: Single Factor: Animation (P<0.05)

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Design	13	49	3.769230769	1.02564103
Non-Design	12	51	4.25	0.38636364

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1.442308	1	1.442307692	2.00348432	0.170337	4.279343102
Within Groups	16.55769	23	0.719899666			
Total	18	24				

Hypothesis Testing: Animation (P<0.05)

$H_0 : \mu_1 = \mu_2$

H_A : both μ's are not equal

Test statistic: F

Reject H_0 if $F^* > F_{0.05,1,23} = 4.2793$.

From the table above, F* = 2.003.

Since 2.003 is not greater than 4.2793, we FTR H_0.

Based on the sample data, there is insufficient evidence to conclude that the means between the video and animation groups are different.

Confidence versus Education

Video	
Design	Non-Design
4	3
4	4
1	4
3	5
5	3
4	4
4	5
3	4
3	5
3	4
	4
	3
	5
	4
	4

Anova: Single Factor: Video (P<0.05)

SUMMARY

Groups	Count	Sum	Average	Variance
Design	10	34	3.4	1.15555556
Non-Design	15	61	4.06666667	0.4952381

ANOVA

Source of Variation	SS	df	MS	F	P-value
Between Groups	2.66666667	1	2.66666667	3.53846154	0.07268077
Within Groups	17.3333333	23	0.75362319		
Total	20	24			

Hypothesis Testing: Video (P<0.05)

$H_0 : \mu_1 = \mu_2$

H_A : both μ's are not equal

Test statistic: F

Reject H_0 if F* > $F_{0.05,1,23}$ = 4.2793

From the table above, F* = 3.538.

Since 3.538 is not greater than 4.2793, we FTR H_0.

Based on the sample data, there is insufficient evidence to conclude that the means between the design and non-design groups are different.

Animation	
Design	Non-Design
4	5
3	5
3	1
2	3
2	4
2	3
5	4
3	4
3	4
4	4
4	4
1	2
4	

Anova: Single Factor: Animation (P<0.05)

SUMMARY

Groups	Count	Sum	Average	Variance
Design	13	40	3.07692308	1.24358974
Non-Design	12	43	3.58333333	1.35606061

ANOVA

Source of Variation	SS	df	MS	F	P-value
Between Groups	1.60025641	1	1.60025641	1.2334522	0.27821297
Within Groups	29.8397436	23	1.29738016		
Total	31.44	24			

Hypothesis Testing: Animation (P<0.05)

$H_0 : \mu_1 = \mu_2$

H_A : both μ's are not equal

Test statistic: F

Reject H_0 if F* > $F_{0.05,1,23}$ = 4.2793.

From the table above, F* = 1.233.

Since 1.233 is not greater than 4.2793, we FTR H_0.

Based on the sample data, there is insufficient evidence to conclude that the means between the video and animation groups are different.

APPENDIX 3

HARDWARE AND SOFTWARE COSTS

This appendix provides information on equipment and software costs of doing in-house visual simulations. Due to the intensive amount of graphics processing involved, a high-end computer is required, with lots of memory and secondary storage space. It must be remembered, however, that the computer industry is a very dynamic and volatile one; prices often change quickly over a period of a few months, weeks, or even days.

Due to rapid advances in microprocessor technology, computers that are nearly twice as fast as their predecessors reach the market every 2-3 years, usually for the same price. Today's high-end workstation is tomorrow's home computer.

Hardware Requirements

The following equipment list should be considered as minimum requirements for doing visual simulations:

Estimated cost ($CAN)

Pentium-class microcomputer (100 MHz or better)
with the following features:

64 MB of RAM
2.0 Gigabyte hard drive
17 inch VGA monitor (0.25 dot pitch)
Pointing device (stylus pen and tablet are best)
Fast video display card, capable of 16 million
colours at high resolutions.
External 1 Gigabyte hard drive
System total $6500.00

Flatbed scanner (for creating image maps) $600.00

Colour inkjet printer (for printing out still images in full colour).................. $500.00

Software

At the present time, a number of software packages are available on the market which are capable of doing visual simulations. They vary in price, functionality, and ease of use. The number of features increases with price, as does flexibility. Higher end software tends to have more features, but also tends to have a higher learning curve. Lower end software tends to be easy to use, but often lacks important features that are needed.

A number of factors will influence which software package is best suited for the individual or department:

- Staff time required to learn the software
- Ease of use
- Compatibility with existing data (most software will import AutoCAD files, but how well they do so varies)
- Compatibility with the existing operating system (some packages run under DOS, some in Windows, some of the newer versions require Windows NT).

Some of the more popular 3-D modeling and animation packages on the market include Truespace, Lightwave, and Autodesk 3D-Studio. The price of the software ranges from a few hundred dollars to a few thousand. A good 3-D modeling and animation package for professional use runs in the neighborhood of $3500.00

Image processing software is also required to create the image maps that will eventually be applied to the wire-frame models. Adobe Photoshop is commonly used. The cost for this package runs around $700.00.

Transferring Images to Video tape

In order to use computer animations at public meetings, it is necessary to have the images transferred to video tape. This can be expensive, with service bureaus charging up to a dollar a frame (a typical animation runs 150-1000 frames). While there are low-cost techniques available for producing a video tape, the image quality is lessened. Special video hardware boards are available which allow 30 fps playback and recording of animated images on IBM compatible computers; these boards require dedicated hard drives, and cost in the neighborhood of $1500 to $2500.

The total cost of all the above is approximately $11,000 - $15,000.