A comparative study of visual elements

in traditional art images and computer graphics

by

MIA JOHNSON

B.Ed., Simon Fraser University, 1971

Diploma, Emily Carr College of Art and Design, 1980

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF

THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF ARTS

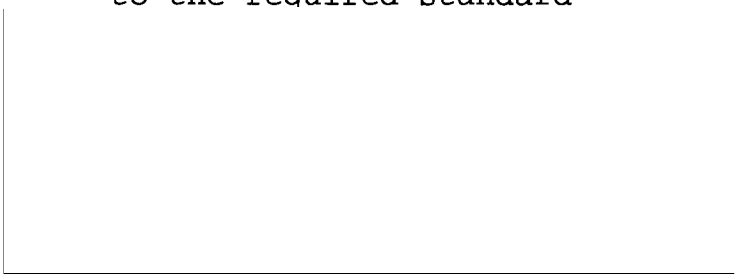
in

THE FACULTY OF EDUCATION

Department of Visual and Performing Arts

We accept this thesis as conforming

to the required standard



The University of British Columbia

September 1993

In presenting this thesis in partial fulfilment of the requirements for an advanced degree at the University of British Columbia, I agree that the Library shall make it freely available for reference and study. I further agree that permission for extensive copying of this thesis for scholarly purposes may be granted by the head of my department or by his or her representatives. It is understood that copying or publication of this thesis for financial gain shall not be allowed without my written permission.

(Signature) _____

Department of Visual and Performing Arts in Education

The University of British Columbia
Vancouver, Canada

Date September 30, 1993

ABSTRACT

This study examines visual elements in two-dimensional art imagery, and compares and contrasts traditional art images with computer graphics. The formalist model of aesthetic response is used as a lens to examine "elements" and "principles" in what has been called the "language of art". Formalist orientations to art education and computer graphics are analyzed through a literature search, a domain analysis, and ethnographic data.

This study employs qualitative research methodology. Data is presented in a comparative taxonomy of elements and principles in art education and computer graphics, and a componential analysis of the visual structure of two-dimensional images.

The findings demonstrate that formalist terms and concepts are not explicit enough to describe computer graphics. The formalist tradition in art education must be expanded to include new terminology and concepts about making and responding to art.

TABLE OF CONTENTS

LIST OF TABLES

PAGE

TABLE

LIST OF FIGURES

PAGE

FIGURE

ACKNOWLEDGMENTS

I would like to thank my advisor, Dr. Ron MacGregor, for his dedication and interest in this study, and for his many interventions and suggestions.

I would like to thank my committee members, Dr. Anna Kindler and Dr. Marvin Westrom, for their helpful suggestions at critical stages.

This study would not have been possible without the assistance of Kevin Arthur and Gary Sim, who acted as consultants for computer graphics. I would also like to acknowledge the anonymous contributions of the eight subjects in this study, who volunteered their valuable time and expertise so I may benefit from their knowledge.

CHAPTER I

INTRODUCTION TO THE STUDY

General statement

The expanding capacities of electronic technology have affected almost every aspect of life in the last decade of the 20th Century. This has forced revision of some ways of thinking, and created opportunities for expansion of others. One of the consequences of considering electronic technology as an active contributor to art production and art criticism has been the need to expand the formalist tradition in art education. Formalist terms and concepts, originally conceived to describe or account for the visual structures in traditional art forms such as painting and sculpture, are sometimes not applicable nor explicit enough to describe these new families of visual images.

While much recent work in the field has focused on sociocultural issues in art education, issues of visual structure have been equally in need of attention. In an attempt to redress the balance between the study of sociocultural issues and formal elements that underpin art education, this study proposes the investigation of a structural model for art criticism and aesthetics, expanded

and enhanced by consideration of technologies for computer graphics.

Background to the problem

Art educators talking about visual images and objects are likely to draw upon paradigms based on formalist art criticism and aesthetics. They do so because those paradigms are common in the literature, and generally form the bulk of courses in criticism taught at the undergraduate level. Formalist terminology and concepts are well-established and tacitly understood. As Feldman points out, "Formalism exercises a profound influence on art instruction, in schools, as well as college and university art departments" (Feldman, 1992, p. 122).

Traditional art terms and inquiry practices are considered useful for developing mental structures or "lenses" (Broudy, 1972) for understanding all kinds of art and the built environment (Greer, 1993). However, the fit is often uncomfortable and sometimes impossible, even to non-representational forms of art. For example, Hobbs questions, "How does one explain away the absence of the principle of 'dominance and subordination' in the prolix linear patterns of a Pollock, or the 'balancing of unequal

but equivalent oppositions' in the coldly redundant stripes of a Riley or the steel boxes of a Judd?" (Hobbs, 1993, p. 105).

Formalist art philosophy continues to be entrenched in such contemporary philosophies as the Getty Foundation's popular Discipline-Based Art Education, commonly known as DBAE (Apple, 1988). However, art educator Nancy Johnson admonishes that the field should not necessarily accept any inherited paradigm as clear or fixed. From an overview of the history of design, she concludes that "parts of the concept of design are continually in the process of dying, being re-born, transformed or modified" (Johnson, 1992, p. 152). Thus, while many art educators have turned their attention to sociological and cultural issues, a number of art educators are focusing on the reevaluation of formalist art education as an appropriate paradigm for an increasingly technological world (Feldman, 1992; Pearse, 1992; Hobbs, 1993).

A number of studies and articles have in turn focused specifically on the impact of computer technology on traditional art education (Varro, 1992; Freedman, 1991). In general, the electronic age and associated technologies for generating and responding to visual images and objects,

such as computer graphics, have created not only a new vocabulary but new ways of conceptualizing information about visual structure that permit the description and analysis of fine art images and objects in ways that do not fit the traditional modes of description. The languages of newer media provide understanding about image and object characteristics that may be useful, even crucial, to a more comprehensive mode of response than is possible using the elements and principles of design, or formal modes of art criticism (Freedman & Relan, 1992).

However, as Johnson points out, "Art educators proposing an increase in the conceptual content of art instruction need to resolve the unexplored issues which surround design as a basic art concept" (1992, p.152). She notes that art educators have taken inconsistent but persistent positions on the concept of design. For example, it is unclear whether principles of art are rules of composition or laws, and whether there are three, five, or six elements of art (1992). Lauer concurs, "It seems that no two designers will ever agree on the same list of design elements and principles - or on which are which " (1979, p. v).

Qualifications for developing this research: A personal ground

As an art reviewer for the past 13 years, I have occasionally been called upon to review two-dimensional computer art. This has posed two dilemmas for me. These images are static, yet at the same time digital and electronic. In what context should I describe computer art: in the context of other digital, electronic art such as video art and animation, which, however, employ movement and the dynamics of time and change; or in the context of traditional two-dimensional art such as painting and drawing, which, while static, results from analog and hand-crafted techniques? If I choose to review these examples of computer art in the context of traditional art, how does my choice then affect the theories and the language by which I review traditional art?

As a professional artist between 1972 - 1986, I was unavoidably influenced by the recognition of photography as a visual language in the art world during these years. While photography is not "made-by-hand" in the same direct way that traditional paintings and drawings are created, much photography was based on traditional elements and principles of design such as composition within the format

and elements placed to create eye movements between them. I observed photography gradually changing art: legitimizing a documentary bias, underscoring notions about field of view and depth of field, and affecting the way traditional art images were scaled, framed or cropped. I observed language originally unique to photography slip sideways into the public and educational domains. Terms and concepts like "selection", "focal point", and "image development" became an accepted part of traditional art discussions and teaching, and were applied to traditional art images.

I perceive that students today are being influenced by the emergence of computer graphics as a visual language in much the same way that artists of the 70's and 80's were influenced by photography. As computer graphics becomes as accessible to the average child or home user as photography now is, there is a definite need to consider how images created by computer graphics might affect traditional theories of art - and vice versa.

It would seem useful to research and analyze the terms and concepts used by art educators to teach, criticize and discuss visual images, and to research and analyze those employed by traditional artists as well as by computer artists and educators, in order to explore the possibility

of expanding the formalist framework for discussing art images in art education. "By changing the parameters of the discussion," Glasser notes, "research generalizations and concepts alter people's understanding of the situation, highlight new issues, change the facets of the problem, help to re-order their priorities, extend the range of alternatives they consider, and allay certain uncertainties and anxieties" (Glasser et al, 1983, p. 427).

Purpose of the study

The purpose of this study is to describe the state of "what is" by examining and comparing expert theory and practice. The investigation will have five facets:

1. To examine formal elements and principles of design in art;

2. To examine terms and concepts in one area of visualization technology: that of computer graphics;

3. To show how terms and concepts in computer graphics have expanded mental frameworks of understanding and discourse about visual images;

4. To find out how vocabulary and conceptual categories underlying computer graphics might be integrated with formal art criticism methods of analysis and description, to

provide a more adequate description and analysis of the visual structure of images and objects;

5. To show how the integration of certain vocabulary, concepts and methods used by computer artists might aid art educators, by providing an expanded - or at least a transitional - framework for responding to, or discussing, visual structure in art.

Research questions

1. What are the terms and concepts currently employed in the *literature* of formalist aesthetics and art criticism that lend themselves directly to description and analysis of the visual structure of images and objects?

2. What are the terms and concepts currently employed by *artists and art educators* to describe and analyze the visual structure of images and objects?

3. What are the terms and concepts employed in the *literature* of computer graphics and computer graphics programs that lend themselves directly to description and analysis of the visual structure of images and objects?

4. What are the terms and concepts currently employed by *computer artists and computer graphics educators* to describe and analyze the visual structure of images and

objects?

5. How may existing formalist notions be enhanced or redefined by the analysis of responses to questions 1-4?

Design and methodolgy

This study was conducted in three stages: a conceptual analysis of terms found in literature and the construction of a comparative taxonomy; interpretation of data from interviews with professionals in art, art education, computer graphics, and computer graphics education; and the componential analysis of conceptual categories for describing and analyzing the visual structure of images and objects.

Procedures

1. A domain analysis of visual elements and principles in traditional art images and computer graphics was developed. The domain analysis identified terms and concepts related to describing and analyzing the visual structure of images and objects in both fields, through literature searches of texts, journals, computer program manuals, and art education curriculum materials.

2. A comparative taxonomy of visual elements and principles in traditional art images and computer graphics

was developed.

3. Four stimuli were chosen. Each one exemplified different elements and principles of design, as well as the terms and concepts used by computer graphic artists and educators.

4. Eight informants were identified: 2 computer graphics artists, 2 computer graphics educators, 2 traditional artists, and 2 art educators. In order to obtain samples that were information-rich, purposeful sampling strategies were used, with network selection and reputational-case selection.

5. Semi-structured interviews with the eight informants were conducted, in order to contextualize the information in the taxonomies. Informants were shown the stimuli and asked to describe and explain the visual structure of each image in their own terms. Prompts were used when necessary to direct attention to particular areas or to unifying elements. Informants were also asked to comment on connections between the way computer artists and traditional artists (or computer graphics educators and art educators) might talk about the same images.

6. Interview data was analyzed for the use of all terms and concepts that described the visual structure of images.

7. A componential analysis was developed in three parts: differences and similarities between design vocabularies, concepts about the elements and principles of art, and issues in computer art and traditional art.

Data analysis and presentation

This study used inductive data analysis in order to facilitate discovery of terms and concepts in the fields; to gauge the applicability of the data; and to categorize and order the data.

The data is presented as:

1. A domain analysis of art education and computer graphics literature;

2. Comparative taxonomies of terms and concepts used to describe traditional art images and computer images;

2. An analysis of terms and concepts found in the interview data;

3. A componential analysis of design vocabulary, elements and principles, and conceptual issues.

Limitations of the design

This study specifically focused on images which could be described as "art images", "illustrations" or "pictures", rather than on graphics or text. It was also concerned with

computer visualization techniques for producing computer art only, not on scientific visualization.

This study focused on the formal qualities of visual images, rather than on their expressive or sociological qualities.

The study sought to examine the visual structure of completed images, rather than the computer procedures or traditional studio processes used to create them.

CHAPTER II

REVIEW OF THE LITERATURE

Introduction

It is often pointed out by computer critics that much of what is considered computer art today will one day, due to its imitative nature, be seen only in the context of earlier art traditions, while art made with the computer in the future will be nothing we can yet imagine. Commenting on the significance of traditional art to computer graphics, technology educator Mihai Nadin points out, "It is not that, in the age of information processing, tradition or tradition-rooted forms of human practice cease; they are complemented by new forms, some impractical or even impossible in previous paradigms of thinking and creating. Two lines - one of continuity that establishes itself as an implicit reference and another of uncompromising revolution/radical change - could represent the topology of the space of artistic or scientific exploration" (Nadin, 1989, p. 43).

Conversely, commenting on the significance of the computer to traditional art, Edward Pope remarks, "Since the computer has an unparalleled capacity to generate,

transform, store, replicate and disseminate imagery, then there is little doubt that the computer will [continue to] figure preeminently in the image making that goes on in our society" (Pope, 1988, p. 328).

This literature review seeks to address the impact of computer art today on traditional, formalist response to art; first, by examining formalist orientations to art education, then by examining the incorporation of formalist approaches in computer art. This evaluation of formalist orientations in the two different fields of image-making is an important step towards establishing grounds for a comparative taxonomy of visual elements found in images in both fields.

This literature review will also examine recent issues in the theories and assumptions underlying both traditional art and computer art of the late 1990's. Issues will be particularly relevant to the componential analysis and the assessment of implications for art educators at the end of this study. "When considering a new medium, and certainly the computer is a new one and can hardly be talked about in historical terms, theory is implicitly an issue, since change is invoked" (Pope, p. 323).

Formalist orientations to art education

Introduction

Art educator Vincent Lanier has noted that aesthetics is distinguished from other areas of artistic study in that it focuses on viewers of art (1986). Formalism can be understood as one of many aesthetic models which a viewer might adopt or be taught. It is a way to view and appraise art images. Formalism "postulates an idea of permanent or residual aesthetic value", thus creating a "search for value within objects" (Crozier & Greenhalgh, 1992, p. 83-4). In other words, the form or appearance of art images is believed to generate aesthetic response in the viewer. This occurs through what has been described as "a kind of language, within which symbolic and formal conventions are organized into coherent constructs similar to a grammar" (Ackerman, 1966, p. 395). For example, such various parts of an image as line, shape or pattern might be perceived as interacting with each other and creating such overall effects as a sense of balance, harmony or rhythm. Identifiable parts of an image are often described as sensory elements, while their interactions and relationships are described as formal principles. In the Western world, formalist theory treats art images as self-contained designs

which generate their own aesthetic.

The history of formalism in art education

Crozier and Greenhalgh believe that Clive Bell's book Art, published in London in 1914, can be credited with mapping out much of the territory of the aesthetic concerns of formalist theory. From Bell, they note, art critics and educators have inherited the idea of "pure form", or an object-oriented aesthetic (Crozier & Greenhalgh, 1992, p. 84). As a confirmed formalist, Bell positioned the aesthetic element inside the object, rather than in its context.

Art education in North America has not always been concerned with aesthetic response. In the past three decades, American art educator Ralph Smith has been influential in moving the concerns of American art education away from early industrial and technical orientations, and, later, social and child-centered orientations, towards an aesthetic study. In 1966 he wrote, "Any work of art in any medium can be examined and evaluated with respect to the following factors: (a) the sensuous materials, (b) the manipulation (technique), (c) the formal design"; as well as its "expressiveness or significance", its "interest" to perception, and any "extra-aesthetic functions it happens to

serve" (Smith, 1966, p. 37). "The important point," he continued, "is that discriminations among the sensory qualities can be made and assertions about them can within reasonable limits be verified. Educationally, moreover, such discriminations can be learned".

Harold Broudy, known in art education as the "father of aesthetic scanning", proposed the concept of scanning during the 1970s as a way of learning sensory discrimination. "Aesthetic scanning, as discussed by Broudy (1972), consists of an examination of the sensory, formal, expressive, and technical aspects of an art object... For example, the abilities to discriminate among design elements, to categorize visual and tactile characteristics, to see underlying structure, and to perceive principles of design are cited as parts of aesthetic perception and aesthetic study" (Hamblen, 1987, p. 82).

Formalism is a rationalistic tradition, with a belief in a world that is separate and external to the viewer. Beverley Jones, an educator with particular interests in art and computers, places formalism in the context of objective realism, which refers to a set of conventions and constructs invented by humans. In the objective realist's view, "reality is structured in such a way that it can be modeled

by a set of theoretical models. That is, the world consists of entities, the properties of those entities and the relations holding among those entities" (Jones, 1989, p. 34).

The elements and principles of design

The impact of the formalist tradition on art education literature is manifested in the many programs and textbooks which delineate specific properties of artistic entities. The delineation of elements and principles was first popularized by an American art educator named Arthur Wesley Dow (Chapman, 1992), and quickly became a formularized method for teaching aesthetic response in the schools. Art educator Dorothy Malcolm describes design as "the act of arranging things to create a single effect. In design, the elements are the things we work with; the principles are what we do with them" (Malcolm, 1972, p. 7). She specifies the following design elements: space, line, shape, color, value, and texture; and the following design principles: balance, movement, repetition, emphasis, contrast and unity. She applies these terms to a wide range of two- and three-dimensional art mediums that includes graphic mediums, painting, sculpture, assemblage, printmaking, textiles, and ceramics.

In a popular art education text, Lauer (1979) notes that while it is customary in art appreciation to present the elements of design first, in a studio course the principles of organization are more fundamental and have a higher priority for practicing students than do particular elements. He focuses on principles of unity, emphasis and focal point, balance, scale and proportion, and on the elements of line, form, texture, illusion of space, illusion of motion, rhythm, and color. He demonstrates the use of these elements and principles with examples of graphic mediums, painting, photography, architecture, assemblage, and sculpture.

Elements and principles are often described in art education literature as the "language of art". Ocvirk, Bone, Stinson and Wigg (1982) describe all works of art as "unique form experiences" we learn to "read" through their "formal roots". The authors believe these roots which compose the language of art give art a "core of universality" (p. 33). The formal roots or "visual signs" are line, shape, value, texture and color. Two principles of organization are manipulated to give art its form: harmony (involving rhythm/repetition) and variety (involving contrast/elaboration). Both harmony and variety employ

balance, movement, proportion, dominance, economy and space to produce unity. The authors also apply these terms to a wide range of 2D and 3D mediums, including graphic mediums, painting, sculpture, assemblage, printmaking, textiles and ceramics.

Two ideas are conveyed in these texts by Malcolm, Lauer, and Ocvirk: first, that there are a finite number of elements and principles, and second, that formalism can or should be applicable to all art images regardless of their medium, function, or intent.

Formalist orientations in computer graphics

Introduction

Whether or not computer art eventually changes its entire nature, direction, and contextual referents, it is currently, like photography, what Galassi would call "a legitimate child of the western pictorial tradition" (Jones, 1989, p. 31). Computer art to date has been firmly entrenched in the formalist tradition. As Jones points out, "Artists create self-conscious art", and computer art has been no exception. "Appropriations of stylistic conventions or earlier art forms, especially modernist formalism, Op art and Renaissance perspective, are evident throughout the

early history of computer graphics" (p. 36). Nadin (1989) believes that in the process of appropriating the new technology, "traditional artists, technologists and scientists have acted to preserve modes of expression they believe in, like, or have tried to explain" (Nadin, 1989, p.44). For example, even "visualization of highly diversified spaces, 3D (virtual space) explorations and color explorations are still treated according to the aesthetics of white paper or canvas" (p.44).

Many artists and educators, like computer educator Stephen Wilson, believe that history will show that the forms of computer art currently most familiar, such as computer graphics, are actually conservative art forms. "They are attempts to assimilate the new technologies to established art traditions" (Wilson, 1991, p. 434).

The history of computer art

Early computer art was much more explicitly concerned with formal elements than 3D computer visualization of the past five years has been. Jones points out how many examples of early computer art in the Western world bear resemblance to the work of modern formalists, by emphasizing purely formal relations of elements and principles of design. "Many works of early computer art may be considered

to express a concern for the relations of pure form, possibly ideal forms, generated with a concern for beauty and based in numerical relations... early computer art [may be analyzed in terms of] its *appropriation* of aesthetic structures and conventions" (Jones, p. 33).

Computer graphics of the fifties and sixties were primarily geometric and planar. They were based mainly on ideas drawn from the European Constructivist tradition - that of system, precision, geometry and structure - and, as Wright pointed out, the rigors of computer programming lent themselves easily to this approach (Wright, 1989).

In the 1960s, three-dimensional wireframe graphics were developed, with consequent development of hidden line algorithms, solid modeling, and lighting, texturing and mapping effects. Programs for three-dimensional modeling, which incorporate phenomena of biology and physics through routines such as fractals or ray-tracing, derive from a scientific tradition which seeks to invent algorithms for close imitation of the appearance of the external, "real" world. As Jones puts it, "A belief that symbolic representations may form an objective, one-to-one, value-free correspondence to reality is the basis for scientific realism. The symbols utilized may be mathematical or

graphic" (p. 35).

Algorithms are often described in computer literature in terms of a graphic "language". Algorithms are mathematical routines or procedures embedded in programs that cause (or enable) image effects, such as reflections or textures. In essence, by bundling up a number of commands that otherwise would have to be "keyed in" or entered separately, many imaging algorithms can provide useful electronic shortcuts to certain sensory appearances. Scientific realism is a form of objective realism. Algorithms for visual appearances in 3D graphics replace elements and principles in the computer art image, but are similarly based on visual response. Thus, while the referents of computer art in the past 25 years have shifted from constructivist geometry to bioscience, computer art continues to be concerned with what art educators would call the sensory aspects of image-making.

Many computer critics believe that, in this century at least, "developments in software algorithmic theory will continue to expand the repertoire of ideas requiring artistic exploration, such as fractals and object-oriented graphics" (Wilson, 1991, p. 435). Whether or not such art could continue to be subsumed to formalist theory, or

whether or not it *should* be, remains to be seen.

Design in computer art

Computer educators Kerlow and Rosebush (1986) describe the incorporation of computer technology into the fields of design and fine arts, and explore the functions and limitations of computers in the creation of images and objects. They agree that while early computer-generated art was predominantly two-dimensional, with a focus on geometric patterns, interpolation, and randomness, the development of interactive paint and illustration systems and three-dimensional techniques has focused attention on the simulation of reality.

They clearly explain differences between the visual language of three-dimensional graphics, which treats objects as virtual entities in a continuous environment, and the pixel representation form of discrete picture areas, such as those produced by Paint programs. While the former produces "seemingly tangible" imagery that may be similar to realist painting or photography, the latter, pixel matrices, have a long tradition in the graphic arts, including needlepoint, halftones, and weaving.

Friedhoff and Benzon (1989) suggest that to create three-dimensional objects within the computer requires the

invention of entirely *new* kinds of visual schemata, since visual and structural qualities of objects have to be defined mathematically. "In computer graphics", they write, "these mathematical techniques are usually called algorithms but they correspond, in many ways, to the art historian's schemata. As with schemata, a successful algorithm becomes part of an ever-expanding vocabulary among computer graphicists and profoundly influences both the conception and appearance of their images" (Friedhoff and Benzon, p. 84).

The purpose of Friedhoff and Benzon's book is to demonstrate how, since the central issue in 3D computer graphics today is naturalism or verisimilitude, computer graphic techniques and algorithms are influenced by the analytic structures of the visual system. Visual structure is in turn concerned with perceptual or sensory qualities such as three-dimensional modeling, shading, texture, pattern, variant color, and expanded palettes. Images tend to be described in this context, creating new algorithms and a recognizable visual language.

Many critics are concerned that commercial software for computer graphics, with their recognizable algorithms, provide the artist with what can only be a predictable range

of image appearances. Batty (1987) advocates that for an artist to be in full control of an image, the artist must write the original program as well as make design decisions, and do both at the same time. Batty demonstrates how conventional ideas about writing procedures and algorithms can be complemented at the same time with a wide range of design principles. These include the unifying ideas of hierarchical structure, iteration, randomness and constraint, the creative possibilities of temporal priority, and recursion, which will be discussed in the domain analysis of this study. They are supported with a variety of visual ideas involving points, lines, patterns, texture, 2D and 3D shapes, scale, edging, nesting, transformations, color mixing, color balance, and shading.

The message conveyed in these three computer art education texts is that formal and sensory aspects of image-making continue to be prominent, even in computer art created with original programming. Perhaps, as Franke (1985) suggests, "conventions of cultural reality embedded in hardware, software, and mental constructs of human participants may inhibit or preclude development of [new] models" of usage and application (p. 165).

Issues in computer art and traditional art

Introduction

Despite the impact of formalist paradigms on the history of computer graphics, it may be argued that computer art has not achieved an equitable status with what some may differentiate as "fine art". The question, Is computer art art? actually begs two others: what are the similarities and differences between "art" and "computer art", and what underlying assumptions confound these questions? An examination of prevalent attitudes and assumptions towards both traditional art and computer art is followed by a literature review of similarities and differences.

Assumptions about art and artists

One enduring (and perhaps endearing) myth is that artists are primarily concerned with intuition and spontaneity. For example, Franke writes, "Those practicing computer graphics are more at home with an exact science of art than artists who *confine themselves to intuition and spontaneity* (emphasis mine, Franke, 1985, p. 163). To support his claim that the "extreme rationality" of "sterile" computer calculations has alienated many artists, Hickman states, "Ever since the Romantic literary movement of the nineteenth century which challenged the rationalism

of eighteenth-century Neoclassicism, creativity has popularly been associated with the intuitive" (Hickman, 1991, p. 50).

Since many 20th century art educators have promoted artmaking as an intuitive, open-ended, spontaneous activity, it is small wonder these kinds of assumptions continue to be made by those outside the field. One legacy of this attitude in art education itself has been studio training which prioritizes experimentation with techniques and materials, rather than cognitive development. This bias has created a belief that in making computer art, as opposed to traditional art, "the act of artistic creativity *shifts from the manual* to those areas which have been described as cerebral", and that "the usual training by academics, *which is confined to manual skills*, is made superfluous by the facilitation of artistic production brought about by computers" (emphasis mine, Franke, p. 163).

Timothy Binkley, a prominent computer art educator, takes a more realistic view of artmaking. He points out that "the thinking activity is absolutely essential in order to construct a picture: the artist figures it out using manual tools, but without the mental process nothing happens". The role of the computer in art can thus be seen

as more of an active creative partner than a passive medium (Binkley, 1989, p. 17).

Another enduring myth is that artists work on the "edge", testing the limits of the status quo in art. However, artists using traditional elements and principles of design - and students being taught to use them to make art - are also simulating traditional forms of art. Gombrich's Art and illusion (1961) identified many of the codes and signifiers that artists employ to ensure continuity of communication, or the "readability" of the image.

Assumptions about computer graphics

Many practitioners regard the name "computer art" as unfortunate, since it implies that the content of the art is the computer. It is true that computers are bound to media, "but to no particular one, and hence work done with them can project all the different appearances of media currently in use" (Binkley, 1989, p. 19). Alan Kay, a computer theorist, points out that the computer is not merely a medium but a *metamedium*: "with the computer you can *create* media" (Hickman, 1991, p. 49).

The concept of the computer as metamedium in turn often creates the impression that the computer is some kind of

tool. Artists in particular appear prone to viewing the computer this way because they are accustomed to using intermediary devices, physically and materially oriented, to do particular things. However, the computer *per se* does not have the capability to be a tool. The computer organizes and activates tools in the forms of programs with specific capabilities. In other words, the computer is used to apply programs, like tools, to an idea. Each program, however, has limited capabilities. "Although a computer language is generative (allowing infinite possibilities), a computer program generally is not. For example, most paint programs only allow a fixed number of operations to be performed" (Hickman, 1991, p. 50).

The speed of execution and the fact that traditional manual skills are no longer a precondition for engaging in art further encourages the impression that making images on the computer is "cheap and easy" (Franke, 1985, p. 153). But, as Wright points out, the process of modeling and rendering can be arduous and demanding, both in terms of the mental effort and the basic knowledge required. In summary, it may be said that "[computer] art does not reflect how powerful technology is, but how powerfully it serves the artist's artistic means" (Nadin, 1989, p. 47).

Similarities between art and computer graphics

The first and most significant similarity between traditional art and computer graphics of this century has been the emphasis on formalist theory and response. When Lucas (1986) studied evolving aesthetic criteria for computer-generated art, he found that "traditional criteria remain an integral part of the aesthetic evaluation of this art form" (Jones, 1989, p. 31). The traditional criteria were formalist elements and principles. For example, five out of eight experts surveyed by Lucas agreed that "visual basics of harmony, symmetry and balance were applicable" (p. 31).

A second similarity is that both traditional art and computer art in hardcopy form are static objects which demand a certain kind of reception by the viewer. Pope describes how formalism, with its notion of art as a passive object to be scanned, and computer graphics, with its emphasis on output to a third party, share a bias towards a certain kind of triangulation: the artist, the art, and the viewer. "Within a theory of art must be included some explanation of how three essential agents of the art experience interact, that is, an implicit definition of the interrelationship, or mutual roles, of artists, artifact,

and audience." In formalist theory, he continues, "Interaction has conventionally been restricted to a physically passive role for the audience, a role marked principally by a mental activity and visual contemplation" (Pope, 1988, p. 326).

A third similarity between traditional art and computer graphics is commitment to experimentation, particularly of a conceptual kind. If the computer is attractive to the visual arts, it may be for its "inherent imaging capacity" (Pope, 1988, p. 323); that is, its ability to simulate the mind. The computer provides the means to implement a major art premise, that of experimentation, for which traditional media have provided relatively limited opportunities. Pope writes, "In many instances, the traditional media discourage broad experimentation due to technical limitations. For instance, in just the area of color theory and practice, media such as paint or colored paper result in as much or more time spent in mixing, cutting, drying, and other manipulative aspects than in simply observing and studying color phenomena" (p. 33). In terms of capacities for conceptual development, it would appear the computer and art are well married.

In addition to similarities concerning issues of visual

structure, there is concern in both fields for sociocultural aspects of art. Formerly, only programmers in technical institutes had access to computer graphics systems, renewing "the danger of being limited to elitist circles which has threatened modern art from another direction" (Franke, p. 163). The emergence of personal, portable computers has created an entirely new situation. Pope writes, "The impact of this concept, portability, is clear when one reflects back upon the effect that easel painting and tube paints had on the development of the history of painting" (p. 329). Commercially available programs and user-friendly interfaces allow easy access to computational forms of artistic effects; in many cases, easier access than can be achieved through traditional means. Some educators therefore fear that commercially available computer graphics systems will result "in a destruction of the prestige, the aura surrounding art... as well as the concept of art as an object of representation and as the symbol of a privileged class" (Adrian, 1986, in Franke, p. 165). Despite these protests, and at the same time as art educators are concerned with the democratization of art and its impact on traditional notions of value in art, computer critics expect a reevaluation of norms that have carried over from

mainstream art. "The digital medium is one of instant replication and perfect fidelity; therefore, the notion of the original, the aura of uniqueness, and the attraction of ownership will have to undergo reinterpretation and change" (Nadin, p. 46).

Differences between art and computer graphics

Using the medium of paint as an example, Binkley (1989) explored differences between traditional and computer art. The paradigmatic difference he sees between computers and media is that the former usually process information in digital form while the latter store it in analog form. In a traditional painting, the paint as an analog medium is the "repository of pictorial information" (p. 17), while the repository of computer art is the conceptual code of a digital format. Paint is literal and material; it does not exist in another form. Digital art is immaterial; it can be output in many forms.

Binkley also described traditional painting as a "locus defined by a set of manual tools and images". The artist's hand - via the tool - is responsible for every single mark made in an image. In computer art, using algorithms or pre-written mathematical procedures, the computer carries out or

completes many visual effects such as simulations of texture or area fills. "Some of the thinking burden carried by the artist using a constructive algorithm is shifted to the computer," Binkley writes. "Here we see clearly that what the computer does is quite unlike what a medium does. The computer 'thinks' - it calculates. Media cannot do this since they are physical and passive; the computer can since it is conceptual and active" (p.17).

Another significant difference is often noticed by critics who claim that computer art doesn't *look* like art. They refer, quite literally, to the surface appearance of digital images. Wright points out that although current programs provide almost all the graphic techniques one could think of, such as washes or graduated shapes, an electronic image has a synthetic and transitory character. It is almost immediately apparent that a computer image is not hand-crafted, since surfaces tend to be uniform and flawless. To aggravate the situation, many high-resolution computer images are so graphically slick that they carry an assurance of image rightness even beyond what they portray. Many have an "insistent, even authoritarian, accuracy that is overwhelming... It is as though the corporate power of the media had joined up with the methodological rigor of the

mathematicians and scientists to create some final, definitive and coercive depiction of the visual world" (Wright, p. 51).

Despite an increased use of fractals and chaos algorithms to introduce a stochastic or random element into computer art, computer art is still almost flawless and sometimes surprisingly passive for what is often called a dynamic graphic form. "As opposed to works of art that look better the more we look at them, electronic art seems to exhaust itself at the first encounter" (Nadin, 1989, p. 43). This may be a result of a kind of digital democracy. In the computer, all the materials assume the same status and can be freely mixed and matched. "Each element of the image can be processed equivalently with no respect for its semantic or perhaps even formal qualities" (Wright, p. 50). This downgrade into what Wright calls "visual fodder" affects the way we view computer art, resulting in a serious loss of signification (p.50).

The value of the artmaking process continues to lie in the experience of the artist. It continues to be important that the artist personally and directly made the artifact. Not only is visible evidence of the human hand valued, but a certain degree of order is expected. While computer art is

often criticized for appearing *too* orderly, it actually seeks to do the opposite and this forms the last paradigmatic difference.

Max Bense, a pioneer of simulated aesthetic design, sees the artistic process "as a kind of anti-process of natural phenomena, along the line that nature tends to bring forth chaos, while art permits the emergence of unlikely conditions of order" (in Franke, p. 156). While traditional art strives to bring order out of chaos, computer art seeks to introduce chaos into order. In computer graphics, the phenomenon of chance, which usually appears as a disturbance, turns out to be a *generative* principle. "As chance destroys order it creates more complex structures and achieves the unexpected, the unforeseen" (p. 162).

Computer graphics and art education

In 1991, artist and art educator Craig Hickman sadly stated that "it has taken over a hundred years for the history of photography to be recognized and taught in art history courses, and it might take as long for the computer's contribution to be acknowledged" (Hickman, 1991, p. 51).

The language of computer graphics is a major barrier to

the acceptance of digital images as art. Language allows us to both form and examine concepts. If we can't speak the language, we can't begin to enter into theoretical discussion. "Artists who work with computers may study programming and physics, and use an expanded vocabulary (i.e. paint programs, frame grabbers, and digitizers). It is difficult to find computer-generated art in most established art museums and galleries. We don't yet know how to think about it, look at it, talk about it, or categorize it" (Ettinger, 1988, p. 55). Linda Ettinger, a prominent computer art educator, points out that "[art] educators often lack an adequate vocabulary and a sense of disciplinary background necessary to begin to study the computer as an artistic medium" (p. 56), although it is seen by many art educators as a perfect fit for teaching design elements. This occurs, she suggests, because "...the underlying structure of the computer screen is parallel to traditional atomistic approaches to teaching the art elements as presented during the past fifty years in many art and design texts" (p. 56).

Nadin sees the opposite problem occurring in the field of computer graphics. Computer artists meet and "talk about pixels, megabytes, and call-up color tables," he notes.

"This language is necessary if we want to understand *how* we do what we do, but not *what* we do and *why* we do it" (Nadin, p. 48) Nadin claims that a theoretical foundation is relevant, despite a tendency on the part of critics, especially those in the United States, to focus on programming and technical discussions when writing about computer graphics. "A professional critic could hardly survive without well-established conceptions, without certain schemas of judgment which he applies to specific situations in forming his point of view. Such criteria usually derive from a background knowledge of art history and comprise insights deriving from the established state of art" (Franke, 1985, p. 153).

Ettinger concurs: "Along with teaching people to use computers comes the responsibility to direct a focus on critical study of the values underlying information-based technology, and simultaneously of the values underlying our field [that of art education] (Ettinger, p. 53).

Weitz (1962) described the attempt to define a theory of art as "a fool's errand", because the dynamics of art change according to time and place. "Art...has no set of necessary and sufficient properties". If this is true, it may be change or transition itself that is most worth studying.

There is no question that traditional theories of art are confronted with significant paradigm changes as the impact of technology gathers momentum in the last decade of this century. However, without a comparative study of the languages of technology and art, it is difficult, if not impossible, to explicitly assess the course and extent of theoretical change.

Summary

Though couched within a formalist tradition, employing elements similar to those of traditional art, and organized in a rational and objective manner, art made with computer graphics has aspects that are unlike or opposite to formalist theory.

In traditional art, the medium itself is a literal, contained, analog repository of information. In computer art, the conceptual code is digital and it can be output to hardcopy in many forms. While an artist's hand must guide every mark made with traditional media, many marks in computer images are "created" by the computer. Traditional images appear more hand-crafted than computer images, despite stochastic elements recently introduced in computer software. Traditional art and computer art proceed from

different intentions: the first to create order and organization, and the latter to generate the unforeseen and unexpected.

Formalist images are self-referencing; recent 3D computer graphics are world-referencing. The most significant difference may be Malcolm's statement that, in traditional art, "Elements are the things we work with; principles are what we do with them" (1972, p. 7). In computer graphics, principles are the things that are worked with, via procedures and algorithms, and the elements are what is done with them, via selections.

Other differences expand formalist notions rather than oppose them. The ideas of interactivity and transformability in computer graphics expand the notion of permanent or residual value. Techniques for replication and dissemination challenge the formalist notion of uniqueness, as do commercial programs. Perceptions of underlying structure and discriminations among sensory elements in formalist response are challenged by computer techniques for hidden element algorithms, cutting and pasting, and image manipulation.

While many art educators subsume computer graphics to formalist theory, whether appropriate or not, practitioners

and critics in computer graphics eschew computer art theory in favor of technical discussions. Ignorance of terminology in both fields is a barrier to articulating common theory.

CHAPTER III

DESIGN OF STUDY

Introduction to research design

Spradley (1980) identifies five research stages of ethnographic studies which seek to examine the role and meaning of language within cultural domains. These stages are: domain analysis, focused observations, taxonomic analysis, selected observations, and componential analysis.

A cultural domain is an intangible, often implicit area of knowledge, such as the knowledge of the visual analysis of art images. Domain analysis involves the identification of basic conceptual areas. In the visual analysis of art images, these may be areas of knowledge that include concepts of "line", "shape", or "balance". Further research provides verification and elaboration of basic concepts. Enriched detail is added in the form of focused observations, such as "broken" line, "two-dimensional" shapes, or "symmetrical" balance.

Language representing conceptual areas can then be structured into taxonomies or inclusive lists, and comparative taxonomies of similarities and differences (say, between cultures) can be developed. For example, the use of

the term "broken" line in response to an area of a traditional art image might refer to a line which has gaps, or is not continuous, while "broken" line in response to an area of computer art may refer to a line which is angular rather than straight. In the cultural domain of traditional art, the latter may be termed "zigzag".

Interviews with people who are immersed in a culture allow selected observations to be made about areas which require further analysis. Interviews can clarify the contextual use of language, and reveal situational applications.

A componential analysis can then be performed of each conceptual area. In a componential analysis, data from the taxonomic analysis can be compared and contrasted with interview data to form a profile of similarities and differences between cultural domains.

Domain analysis

Introduction

A domain analysis was made of terminology found in both art education and computer graphics literature. The analysis focused on terminology, verbs, and concepts used to describe or identify visual structure. Particular attention

was paid to vocabulary that described the elements and principles of art, and the visual structure of computer graphics rather than the procedures.

Procedure

Art education literature and computer program manuals used in this study (Appendix A) were selected on the basis of frequent and popular use. References recommended by art and computer graphics educators were explored, together with references frequently cited in the literature search. The suggested texts and program manuals were found to provide succinct summaries of concepts, and clear definitions of terms.

As the domain analysis developed, terminology in both fields was cross-referenced. For example, once the literature of art education was explored for terminology used to describe an element such as "line", the literature of computer graphics was similarly explored for concepts to do with the idea of "line". Terminology and descriptive language was variously found in text (Appendix B-1), listed in glossaries (Appendix B-2), and isolated in indexes (Appendix B-3) of both textbooks and program manuals.

Findings

In the art education and design sources examined, many references were made to formalist theory, the elements and principles of design, and terminology describing the visual structure of imagery. The search was terminated as the number of terms and concepts became finite.

As noted in the literature review, there appear to be a finite number of elements and principles. However, many discrepancies were noted in the categorization of characteristics, as Nancy Johnson (1992) had predicted. For example, Malcolm (1972) categorized repetition as a design principle on its own, which occurs when common elements are repeated regularly or irregularly to create rhythm (p. 93). Lauer (1979) classified repetition as one form of the design principle "unity", and described it as a "device" used to relate parts of the design to each other (p. 8). He classified rhythm as a design principle on its own, and related it to the movement of the viewer's eyes in terms of speed and smoothness (p. 141). Ocvirk et al. (1975) equated repetition and rhythm, which they describe as "agents for creating order out of forces that are in opposition" (p. 27). They stated that repetition is an essential ingredient of "harmony", which, with "unity", is one of their two major

design principles. Neither Malcolm nor Lauer list "harmony" as a principle or element.

Contradictions occurred not only in classifications of design principles but elements as well. For example, Lauer describes pattern as an irregular kind of texture, and thus an element (p. 208). Malcolm refers to pattern only briefly, as a result of a "system of repeating elements" (p. 96). Both Chapman (1992) and Ocvirk et al. categorized "pattern" as a principle rather than an element. Ocvirk et al. defined pattern in terms of value, or the "total effect of the relationships of light and dark within the pictorial field".

The number of elements and principles referred to in art education literature appeared stable or finite, despite differences in definitions and classifications. However, different terminology for characterizing elements and principles was noted in newer textbooks. For example, while in 1972 Malcolm used such geometric terms as "cubic" and "volumetric" to describe characteristics of three-dimensional shape and the term "perspective" to describe 3D space, in 1992 Chapman used terms more relevant to physics to describe shape and space, such as "solid", "ambiguous", "void", "scale", and "orientation". Chapman's terms would

suggest the incorporation of different modes of thinking about shape and space after twenty years.

Chapman (1992), like Ocvirk et al. (1982), continued to use associative and expressive terms to characterize elements, such as "dynamic", "active", "passive", "bold", "subtle" and "intense". This anthropomorphic approach to describing elements and principles was also noted in other art and design texts, and may be part of an older tradition of responding to art.

Two striking differences were noted between art education and computer graphics terms and texts. First, where formalist descriptions often related feelings or reactions, computer graphics terminology provided more specific detail about objective procedures and perceptual structures. For example, Ocvirk et al. described pattern as having "intrinsic meaning", or "supporting the emotional characteristics of a mood". The texts and manuals of computer graphics described details of selected patterns (including pen, brush, and area fill patterns), bitmaps, created patterns, and fractals, as well as procedures for duplication, replication and recursion in an objective manner, without conveying emotions. Terminology for aesthetic response, such as "bold" or "dynamic", was not

apparent in computer graphics. Second, art education texts relied heavily on examples of visual images rather than on words to define terms. Conversely, computer graphics texts were heavily oriented towards text.

It was difficult to formulate equations between formalist elements and principles and computer graphic elements and principles for two reasons. First, the milieu in which computer art takes place is very different from that of traditional art. In order to identify a computer graphics term such as "region" as a type of art education "shape", it was necessary to assess possible comparisons between the environments in which the terms operated. In computer graphics, the elements and principles appear to be "bound" to different types of space. In computer graphics, at least three kinds of "space" appear to exist, and the choice of space determines both the procedures and the effects that may be achieved or selected. Further, these spaces may be combined through "windowing", "layering", or "importing". It became apparent that ideas about space were going to require careful analysis and interpretation in subsequent stages of the study.

Second, it was soon determined that each formalist concept had more than one meaning and often more than one

design term. A concept like "shape", for example, had four (and possibly more) very different meanings in traditional art, such as a section of a matrix design compared to an illusionistic projection. In the literature of computer graphics, seven or more different design terms for "shape" were found, including "region", "wireframe", and "solid object", with at least three distinct conceptual differences.

Sometimes the similarities between concepts (despite differences in vocabulary) were significant. For example, "contour line" in art education and "silhouette line" in computer graphics both refer to an exterior outline of a shape. Sometimes there was no existing correlation. For example, there does not appear to be an equivalent in computer graphics for the idea of "color field", and in traditional art there do not appear to be a two-dimensional art equivalents for the computer graphic ideas of solid object properties or procedural modeling.

However, despite the immensity of the proposed task, it appeared at this stage of the study that an extensive domain of knowledge about the visual structure of images was readily available and that it would be possible to make comparisons between the two fields.

Summary

Both the literature of art education and computer graphics were dense with terms for describing the visual structure of images. Art education descriptions tended to be more expressive than objective. Computer graphics texts and manuals tended to describe appearances in terms of the procedures used to create them. Newer texts incorporated newer terms, in both fields. A great variety of concepts about elements of art appears to exist in art education, and a great variety of procedures exist for working with elements in computer graphics. In conclusion, it would appear that focused observations of elements and principles in the two fields will be fruitful in portraying concepts of visual structure more explicitly.

Focused observations

By virtue of their traditional identity as formalist features, the elements and principles of art were used in this study as a structuring framework for listing terminology found in the domain analysis. The elements of art were: line, shape, space, form, pattern, texture, color and tone. Comparable elements were then examined in the literature on computer graphics. No articulated framework

of "elements and principles" appears to exist in computer graphics theory. However, the structure of elements in computer graphics was soon determined as depending on one of three forms of graphics: pixel-based systems (Paint programs); 2D object-based systems; or 3D graphics. Therefore, terms such as "line", "shape", "texture" and "tone" were investigated on three domain levels in computer graphics.

The principles of art were balance, emphasis/focal point, variety, unity/harmony and repetition. The same concepts were examined in computer graphics. In additional, concepts about the formal image or image as a whole, such as concrete/abstract or discrete/continuous, were explored in both fields. These terms were also derived from the literature in Appendix A.

Procedures

All terminology referring to the elements and principles of art in both art education texts and computer graphics texts was listed. Four separate lists were created: elements in art education, elements in computer graphics, principles in art education, and principles in computer graphics. All similarities and differences between computer terminology and art terminology were therefore listed. In

addition, terminology was listed for computer concepts without an equivalent in traditional art, and vice versa. Elements and principles requiring further explication or areas which were unclear from the literature searches were marked in italics for further investigation (Figures 1 and 2).

A pattern of analysis developed during the focused observations of basic concepts. It became apparent that each basic term such as "line" had one or more meanings or concepts; different ways of formulating dimension or measure; several genres or types; different kinds of surfaces; different orientations or directions; different terms for describing light and dark values; and different types of depth devices. For each element and principle, focused observations were therefore grouped into sub-categories under the headings *concepts; measure; type; surface, structure,* or *edges; orientation, location* or *direction; value;* and *depth.*

All focused observations were included in the final domain analysis (Appendices C and D).

FIGURE 1

Sample of domain analysis:
Sensory elements in art education

line

- concepts
  - a mark
  - a continuous mark, path of movement
  - a path, mass or edge where length is dominant
- measure
  - length
  - width
- type
  - straight
  - curved
  - angular
  - contour
    - *interior*, cross-contour
    - *exterior*, outlines
  - continuous
  - broken
  - connecting
  - repeated
    - rhythmic
  - simple/consistent (thickness and value remain the same along the length)
  - complex
  - geometric
  - organic
  - precise
  - irregular
- direction
  - horizontal
  - vertical
  - diagonal

FIGURE 2

Sample of domain analysis:
Sensory elements in computer graphics

line

concepts
- in Draw mode, a linear location with no thickness between available pixels (a mathematical model rather than an actual graphic element on the screen)
- in Paint mode, a continuum of adjacent pixels (2D lines with x,y coordinates)
- in 3D graphics, vectors (3D lines with x,y,z coordinates between width, height and depth)

measure
- length
- width
- location

type
- straight: horizontal, vertical, diagonal
- curved: arcs (have a start, end, and radius); semi-circles; or curves (wander)
- "jagged" diagonal curved lines, often as a result of output resolution
- silhouette (designate outline)
- contour (designate the height of areas, as in contour maps)
- hatch patterns (dots, dashes, etc.)
- connecting (vectors)

direction
- horizontal
- vertical
- diagonal
- slope (degree of grade or orientation of line on a plane)

Findings

At this point in the study, the focus was on gathering as much information as possible about concepts of visual structure. The search was directed at terminology describing the elements and principles of design in art education, and terminology in computer graphics that embodied concepts similar to "sensory elements" and "formal principles". No comparable articulated aesthetic framework was found in the analysis of textbooks or manuals for computer graphics, though comparable sensory elements were readily found in computer graphics.

In fact, a greater quantity and a more specific delineation of terminology was found in computer graphics for the elements of "line", "shape", and "space". The amount and degree of complexity of data on "texture", "pattern", "color" and "tone" was roughly equivalent. Although there is computer graphics output (such as architecture, sculpture, or garment design) which is a counterpart to the physical, dimensional idea of "form" in art education, this concept was not explored further as the emphasis in this study is on two-dimensional output.

Information on "texture", "pattern", and "color" in art education was largely theoretical or abstract, while the

same information in computer graphics was technical and concrete. For example, the element of "texture" in art education was described as a "surface quality" which can appear "even", "uneven", or "smooth". In computer graphics, "uneven" surface quality was described was "block-pixed", "bump-mapped", "texture-mapped", or as evidence of "manipulated intensity values". "Smooth" texture was subcategorized in computer graphics as a "blend", a "graduated fill", "polygonal shading" or "continuous shading".

Art education literature described areas of "pattern" with abstract words like "distorted", "variant", or "localized", while computer graphics literature made such concrete distinctions as "pen patterns" or "area fill patterns". Art education literature favored what could be described as "expressive" language. For example, qualitative descriptors such as "receding", "advancing", "cool" or "warm" were frequently used to describe the element of color in art education. Quantitative descriptors such as "pixel format resolution" or "24 bit color" were used to describe color in computer graphics.

In comparison with the design elements, formal principles were not readily apparent in computer graphics.

There was an abundance of data on the idea of the formal image as a whole and the hierarchy of its assemblage. However, traditional concepts of art education such as "balance", "emphasis", "unity", and "repetition" were much more difficult to discover in computer graphics. They tended to be embedded in such specific procedures as "regularity" (for balance), "windowing" (for emphasis), "low color variety" (for unity), and "recursion" (for repetition).

Significant additions to the idea of the image as a whole were computer graphic concepts of "resolution", "lighting", and "field of view," which can uniformly affect the whole image in ways not traditionally accounted for in art education analysis.

Summary

A focus on *practices* in computer graphics rather than *principles* was the most significant difference between computer graphics and formalist aesthetics. Terminology in computer graphics was concrete and often quantitative. An aesthetic framework comparable to a formalist model did not appear to exist in computer graphics. Formal principles were embedded in procedures, rather than discussed in terms of effects or aesthetic response.

Taxonomic analysis

Introduction

A taxonomic analysis of terms and descriptions found in the domain analysis was developed in two parts: a taxonomy of terms used to describe sensory elements in both fields and a taxonomy of formal principles in both fields (Appendices E and F). The taxonomy of sensory elements was organized according to traditional individual elements of art; that is, identifiable areas or parts of two-dimensional images such as "line" or "texture". It includes concepts about traditional aspects of two-dimensional image-making such as two- or three-dimensional space. The taxonomy of formal principles lists concepts about the image as a whole, such as "formal balance" or "emphasis".

1. Comparative taxonomy of sensory elements

Procedure

Five columns have been used to structure the taxonomy of sensory elements (Table 1). Major terms for elements such as "line" are placed in the left-hand column of the taxonomy and highlighted. Major terms are broken down into conceptual areas in the second column for art education and in the fourth column for computer graphics. For example, in the second column, art education concepts about "line" are

analyzed as concept, type, measure, depth devices, structure, presence, and character. Similar concepts about "line" in computer graphics are analyzed in the fourth column as concept, type, properties (rather than measure), depth cues (rather than depth devices), structure, presence, and regularity (rather than character) in the fourth column. The subdivision into conceptual areas thus reveals similarities in terms, such as "type - type" or "structure - structure", as well as differences in terms, such as "measure - properties", "depth devices - depth cues", or "character - regularity".

Focused observations and definitions for each conceptual area are placed in the third and fifth columns. The focused observations allow an examination of further differences and similarities between the fields of traditional two-dimensional art and computer graphics. For examine, "line" (column 1) in terms of the conceptual area "measure" (column 2) in the field of art education reveals three additional sub-categories: "direction", "weight", and "value" (column 3). However, "line" evaluated in terms of "properties" (column 4) under computer graphics education reveals different terminology for similar concepts: "orientation", "intensity", and "value" (column 5).

The sub-categories are broken down one more step within the third and fifth columns, with definitions where applicable. For example, while "direction" in traditional art was defined simply as horizontal, vertical, or diagonal, its counterpart in computer graphics, "orientation", was defined as horizontal (x), vertical (y), a 2D diagonal line or slope (degree of grade on a plane, x+y), or a 3D vector (x,y,z).

TABLE 1

Sample of comparative taxonomy:
Sensory elements

ELEMENTS	ART EDUCATION		COMPUTER GRAPHICS	
LINE	concepts	- a mark - a point	concepts	- a pixel - a dot-per-inch (in hardcopy)
		a path, mass or edge where length is dominant		- a continuum of adjacent pixels - a row
		a continuous mark		- 2D segments with x,y coordinates (go between width and height or between local coordinates) - 3D vectors with x,y,z coordinates (go between width, height and depth)
				a invisible linear location (a mathematical model rather than an actual graphic element on screen)
	types	- freehand - geometric - organic	types	follow grid patterns on screen and in hard copy
		straight - horizontal - vertical - diagonal		straight - horizontal (x) - vertical (y) - diagonal/slope (x+y)
		curved - geometric - freehand		curved - arcs (have a start, end and radius) - semi-circles - curves (Bezier, quadratic and Fournier are equations that describe the mathematics of the curves between the defining points) - freehand in Paint mode
		continuous		continuous
				jagged diagonal and curved lines (a result of output resolution in 3D graphics)
		contour lines/ cross-contour lines (exterior outlines)		silhouette lines (designate the outline)
		cross-contour (designate surface changes)		contour lines (designate height of areas)
		connecting		- 2D lines/segments - 3D vectors

The idea of a parallel taxonomy for terminology used to describe visual imagery in both fields was initially developed in order to analytically compare differences and similarities in vocabulary and concepts. However, the taxonomy also provides a unique visual assessment of complex semantic areas in both fields. In many cases, the counterparts can be seen to match one-on-one in terms of quantity or variation. For example, the traditional idea of line as a path, mass or edge where length is dominant was comparable to the idea of line as a continuum of adjacent pixels in computer graphics. In other cases, there is a significant difference in the complexity of concepts and thus a greater number of definitions. For example, the traditional idea of "line" as a "continuous mark" had three counterparts in computer graphics: a) 2D segments with x,y coordinates that go between width and height or local coordinates; b) 3D vectors with x,y,and z coordinates that go between width, height, and depth; and c) invisible linear locations or mathematical models, rather than an actual graphic element on screen. All conceptual uses of terms were listed for both art education and computer graphics, whether or not they had a counterpart. If no comparison could be made, a blank space was left.

Findings

The greatest area of confusion in the literature search, the domain analysis, and the development of a taxonomy was in regard to the elements of shape and space. This resulted from, first, contradictory uses of the terms "two-dimensional space", "three-dimensional space", "two-dimensional shape", "three-dimensional shape", and "form" in art education literature, and second, the existence of three unique and distinct kinds of "space" in computer graphics. Different mathematically-defined operating environments in computer graphics dictate specific kinds of operations for creating individual elements such as line or shape. These operations in turn create different kinds of visual evidence.

In the domain analysis of art education literature, the term "two-dimensional space" was used to describe a two-dimensional working surface, as well as the kinds of spatial activities that occurred there - including illusionistic simulations. The term "three-dimensional space" was used to describe both an illusionistic artistic environment which is simulated on a two-dimensional surface, as well as to describe an actual, physical space in the real world. Focused observations revealed further discrepancies in

definitions. For example, "two-dimensional shapes" were described in several cases as "plastic" if their contours were biomorphic, even when the shapes were flat planes, and in other cases as "plastic" only if they were three-dimensional simulations.

The term "three-dimensional shape" was often used interchangeably with the term "form", and applied to actual three-dimensional objects such as sculptures. In other cases, the term "three-dimensional shape" referred to an illusionistic simulation on a two-dimensional surface. Similarly, "form" was used to describe both real-world objects and illusions of them on a two-dimensional surface.

There was less confusion about these terms in computer graphics literature, since computer graphics take place in three distinct operating or spatial environments. Both pixel-based shapes, and shapes created or selected in 2D object-based programs, are two-dimensional. They do not have true volume. Pixel-based "paint" programs allow the user to create lines and shapes spontaneously, in a freehand manner, by "drawing" with an input device such as a "mouse". A trail of bits of color called "pixels" lights up on the screen to mark the evidence of the user's hand movement. The screen is a rectangular "bitmap" or matrix of invisible

lines, and the movement of the mouse actually lights up pixels to the right or below the invisible lines. Thus a pixel-based shape is a flat region of lit up pixels on the screen. It is duplicated by means of a flat group of dots of ink when it is printed out in "hardcopy". In both cases, the shape is composed of bits, like an area of a mosaic in traditional art.

2D object-based systems, known as "draw" modes rather than "paint" modes, also allow the user to create pictures using the invisible screen matrix. The process is spontaneous, but in a different way. Points are connected with lines to create "polygons", or sequences of connected lines. The flat, planar polygons can be "filled" with color or texture, by lighting up pixels within them. Along with many other procedures which are dependent on the capabilities of different programs, these two-dimensional shapes may be "layered", "resized", or "transformed". Since the shapes rely on geometric configurations, many basic shapes in traditional design, such as circles, squares, or rectangles, are pre-created. They are kept in a file for the user to select as needed. Most programs also offer "procedures" for altering both selected and created shapes.

Many recent software programs combine the capabilities

of "paint" and "draw" modes, and the user can work back and forth between layers called "windows" to switch modes when desired.

3D graphics, on the other hand, are to date procedurally less spontaneous than "Paint" or "Draw" programs. In three-dimensional space, objects behave and are treated more like real-life forms. They have volume as well as area, and some programs allow the user to assign them other physical characteristics like weight or inertia. Objects are in geometric relationship to others in a three-dimensional space which is like a "void". Although the screen as well as hardcopy show a flat view of the objects, because the screen and hardcopy are flat, the objects are true three-dimensionals which can infinitely recede and which have calculable volume. In this sense, three-dimensional shapes in computer graphics are like real-life "forms", although the term "object" is used in computer graphics rather than "form".

In addition to finding a way to sort out confusing and contradictory descriptions of "space", "shape", and "form" in art education, this study sought to develop a taxonomic structure that permitted comparison with terms in computer graphics. While the terminology of art education provided a

conceptual framework for organizing language, the structure of the three kinds of space in computer graphics provided a physical framework for the taxonomy that is unlike typical sequences of art education texts.

Many art education textbook chapters follow a similar sequence in developing concepts about the elements and principles of design. A typical structural order begins with "line" in the first chapter or lesson, followed by "shape", "pattern", "texture", "form", "space", "color" and "tone". Both the domain analysis and focused observations in this study followed this sequence because it was so pervasive. However, it soon became apparent that the framework of the comparative taxonomy was to be determined to a large extent by the dictates of different mathematical methods for creating computer graphics. For example, the analysis of vocabulary used to describe and conceptualize an individual element such as "line" in computer graphics quickly became confusing and meaningless without prior identification of the kind of mathematical environment in which an element such as that line was created. Different notions about creating images in space result from the capabilities and constraints of the three mathematical environments - pixel-based systems, 2D systems, and 3D

systems - and thus constrain the kinds of "line", "shape", "pattern" or "texture" activities that can be performed in each. This in turn constrains the kinds of visual evidence of lines, shapes, patterns and textures in the hardcopy or output of computer graphic images.

Therefore, the comparative taxonomy of elements in art education and computer graphics in this study (see Appendix E) begins with three concepts about "two-dimensional space", followed by three concepts about "two-dimensional shape". Next, the concept of "three-dimensional space" on a two-dimensional surface is followed with two concepts about "three-dimensional shape" on a two-dimensional surface. The concept of "form" in art education was defined as a 2 1/2D or actual 3D object with mass, such as a sculpture or mobile. The art education concept of "form" was not given a taxonomic counterpart in computer graphics, since the term "form" in computer graphics does not exist in the same sense that it does in traditional three-dimensional art such as sculpture.

The concept of "line" is thus the sixth element listed in the comparative taxonomy of this study. By this point, a referent such as "x" or "vector" in the third or fifth column of "line" had previously been defined under the

elements "two-dimensional shape" or "three-dimensional space". The development of the taxonomy as constrained by different computer graphics environments also afforded a more detailed, specific, and complex analysis of the conceptual area of "line".

"Line", as the sixth listed element, is followed by a comparison of concepts about "pattern", "texture", "color", and "tone", in that order. A visual assessment of the taxonomic categories for "pattern" reveals an extensive description of procedures for different pattern effects in computer graphics, while art education descriptions are conceptually very general. Effects of patterns in art education and computer graphics are both local and global.

The term "texture" in traditional art has more extensive applications than in computer graphics. These include "natural", "invented", and "illusory". Since texture in computer graphics is illusory only, the descriptions of texture surface in the taxonomy focus on illusory effects in traditional art. As an "illusory" type, texture is local in both traditional art and computer graphics; that is, it appears to be used for areas of shape or space. The significant difference is that texture is a surface *quality* in traditional art and a choice of *rendering* in computer

graphics.

Concepts about color are equally well-articulated in art education and computer graphics. Texts in both fields carried detailed color theory and distinctions between such properties as "intensities", "hue", and "value". Art education theory also incorporated *expressive* vocabulary for color depth and temperature, such as "receding" or "cool", for which there do not appear to be counterparts in computer graphics. However, it should be noted that some computer programs provide capabilities for color tables based on such variables as natural and artificial light effects or weather.

Different procedures for tone are explicitly defined in computer graphics. They include several kinds of shading, color mapping, and different shadow effects. These procedures give precise and uniform tonal effects to images since they are applied by the computer during the rendering process rather than by hand.

Summary

In summary, procedures peculiar to computer graphics determined the taxonomic structure of sensory elements to an unexpected degree. However, this results in an analysis of art education concepts in a way that is not readily apparent

in the literature. For example, art education literature often applies the same term, such as "line" or "shape", to a wide variety of styles, methods, and mediums. The comparative taxonomy affords a reevaluation of this practice.

Ideas about "shape", which became particularly important, are not seen in an abstract form nor were they nebulous. "Shape" is not only defined as two-dimensional or three-dimensional per se, but is evaluated in terms of its type, position, area or structure, surface, and edges in *different kinds* of two and three-dimensional space. Thus "two-dimensional shape" can be seen as having quite a different set of intentions depending on the kind of space in which it is created. For example, the computer graphic concept that shapes are intensities of color selected in a bitmap in pixel-based graphics afforded a comparison with the concept of shape in traditional art as a composition of individual stitches, tiles or sections in two-dimensional matrix-based art such as needlepoint, mosaics, or weaving. This concept is quite different from the concept of shape as a flat plane which may be overlapped. In the latter concept, descriptions of manipulation and convergence and the idea of a non-conscious format further underscore

significant differences between these two types of two-dimensional art. In both computer graphics and traditional art, ideas about space appear to be a guiding principle for structuring and creating other elements, rather than an individual element of the picture.

The elements of pattern, texture and tone in computer graphics are created through specific computer-driven procedures (such as the various kinds of mapping) which ensure a uniformity to flat surfaces and a perceptually-correct perspective to three-dimensional objects. The same elements in traditional art may have variant or uneven characteristics as they are handcrafted.

2. **Comparative taxonomy of formal principles**

Procedures

The taxonomy of formal principles (Table 2) was developed following the five-column structure of the taxonomy of sensory elements. Eight major conceptual areas were explored: the concept of the formal image as a whole, formal balance, informal balance, variety/contrast, unity/harmony, emphasis, lighting, and format. These eight conceptual areas are subdivided according to different definitions or applications of the major terms. For

example, "formal image" is analyzed in terms of "concept", "content", "structure", and "procedures". The third and fifth columns break down these sub-categories one step further, with definitions where applicable. For example, the conceptual area of the principle "emphasis" is analyzed in terms of "concept", "type", and "structure". "Concept" is in turn defined as "focal point(s)", "center of interest", or "weight" of the picture. "Types" of emphasis are "degree of emphasis", "restraint in emphasis", and "absence of focal points". "Structure" is described in terms of "isolation of elements" or "placement of elements".

TABLE 2

Sample of comparative taxonomy: formal principles

PRINCIPLES		ART EDUCATION		COMPUTER GRAPHICS
FORMAL IMAGE	concept	image viewed as a whole	concept	- hardcopy image - screen or cyberspace image
		matrix forms		digital medium in Paint snd 2D object-oriented systems
		analog forms		continuous medium in 3D graphics
		concrete		- concrete in hardcopy only - dynamic on screen
		image is stable		only hardcopy is stable
		one original		three originals - digital data - multiple screen originals coexist in pixel-based, 2D or 3D graphics - hardcopy graphics
		printmaking multiples		hardcopy multiples
	content	content is created in a discrete environment called a format	content	- 2D bitmap content is created in a discrete (matrix) environment - 2D object-oriented content is created in a discrete (coordinate) environment - 3D graphics content is created in a continuous environment
		contents are passive		contents are passive only in hardcopy
		contents are bound to form		contents are bound to hardcopy
		artworks contain signifiers (the "language" of art)		contain signifiers (evidence of selections and procedures, such as "sweeping" or a partical procedure)
		several formal principles may operate simultaneously		formal principles are applied hierarchically
	structure	formalist images are composed of parts called "elements" of art	structure	pictures ("universals") are hierarchical assemblages of parts or elements called "primitives"
		elements of art can be further broken down (ie. motif + repetition = pattern)		primitives are often incorporated into procedures or subroutines

Findings

It should be noted that while this study sought to focus on the *results* of image-making rather than on the procedures used in making images, *evidence* of procedures was often cited in descriptions of the visual structure of images. Procedures therefore played an important part in expanding the notion of signifiers in formal images. Traditionally, art has been seen as containing signifiers in terms of an abstract language of elements. A comparative study with the idea of signifiers in computer graphics affords an expanded idea of signifiers, which may include evidence of specific techniques, selections and procedures as much as abstract language.

The delineation of the formal image as the first concept in the taxonomy allows an examination of the kinds of conceptual and practical environments in which image-making takes place. In other words, the *context* for elements of art, including the kind of space used, is made specific and concrete. For example, the content of traditional 2D art images is seen as created in a discrete environment called a format; with passive contents bound to this format; with the possibility of several formal principles operating simultaneously in the organization of that content in the

format; and as having content signifiers. By contrast, to quote from the taxonomy of formal principles (Table 2), content in computer art is created in a discrete or continuous environment; passive only in hardcopy, with contents bound to the hardcopy only; with formal principles having a hierarchy in the creation of the image; and as showing evidence of selections and procedures.

Although space has traditionally been viewed as an element of art rather than as a principle, certain similarities were noticed between notions of space and the environment of the formal image. For example, traditional art was often referred to as an analog medium in the literature review and domain analysis. This distinction, while noted in articles by Hickman (1991), Nadin (1989), and Pope (1988), was particularly important in the work of Binkley (1989, 1990). However, the content of matrix-based traditional art images is actually discrete, if not, in a sense, digitized. The notion of "one original" has also been an important idea in formalist art theory. However, concepts of printmaking multiples, computer hardcopy, and the replicability of matrix-based imagery beg the definition of "one original". It would be useful to develop a theory of art in which notions of space and the ideas of

"originals" or "multiples" are seen as guiding principles for the kinds of aesthetic responses which are generated.

A comparative study of the principles of formal and informal balance, variety/contrast, unity/harmony, and emphasis revealed some conceptual similarities between the meanings of these principles in computer graphics and traditional art. However, while these specific vocabulary terms were frequently cited in art education literature, they were seldom used in computer graphics. Generally the terminology was different: symmetry - global regularity; radial balance - rotation; allover pattern - continuous pattern; asymmetry - broken symmetries; clarity of image - graphic form variables; surface - image. In many cases, the sub-categories had no counterparts. For example, there were no counterparts to the traditional art education concepts of approximate symmetry, dominance, subordinance, visual unity, proximity of figure to ground, relationship of format to contents, continuation, conceptual unity, or notions of emphasis such as "focal point", "weight" of the picture, or the "isolation of elements".

Often a concept in computer graphic imagery was more local than global, and thus could be seen as an element rather than a principle. For example, while "asymmetry" was

often cited as a traditional art principle used to structure content in relationship to the format, "broken symmetry" in computer graphics applied to the transformation of specific regions, polygons or objects, or to the randomness of local detail.

Conversely, two concepts which were viewed as incidental characteristics of specific elements in art education (when they were mentioned at all) were significant unifying structures in computer graphics. First, the concept of "resolution" in computer graphics is very important. The computer art image is affected uniformly by the resolution of the output, both in terms of the kind of printer and in terms of the density of color and dots-per-inch. With dot matrix printers, the computer graphic output is always an even, grid-like series of dots, regardless of content. Dye sublimation printers produce images with continuous tones in one layer of ink. Conversely, in traditional hand-made art, the density of the media - whether pigment, ink or fibre - varies across the surface. The term "resolution" in traditional art texts, when it was applied, referred to the idea of the image as either "successful" or as "finished", rather than to a sense of unity through a balanced distribution of pigment.

Second, the concept of lighting in computer graphics plays an important part in unifying three-dimensional graphics. Several kinds of reflective techniques, ray-tracing, and techniques for transparency or self-illumination can be applied to images. The overall lighting effect can also be altered by colored spotlights in the same way that glazes are applied to oil paintings.

Summary

The terminology of art education provided the structuring framework for a comparative taxonomy of the principles of art. There does not appear to be an articulated theory of comparable principles for computer graphics. Terminology in computer graphics regarding symmetry, balance and pattern tended to be locally specific, rather than global. Well-articulated global concepts in computer graphics such as resolution and lighting were not well-developed in art education literature. However, concepts about the structure and procedures of the formal image as a whole were markedly similar and well-developed. Thus computer graphics appears to be structurally similar but theoretically deficient in terms of art education principles.

Interviews

Introduction

Following the taxonomic analysis of terms, interviews were conducted with eight informants who can be considered experts in the analysis of visual images. The interviews were used to clarify terms and concepts found in the literature of art education and computer graphics, and to identify terms in colloquial use. A second purpose of the interviews was the opportunity to clarify concepts in the context of an ethnographic situation.

Four stimuli were used in order to provide a concrete base for observations. Informants were shown four art images in the form of two-dimensional reproductions (Appendix G). They were asked to describe each image in their own terms, and to compare and contrast images. They were also asked to comment on connections between the way computer artists and traditional artists (or computer graphics educators and art educators) might talk about the same images.

Informants

Informants were selected on the basis of their verbal fluency and ability to articulate concepts about visual images. All informants were well-established professionals

in two or more areas of traditional or computer art. These areas included art education, studio art practice, knowledge of art history, computer art practice, and computer art education (Table 3).

The purpose of the selected observations was to gather interview data on visual analysis from informants with a range of expertise in these areas. The informants were selected to create a balance of expertise. Informants are identified throughout the study by numbers 1-8 rather than initials.

TABLE 3

Profile of informant expertise

	art educator (level)	studio artist (specialty)	art historian	computer artist (specialty)	computer art educator (level)
1	secondary, univer. *	textiles	yes		
2	secondary *	painting	yes		
5	college	photography	yes *		
6	college	painting, drawing *	yes		
4		painting, drawing *	yes	Paint and Draw	
8		graphic design	yes	Paint and Draw *	public
3		drawing/crafts	yes	2D and 3D *	secondary
7		sculpture	yes	Paint, Draw, 2D,3D	college *

* Designates area of specialization

Stimuli

The stimuli were reproductions of two-dimensional images. They were color lasercopied from art and computer textbooks and mounted on 8 1/2" x 11" white card both for handling reasons and for a uniformity of scale. A pixel-based image and a three-dimensional graphic were used as examples of computer graphics. An oil painting and a painting which showed characteristics of both drawing and painting were used as examples of traditional art. The images were selected on the basis of clarity of image and were representational rather than abstract, to ensure a base of understanding among subjects. They were also chosen for their appropriateness as examples of different kinds of visual structure, rather than on a value basis of "good" or "exemplary" art.

Each image was characterizable in formalist terms to accommodate artists and art educators, and characterizable in technological terms to accommodate computer graphics artists and educators. Each image demonstrated different concepts of sensory elements, including line, shape, space, pattern, color, texture and tone. Each image also exemplified concepts of the image as a whole, or formal principles, including unity, repetition, emphasis, balance,

scale or proportion, lighting, uniformity of surface, and field of view (Figure 3).

In choosing the stimuli, an attempt was made to represent as many concepts as possible about each element and each principle. For example, the element "line" was represented in the first image with uneven contour or jagged silhouette lines; vertical, horizontal and diagonal lines; and negative or reversed lines. The second image had broken interior lines with no contour or silhouette lines. The third image had continuous, bold, irregular contour lines, and positive and negative lines. The fourth image had delicate contour or silhouette lines, repeated lines, and perspective or diagonal lines. "Repetition" was exemplified in the first image with a regular, repeated pattern. The second image had an irregular, decreasing repeated pattern. The third image had repeated shapes and motifs. The fourth image had repeated lines and technical styles.

Complete descriptions of all sensory elements and formal principles exemplified in the four stimuli were written following the taxonomic analysis and in advance of the interviews (Appendix H).

FIGURE 3

Sample description of stimulus

Stimulus 1: *Untitled*, Pixel graphic.
Tosiyasu L. Kunii, Tokyo Univerity.

Elements of art

line
- uneven contour/silhouette, jagged
- vertical, horizontal, diagonal
- negative/reversed

shape
- two-dimensional
- geometric, organic
- solid, outline

space
- two-dimensional
- matrix, bitmap
- positive and negative

pattern
- localized (dress)
- allover/invariant (dress)

color
- limited palette
- analogous
- cool

texture
- illusory
- even/uniform/invariant (pixel pattern)
- localized (figure)

tone
- flat
- contrast

Sample description of Stimulus 1

Principles of art

unity - format to content
- unified palette
- proximity of figure to ground: separated

repetition - regular pattern (on dress)

emphasis - isolation of element (pattern on dress)
- outline/ silhouette line

balance - horizontal

scale/proportion - actual

lighting - diffuse reflection

uniformity of surface - low resolution "jaggies"
- contrast (pixel texture against solid)

field of view - almost enclosed (cropped feet)

Interview questions and procedures

Interviews were conducted in informal surroundings according to the choice of each informant. Most interviews took place in the informant's workspace. Meetings began with a casual discussion of our personal interest in the visual arts at this time, followed with a brief description of the purpose of this study, which was to analyze terms and concepts used to describe the structure or appearance of visual images, rather than emotional or narrative response. They were informed that they were considered experts in this ability, and I was interested in their ways of describing an image.

The four art images were used as stimuli to discuss elements and principles of art, and also as catalysts for discussion about different aspects of traditional and computer art. Each interview lasted 30-55 minutes.

Interview questions and prompts were prepared in advance of the eight interviews. There were five main interview questions for each image, with prompts specific to each image (Appendix I). To begin, informants were simply asked to tell me about each picture. Their attention was then directed to different areas of each picture, such as foreground shapes, edges, or background areas, and they were

asked to describe the different parts of each image. The second question thus focused on sensory elements and the language used to describe sensory elements.

Third, informants were asked to describe the image as a whole, in terms of "composition" or "arrangement". Prompts were used to direct their attention when necessary to such formal principles as color scheme, balance, or lighting. In response to the first three questions, the informants proved extremely loquacious and provided detailed observations about sensory elements and formal principles with very little prompting. Therefore the prompts were not needed as much as expected.

Fourth, informants were asked whether they thought each image was "successful" on the basis of its visual structure. They were asked to clarify their reasons and encouraged to compare and contrast images for "successful" visual structure. This question elicited further comparison of the elements and principles of design, information about procedures in computer graphics and traditional art, and comments relevant to many of the issues raised in the literature search.

Informants were then asked to comment on any connections between the way people in both fields might talk

about visual images. In many interviews, this question elicited more specific terminology and clarification of concepts in both art education and computer graphics, and also provided further data on concepts and issues revealed in the literature search regarding similarities and differences between traditional two-dimensional art and computer graphics.

Procedure for the analysis of interview data

The eight interviews were taped and transcribed verbatim in single space formatting (Appendix L). All terms used to describe visual structure were highlighted. Highlighted terminology included nouns, verbs, adjectives and adverbs that referred to evidence of procedures or techniques, as well as to evidence of elements and principles.

The following sample from the interview with informant 3 reveals terminology used to describe "resolution" in computer imagery. Words describing the visual evidence or signifiers of resolution and the procedures used for resolution are highlighted. They include nouns, verbs, adjectives and adverbs. Quotes in this study are identified by the informant's number followed by the transcript page number.

I would say that the resolution of this image is much higher than the earlier one. The edges are very crisp, and clear, continuous, smooth. The anti-aliasing would be set quite high to prevent jagged edges, if it was computer-rendered. (3.5)

CHAPTER IV

INTERPRETATION OF INTERVIEW DATA

Introduction

Six theme-groupings emerged from the analysis of interview data. These were similarities between traditional 2D art and computer graphic output; differences; the idea of art images as a "language" which can be "read"; themes to do with the idea of space, both two-dimensional and three-dimensional; descriptions of classic "sensory" elements; and descriptions of formal principles or unifying devices. Chapter IV is structured according to these groupings.

Similarities

Four themes emerged in terms of similarities between traditional art and computer art: artmaking as a cognitive process; the elements and principles of design; artviewing as a cognitive process; and simulation.

Artmaking as a cognitive process.

Five informants commented on the similarities between traditional artmaking and computer artmaking as a cognitive process. This was often described in terms of "thought".

Three informants also commented on artmaking "thought" processes in terms of communication with a viewer.

> It's the final image that is the real thought. It's the thought that someone makes and puts out, and it's the thought you get when you look at it. They may be two different things, but we shouldn't place so much attention on how they get there. That's what so exciting about computers, you can make them do anything you want to. It's your thoughts that are in control, not the computer. (8.12)

Informants with strong backgrounds in computer graphics studio practice emphasized the role of the computer as an intermediary for thought, rather than a determinant of the appearance of the outcome.

> Dimensions are all approached in a mathematical way in a computer, obviously, but geometry is just a description, you telling the computer what to do, and you're the one who makes the decision about how the space is working. (8.10)

There was a clear understanding that the computer is an intermediary for original human thought processes, even when the artmaking process is at its most intense.

> It absorbs you. You go off into computerland. But it's *not* computerland, it's your own mind. (8.11)

Several informants identified the computer with traditional artists' tools, and discussed the way the

computer can be used as an aid in developing ideas. The difference between traditional image development and computer image development was described in terms of the *numbers* of concrete images generated, rather than questions of quality or appearance.

> You do numerous "runs" of images, to kind of tune it, so you can get it right. Because you don't always know what you're going to get. You might set up some lights, some materials, whatever, so you do it, tweak it, do it again. You end up with as many as twenty or thirty different images. (3.6)

Elements and principles of design

Informants who taught computer graphics were on occasion ambivalent about the language they used. Sometimes they described teaching the same elements as art educators. At other times, they used terms that were distinctly derived from computer graphics. While the design vocabulary of computer graphics often appeared to differ from that of traditional art, informant responses indicated that conceptually their ideas about elements and principles of design were the same.

> Whether you're using a conte or paintbrush or a ball-point pen or a computer image, the elements and principles of art and design are the same. You know, we talk in texture, line, color, lighting, tone, movement, 2D, 3D, juxtaposition. I could go on ad infinitum, and things don't change. And

nor *should* the approach. (2.11)

Differences between the media were described in practical rather than theoretical terms.

> If I were using a computer and I would start to discuss an image, I would be using a similar language as I am using here, except that I would be talking about nodes and angles and pixels... but I would still be talking about positive and negative space, I would still be talking about depth of field and composition... (4.11)

One informant described computer artists as working solely with visual feedback.

> I think a lot of people who work on computers have no language; they just do it. Now they might run into trouble when they have to describe it to someone later on! But generally, they don't talk about their images the way fine artists might, or the way art critics would talk about paintings. (8.10)

However, several informants commented on the difficulty they had in focusing on the elements and principles of art, rather than the techniques, when viewing a piece of computer art.

> In almost all the computer images I've seen, for me, technique overrides the image. I'm always, "How the hell did they do that?" (5.10)

Artviewing as a cognitive process

At some point in every interview and in response to

most stimuli, informants used simple math terms to describe or locate an image.

> (Stimulus 2)
> The lines are radiating. I see very distinctively one, two, three, four, five, six, seven, eight, nine, ten, eleven, twelve lines. (2.3)

Perhaps because all eight informants had a strong background in studio practice, artviewing as a cognitive process entailed frequent discussion and conjecture about techniques and processes.

> (Stimulus 2)
> To me it looks like they would have had some kind of photographic or original things as a reference. But I know that the computer can do things. Like for instance the vine looks like it's made out of molten gold, rather than actual wood. But clearly, it has a photographic-looking base. (8.5)

Informants also used techniques and processes, often in terms of their own experiences with techniques and processes, as cues for identifying the medium in which images were created when viewing an image.

> (Stimulus 2)
> Because of the fading of the color and the receding, I doubt if an artist would have painted it. And again, that losing of the color into the kind of the gray throughout, is so masterfully done... I don't think anyone could paint that well. (6.4)

As in the following example, techniques were frequently related to discussions of structural elements, such as repetition or negative and positive space.

> (Stimulus 2)
> You can see the same flower or the same leaves in the same arrangement, heading off. You know that the whole structure, if it was a 3D structure of branches and flowers, had just been copied back again and again. (3.4)

Simulation

Seven informants mentioned the similarity between traditional art and computer art in terms of the computer's ability to simulate traditional effects.

> I don't think there's any difference at all. Even in applications... in Paint programs, you can apply that brush now in multiple ways. You can make your paint look like you're applying it with a palette knife, on the computer. (7.10)

Effects of different areas in computer images were often compared to art historical intentions in traditional art. It was pointed out that computer artists may not be aware that what they are doing is an art historical technique, even though their intentions are the same.

> For instance, in Photoshop, you can take a photograph, put it through a filter, and turn it into a Pointillist painting. Now it may not be called a Pointillist filter, it'll just be called an "art effects" filter or

> something. And somebody new to the computer might only ever know it as the Art Effects Filter #7, and not ever realize that this is a painting style. (8.10)

Informants frequently identified areas of images in terms of both computer techniques and art historical techniques.

> (Stimulus 4)
> Only when you look really closely... The table is a whole series of colored dots... it's either Pointillism or it's just a computer image, like a paint package. Like somebody sprayed a series of multiple colors of paint and tried to simulate another kind of art, possibly. (3.11)

In this sense, computer techniques and art historical references were often seen as being *equivalent* to elements of art. Frequently, informants summed up the appearance of an image or area with an art historical term or reference.

> (Stimulus 4)
> I just go a little bit up, and now here's Leger, these red and brown tube structures and crosses. (2.8)

In one case, a informant summed up a procedure in computer graphics with the name of the computer artist who popularized it.

> (Stimulus 2)
> This Ned Green effect, you can't do that as a painter, it would take forever. For a computer artist, who just has to make one plane, one

> field, all he has to do is reduce it and add a little distance cueing. (8.6)

Summary of similarities

Informants described making art on the computer and by traditional means as a cognitive process. Any differences were practical: first, different terminology was used for the same concepts, and the capability of the artist to generate multiple variations on themes was perceived as easier on the computer. Educators in both computer graphics and traditional art fields taught the same elements and principles, with differences only in the "tools" they recommended for creating images. However, computer artists were alleged to be less articulate about describing images, and computer images themselves may less articulately convey a "language" of art. This may be because computer principles are "hidden", leaving the elements visible only as techniques.

Artviewing, on the other hand, was less a reflection on cognitive process than a discussion of techniques and processes. Techniques were equated with compositional effects. Recent computer art was perceived as being concerned with simulating traditional art effects and art historical styles. These referents were more obvious to

informants than the sensory elements of art.

Differences

Two differences between traditional and computer art were described: the evidence of "human touch", and evidence of the conceptual processes of making art.

Evidence of "human touch" in traditional art

Evidence of the human touch in traditional art was often cited as an important difference between traditional art and computer art. The "human touch" was described in terms of spontaneity, tradition, physicality, and discontinuities or errors.

One informant described the edges of a traditional painting (stimulus 3) in detail, and equated "spontaneity" with evidence of mixing, layering, and visible paint strokes.

> There's no sense of creating a hard edge. All of these edges and all of the quality of paint on the canvas is right there, so that you feel the edge of the brush stroke, you see the mixing of the color, the yellows around the shape of the horse. You see the way the color has been butted up against the background border edges, one color painted directly on top of another. It's very spontaneous, you get a sense of the artist's hand in it. (1.5)

The difference was perceived as a property as well as a historical tradition of man-made art.

> Since cave drawings there's always been that idea, the undulation of gesture of the hand, mind, mark-making... which is totally different from what you get in computer graphics. (5.10)

While traditional art was perceived as being the result of physical manipulation, computer art was perceived as analytic rather than physical. The physical differences between the mediums created an impression of distinctions between what was possible in terms in aesthetic response.

> I've never seen a really *tough* computer image. You know, one that's raw, that's alive, with a passion. It's very analytic. Your whole frame of mind is sitting in front of a television set and a keyboard. It's not physical. Most art is very physical. It involves a lot of arm movement, sensuous materials, fluidity of paint, even the smell of pastels is a very sensuous thing. (5.9)

I asked informants to identify and characterize evidence of the "human touch" in traditional art. Human touch was characterized in terms of "messiness", "errors" "irregularities", discontinuities and "mistakes".

> ...this controlled messiness, which is so difficult to do with the computer... a good example would be [the paintings of] Francis Bacon. They're loose, and yet there's an incredible amount of control.

> That mess, dripping, texture... you know, with a computer you can get texture but it's always a multiplication of that texture. (4.6)

> ...some of the little details that you get. It's very difficult to tell the computer to make a mistake on an edge, or blurred. (8.7)

Evidence of electronic mechanics in computer graphics

Informants frequently referred to computer graphics as "mechanical", particularly in response to stimulus 2. I asked informants to clarify what they meant by "mechanical". One informant cited similarity in repeated form and several informants described the "smoothness" of imagery. Unnatural complexity of detail was also mentioned twice.

> The almost artificial plastic look of the flowers are so smoothly rendered. Plus the incredible complexity of the whole image. (3.11)

Informants also cited unnatural depth of field and arbitrary depiction of objects in space as evidence of mechanical means.

> The other thing is, in painting and in photography, there tends to be what's in focus and what's out of focus. Here everything is in focus. Which is very scary. You don't tend to see the world this way. Ever. Where everything in our depth of field is focused. Up to where it disappears into the atmosphere. (6.4)

Stimulus 2 was a catalyst for thoughts about what makes an image convincing. An image was considered to be convincing if it appeared unique or individualistic, with some degree of abnormality.

> There's a real difference in my mind between a program image and an artistic image. In the second image, information is fed into another mind, that of a computer, and you *arrange* it, but you do not need to have the manual abilities nor the artistic knowledge to make a pretty convincing image. One that looks professional. But in fact what you get is something without the life, the wit, the abnormalities. (5.9)

Throughout the interviews, informants frequently referred to computer graphics as "too perfect". I asked several informants to clarify this description, using stimulus 2 as a catalyst.

> ...there aren't enough glitches in it. I would like to have seen at least one petal a little bit eaten away by a bug. You know what I mean? Or maybe one of the petals dying a bit? (6.12)

Art as a "lived-through" experience

Several informants placed computer graphics near the beginning of a kind of scale of consciousness about what art is. At the beginning, many stated, artists are learning techniques and making illustrations.

For most people, when you start doing art, your

> reinforcements is that "it looks so real". That's the first feedback you get. So most people begin as illustrative artists. Trying to be as *truthful* to reality as possible. (5.7)

Art was perceived as "lived-through" if the artist personally worked through an understanding of the processes of "playing with", "confronting", or "manifesting" images, rather than copying them from the real world. In describing stimulus 3, one informant commented,

> Call it "magic" or call it mystery... the subject matter has not stood in front of this artist. He had to make this work from the very beginning of that image. He could not rely on a still life or on a tangible world to arrive at this image.... it is a *lived-through* experience rather than a rendering of an image. (4.9)

In response to the two traditional art images (stimuli 3 and 4), informants frequently described evidence of artists "playing" with elements of art. Images were also frequently discussed with art historical reference to recognized "ways of playing" with images, which referred to the particular perceptions and styles of different artists. There appeared to be a high awareness of different levels of making, comprehending, and responding to art, and the different standards applied to different levels.

Computer artists were perceived as not understanding enough of the second level of making art.

> I'd say it's the kind of image that computer graphic artists make. Because they have no understanding whatsoever of visual art. (6.5)

The inability to "play" or incorporate original perceptions was perceived, in response to other computer art informants had seen, as a result of a lack of personal commitment and struggle necessary to make computer art.

> The medium itself... you circumvent nearly all the struggles, the questions... it's like cooking with pre-packaged stuff. All you have to do is add water and you're going to get something. But it's not going to be the same as if you went through the process of learning. (5.11)

Correctibility of computer images

By affording image corrections and manipulations that don't show any trace of changes, the computer produces images that appear pristine and "perfect". However, three informants who use a computer to make art pointed out the advantages in terms of challenge and time.

> I think that's one of the things about the computer: it lets you correct things so easily. It really does become a tool, that is fast, and makes it feasible to try anything *difficult*. (8.13)

Computers were perceived as a device which enables an artist to fulfill his or her original intentions, and even to experiment beyond the original intentions. They were

also perceived as a device which enabled a greater quantity of work to be done in the same time period.

> If I had had a computer when I was in art school, I would have done everything I did in art school and a lot more. (8.15)

Summary of differences

Uneven technique and even an occasional mistake in applying elements of art, such as a mistake in a sequence of motifs in a border design, were not only tolerated but given high value and significance in traditional art. Computer graphics also contain "man-made" errors, such as discontinuities in composition or use of space, but these errors were less well-regarded. Artists who "played" with paint and ideas were valued the most.

Computer graphics which simulate realism are perceived as intending to embody the fine detail of natural or life-like appearances, and are criticized on the basis of "not going far enough" in terms of natural flaws in real life. On the other hand, arbitrary use of space and compositional techniques means that they are not accepted as depictions of real life either, as photographs often are. This is an area of computer graphics which is seriously in need of its own set of theoretical foundations.

While traditional artworks were not criticized by the informants according to the criteria of computer graphics, computer graphics were criticized according to the standards of traditional art. Yet the technology of the medium makes it impossible to generate the kinds of features which are most highly valued in traditional art.

Art as a language

The third theme that emerged from an analysis of the interview data was the idea that art images could be "read". Art was "read" in five contexts: as an object like a book, with specific directional approaches; in terms of perceptual cues; in terms of process or techniques; in terms of art historical references; and as a visual "game".

Reading art like a book

All eight informants made references to the order in which they "read" an art image. One informant mentioned a left-to-right reading order. As a determinant for reading the Stimulus 1, he described the line on the right as emphasizing the order.

> [The line] gives her a direction. It's having an effect in a forceful way. Either she's looking towards it, or it's forcing something towards her... It could be a door that she's going through.

> It makes a whole left to right reading direction. She's also facing towards the line. (8.2)

Another informant also mentioned this line in terms of reading the figure image as part of the whole.

> If the line wasn't there, it would really read as an isolated image, almost as an island. This line brings this negative space, like the black is not so isolated. There's an attempt at making the format. You know, the composition depends always on the format of the piece, reading it from the corner, or from the center. (4.3)

All informants turned stimulus 2 upside-down during their analysis, and many experimented with turning other images upside-down as well. I asked informants why they did this. In many cases, particularly in response to the figure of the woman in stimulus 1 and the flowers in stimulus 2, the responses were based on real-world cues.

> [Stimulus 2]
> Because you have a growth pattern that seems to stem from one corner, I would be more comfortable having it this way, upside-down. Because in terms of actual space, the growth goes up. Well, it works this way too [on its side.] (5.6)

Several informants discussed stimuli 1 and 3 in terms of their graphic appeal, and felt that the appeal was the same regardless of which direction these images were turned. Comparisons were made with logos or emblems, signs, banners,

and flags.

> [Stimulus 3]
> Because it's like a banner... it's like a flag, or it has that real kind of graphic punch you get with flat colors. [5.6]

Turning the image upside-down seemed to afford a sense of objectivity; an opportunity to evaluate elements of design and compositions differently. It also seemed to remove real-world associations in a way that was satisfying to informants.

> [Stimulus 1]
> Now, just seeing it [upside-down] as an abstract image I like it. It doesn't matter that there's no face when the image is upside-down. The horizontality of these repeated lines on the texture of legs or stockings, arms or face, aren't as strong... And I lose the fabric association. (6.3)

Twice informants remarked that, in design terms, art should work "any way".

> [Stimulus 4]
> Art works any way. Good art. Good art you can turn any way and it'll work. (7.12)

Reading perceptual cues

Informants frequently looked for cues to identify both content and depth.

> (Stimulus 1)

> The white line that's supposed to infer chin bottom, between the face and the neck, it doesn't work as a shadow, and it doesn't help push the neck back from the face. (6.3)

"Reading" an image was also described in terms of timing or pacing.

> In some places he tends to slow down the eye where he works with detail, then he gives it some sort of quiet area where there is less descriptive form. (4.11)

For the most part, informants relied on familiar traditions in art to provide cues for depth and space. They expected these cues to be done "correctly", following "formulas" or "institutions".

> Yes, [depth is created by] the contrast. That's the old academic school for illusionism: images that possess contrast will appear that they're coming forward. The reduction of contrast will create the illusion of space. And this is exactly the formula I'm seeing here. (4.5)

> It gives the illusion of space and depth, but it's not visually correct. An artist who understands this would do it correctly, using Renaissance perspective. So it's not even working within the institution. (5.3)

Several informants commented on the fact that they tend to "read" more than they "see" in a picture. This was described in terms of "imagining", "filling in", and "knowing". It appears that images, as well as parts of

images, serve as cues for both memory and associations with real-world experience.

> That's one thing with high resolution [images.] You often imagine more detail than is really read there. The photo goes halfway, then the brain goes the rest of the way. (8.5)

Reading art as a process

To a lesser extent than expected, images were "read" in terms of technical process. While there were frequent discussions and conjectures about the technical processes that might have been used to *create* images, technical processes did not play a large part in describing the *appearance* of an image. In response to stimulus 3, one informant used evidence of brushwork as a cue that it was painted.

> This image has irregularity. I can read his handwriting. I call it handwriting, but I mean his brushwork. (4.6)

In response to stimulus 2, another informant referred to a technical process in computer graphics in terms of its impact on the viewer's attention.

> In terms of the output, the flower, the spiraling one, is a much higher resolution, and therefore will get a person's interest in a way that a basic bitmap like the first one

never will. (8.5)

"Computer language" appeared to have signifiers of its own. Informants identified features peculiar to computer graphics.

> ...this particular one, compared to what computer things can do, is very primitive. All the non-gestural indications of computer language, visual language, are very rough and raw and very crude in this drawing. (5.2)

However, five informants identified the pixel graphic of stimulus 1 as a needlepoint or weaving. Three of these informants were computer artists or computer art educators. It would appear that there are different kinds of signifiers or indicators of computer graphic techniques and processes, and not all types are recognizable to everyone who works in computer graphics.

Reading art historical references

Most of the informants appeared familiar with different kinds of art historical references, although they did not always apply them correctly. Art historical references took on a general, synoptic kind of quality in some statements; that is, a name was used to sum up a whole body of techniques and ideas about making and responding to art, like a kind of shorthand code.

> There are various art forms around that, from a very simple contour line, to very realistic, and Impressionistic, to a Pointillist representation of a table, through to the Cubist representation of a Cubist bust in the corner. (1.6)

Parts of images were often identified directly with styles or artists, particularly in stimulus 4.

> That [lattice work] comes out of Mondrian, that geometric kind of style. (8.9)

> I see Picasso in the two-nosed woman... a very Guernica image. I see Piet Mondrian in the bright, bright primary colors... (2.8)

One informant described knowledge of art historical signifiers as a kind of vocabulary that is passed between artists and thus to the viewer.

> An artist like David Hockney looks at Picasso and says, "I share that vision. I want to celebrate that vision". So what he's doing in works like this - and many of his other works - even when he does photography, he does Cubist photography. He shares that vision, using something Picasso never did, as far as I know. He never did do photography. But if he *did*, it would look like David Hockney. So what's happened is that there's a certain *vocabulary* that's come through in the 20th Century. (5.7)

The same informant pointed out that, "Knowing art history, I can read his little games, his puns, and I love them". Other informants described this kind of literacy as

"art about art" and "statements about making art". They referred to a kind of knowledge about styles that can be "read".

Although informants were not asked at any time to identify art historical referents or artists, four informants recognized the work of George Littlechild, the painter of stimulus 3; one informant recognized the work of Ned Green, the computer artist of stimulus 2; and six informants identified referents to Picasso and to Pointillism in stimulus 4. Three informants identified stimulus 4 as the work of David Hockney. In several cases, this knowledge determined the way the images were read.

> So, knowing that it's David Hockney, and knowing his interest in Cubism and the breaking down of space, I can see what he's doing. (5.6)

Knowledge of art historical referents appeared to enrich the viewing experience for most informants.

> I find it just a lot of fun, because these are all classic styles in art history. There's Cubism, there's pointillism, there's the theater. I see this shadow of the modern office chair as the evolution of furniture and design. And the bowl with flowers in it is sort of a classic, almost a cliché in painting. (8.9)

Art as a visual game

The verb "play", in various tenses, was used more than any other verb to describe the intentions of the artists who created stimuli 3 and 4. There was a consensus of belief that these artists intended to *engage* the viewer, and to communicate with the viewer on different levels.

> Yes, I think [stimulus 4] is a successful image. Because it creates a context for the viewer to again get involved with the image. It has linked the visual elements together in a way that causes you to be involved in a search-and-find kind of way, an intellectual game with the image, as well as an appreciation of the way the elements are put together in terms of a design. (1.8)

The "play" of the artists was in almost all cases perceived as conceptual. Their intentions were described with phrases like "playing with perspective in a joking manner", "playing with issues", "trying to make a point", "bending and molding laws of art". The viewer's response was also described in conceptual terms, such as "figuring out how thing relate to each other", "studying what it represents", and "pondering" the themes.

Summary

Informants did not tend to "read" images in terms of elements and principles of art, although composition and elements were described as guiding the movement of the eye. Images were examined from the standpoint of how they might reflect visual aspects of the natural physical world. They were also read for artistic traditions such as the use of perspective or contrast for depth cues, and according to art historical referents. Most of all, informants "read" images as a kind of mental puzzle, as "shared" knowledge, or as a "game" to be played with the artist. Thus informants tended to "read" images conceptually, based on their knowledge of art, as much as perceptually, or based on immediate visual evidence.

Space

Since the domain analysis revealed an emphasis on different kinds of "space" in images, particular attention was paid to comments and concepts about space during the interviews. In addition, informants were often prompted to clarify types of space and the use of space in different stimuli.

Two-dimensional space

In descriptions of stimulus 1, informants freely equated traditional matrix-based art forms such as needlepoint with pixel-based computer graphics.

> I assume it's a computer-generated image, although it could just as easily have been an image that was produced by stitchery or needlework, given the grid pattern that developed on it. (1.1)

A informant who identified stimulus 1 as "some kind of sewn image", rather than a computer graphic, used terminology from computer graphics to describe the image regardless.

> It would be a fairly low-resolution image, because the colors seem to be in fairly large chunks, simulating a sewn image. (3.2)

The terms "flat", "overlap", and "positive" and "negative" were used more than any other terms to describe

two-dimensional compositions.

There seemed to be a consensus that parts of images could overlap in space if they were "co-planar", or on the same picture plane, without any artistic indication of depth or thickness. However, this concept frequently was in conflict with real-world knowledge, particularly in response to stimulus 3.

> The only depth is by overlap. The imposed head or face image over the horse figure against that yellow field. Why the horse is in front of this particular border may be to clarify that the horse is standing on the earth. But I can't see any reason for it to be overlapped. Unless that's the reason. (6.7)

Most images were considered to be two-dimensional or "overlapped" if *artistic* devices were more obvious than real-world references.

> (Stimulus 4)
> We're not dealing with an illusion of space there, we're only reminded of the geometric design of the parallelogram... but there's no depth of field here. (4.10)

The terms negative and positive space were used by five informants to describe areas of design in all images but stimulus 3. Three of the informants discussed negative and positive space in terms of "ambiguity" or "integration".

> The negative image is important, because without it you can't have a positive... it's ambiguous, as to the positive and negative. For example, between the horse legs is a negative space, but the color, the space has been treated equally important in terms of color, color-mixing, and intensity. (2.6)

Informants indicated that it was important for an artist to preserve the sense of flatness by emphasizing a kind of equality among elements in two-dimensional images. Areas which shifted in terms of space stood out.

> (Stimulus 3)
> It's a 2D image with a slight hint of the 3D in the image of the face on top of the horse. (2.6)

When this occurred, three informants checked the information against other areas in order to verify whether the image was indeed flat or 3D.

> (Stimulus 1)
> [The image is] almost 3D the way the white outline goes around the object. It almost seems raised, to me. But it's basically a flat image. There's no sort of three-dimensional contours or textures relationships there, it's all sort of a flat image (3.2)

Several informants felt quite strongly about definitions of space and the kinds of images to which they applied. One informant had difficulty with the term "space"

applied to a two-dimensional traditional art image, although the same informant talked about space in response to a two-dimensional hardcopy of a three-dimensional computer graphic.

> (Stimulus 3)
> You're talking about a flat painting, or a picture of a flat painting in my hand, and asking me about space in it... and I see no space. It's like a collage, or mosaic of images, just sort of glued one on top of each other, flat. (3.8)

There was a definite impression that collage work, needlework, and mosaics are flat or two-dimensional, and are therefore synonymous with two-dimensional space. Identification of two-dimensional space therefore seemed dependent to a large extent on identifying specific mediums.

Three-dimensional space

One informant remarked that the term space "conjures up an idea of three dimensions and illusionism, rather than things that are stacked and layered in a two-dimensional way" (3.8). However, in describing three-dimensional space, several informants referred to the idea of multiple "planes" or "grounds".

> (Stimulus 4)

> This is three-dimensional. There's obviously several planes. There's the plane where his feet are resting, there's the plane where the table top is, and there seems to be this plane behind him, defined by this yellow stripe, which gives the impression that there might be another plane there. (8.6)

Informants perceived images as receding or advancing spatially through the planes.

> Because of the graduated depth, and everything seems to recede spatially in a very regular way. Very ordered way. (6.4)

Informants also used words like "centered", "from the edges", or "to the middle of the picture" to connect the idea of planes to the idea of the format, and composition within the format.

> It seems like the images that are forward, or the foreground, are collected on the edges of this particular piece. (4.4)

The idea of illusionism did not appear to be antithetical to the idea of planes or grounds for informants with strong backgrounds in traditional art.

> So this is a very illusionistic image. I do get the sense of a foreground, the middle ground, the background. (4.3)

However, two informants with expertise in computer art distinguished between the idea of planes and the notion of a

"void".

> In a void, there's nothing there unless you put something there. It's not like a drawing program where you draw on a plane. (7.3)

The idea of the "void" was described in terms of working with "objects," and compared to the idea of physical forms in the real world.

> When you work in the void, you work with *objects*. You can describe it as assembling these things, like assembling the universe; all these planets and things live in the void and make up the universe as we know it. Same thing. (7.3)

In order to ascertain whether or not an image was three-dimensional, informants examined the stimuli for specific depth cues. All informants appeared to have extensive knowledge of different kinds of techniques for creating space or illusions of space. Three-dimensional space was described both in terms of simulation or techniques for illusionism, as well as real-world depth, and informants were specific in delineating techniques.

> No, there's no attempt to simulate 3D, or create 3D, either by doing a sculpture, or a montage, or making the face recede, or using perspective. Everything's right here in one frame, on top of each other but not further back. (3.7)

The idea of physical distance played an important part

in determining three-dimensionality. I asked informants what clues they would use to determine a sense of distance. "Scaling" and "size" were cited most frequently.

> The reduction of size: the flowers in the foreground are larger, and as we move towards that depth of field the size of these objects is being reduced. (2.4)

"Aerial perspective" and "depth of field" were also cited as important indicators of depth which are peculiar to three-dimensional images. Informants did not tend to identify perspective in terms of one-point, two-point, or three-point perspective. "Perspective" or "perspectival views" were used as terms synonymous with the *viewpoint* of the viewer, rather than applied to structural views of objects or images.

Five informants used their own bodies as referents for depth; one perceived both depth and height in relation to his own body in response to stimulus 3.

> My vanishing point of course is in the very center. My horizon line would go directly through the equator of the picture, if you will. So I'm standing here, and I'm looking straight through. I'm standing on the ground, and I'm not looking up or looking down. (2.5)

Six informants found combinations of three-dimensional and two-dimensional space disconcerting. In response to

stimulus 4, informants identified mixtures of two-dimensional, three-dimensional and orthographic spatial aspects as "puzzling", "irritating", "confused", and "unlikely". For this reason, three informants perceived it as a "puzzle", a "whimsy", or a "game".

> It would almost be a whimsy, in a sense. It's very... almost surrealistic in the way things are visually and spatially jumbled, or not oriented. (2.7)

Another took a harder view.

> Whoever did this, they're all over the place. Visually, it just doesn't work. (7.9)

Summary of space

Two-dimensional

Informants equated the matrix-based art forms of pixel graphics and needlework, and freely mixed terminology used to describe both mediums. Negative and positive space and overlapping shapes were perceived as co-planar, or as being integrated on the picture plane. Informants expected artwork in specific mediums such as fabric art or collage to be two-dimensional. They also expected two-dimensional art to be *consistently* two-dimensional, and were confused if elements of illusionism were incorporated. Therefore, equality among elements in two-dimensional art was most

important.

While informants were definite in their views about *two-dimensionality*, there was some confusion in relating the term "two-dimensional" to the term "space".

Three-dimensional

Three-dimensional space was equated with the idea of multiple planes or grounds, and with the idea of a "void". Informants cited extensive knowledge of techniques for creating space, such as perspective systems, reduction of scale, depth of field, and aerial perspective. "Perspective" was equated with "viewpoint" (rather than systems such as three-point perspective), and informants used their own bodies as a referent. Again, informants were puzzled if three-dimensional space was not consistent.

Sensory elements of art

Two-dimensional shape

While the term "two-dimensional" was frequently and voluntarily applied to the term "space" by all informants, the term "two-dimensional" was applied to "*shape*" by only one informant.

> If I were to take a petal off a flower, for example, I'd be taking away 2D triangular shapes. (2.3)

Generally, shapes were referred to as "spaces", "areas", "regions" or "images".

> The dress was filled in, in a crude computerish manner. There's no time taken to scale the pattern, or tweak it so it curves around and make it look three-dimensional. In other words, it's totally two-dimensional. It just looks like a space filled in. (8.1)

Three-dimensional shape

Only one informant made frequent reference to three-dimensional shapes, but referred to them as "basic" shapes. He also included two-dimensional shapes in his descriptions of basic shapes.

> It's very basic shapes. In other words, the cylindrical shapes are very, very clearly defined, the circle, the triangular shapes, the cube shapes - so you have all your basic shapes. (2.1)

Generally, informants referred to three-dimensional shapes as "objects", or by name, such as "flower" or "chair".

Line

Lines created by continuums of adjacent pixels in stimulus 1 were compared to "stitches" by three informants. Pixels in computer graphics were differentiated from stitches in needlework or weaving by their "regularity", flatness, and spacing. The weight of the lines did not appear to be a factor in differentiating between them, since it was perceived that computers were capable of generating lines of different widths.

An "inconsistency" of line, which was described as variations of pressure or color in line, was highly valued. All eight informants expressed positive responses to lines that were "gestural" or which had "gradients". Four informants commented on the gradient properties of the vertical line on the right side of stimulus 1. It was said by one informant to "fluctuate with tonality", although a informant who had expertise with computers described it in computer terms:

> There's a dithered line, that's a gradient line, on this side... it's "ping-ponged", so that it starts off, and when it gets to the middle it goes back on itself. So it starts out blue, goes to the red, then goes from red back to the blue again. (7.1)

Contour lines in stimulus 3, which evidenced variations

that were not systematic or computer-generated, were described at length and in detail by three informants.

> There's more to line... every line is different. One line is a sheer color. The next line is supported with a red line on the inside. Here it's supported with an orange, he's mixed some of his orange with it... If you just go around, if you start looking at this structure, this is a line he's working on not in a systematic manner. (4.8)

All informants appeared aware that there were different kinds of line and styles of line.

> He's got a watercolor feel, where you get that blobby line that fades off with the touch of the brush - the blue and orange. He's got a very unique Pointillist kind of style in the table... and he has a very simple line drawing here of the chair. (8.8)

Informants expressed dislike for lines that were perceived as "mechanical", "electronic", or "computer-esque", but were unable to give specific rationales or to differentiate between graphic and computer mediums in any way that supported the dislike.

All informants were aware of "implied" lines and their importance in both guiding eye movement through the composition and creating illusions.

Pattern

"Pattern" was defined in terms of "a multiplication", as "re-ccurring", and as "repeatable". Pattern appeared to be most noticeable when it was global, as in the allover repeated flowers of stimulus 2. Five informants were concerned with interpreting the global patterns of stimulus 2, or "figuring it out". One returned repeatedly to this image throughout the interview until he said he "got it".

Informants rarely mentioned local pattern voluntarily. Most informants did not use the word "pattern" to describe patterned areas in stimulus 1 and 4, *even when prompted* to notice and describe these areas in detail.

Texture

Six informants distinguished between texture in original art and the appearance of texture in reproduced art.

> (Stimulus 3)
> Well, assuming that it's actually texture and not something simulating texture - which is hard to tell because this is not the original - it looks almost like finger-painted on, or with a very solid-ended brush. (3.6)

Three informants evidenced fine visual acuity when describing parts of images less than a centimeter in reproduction size.

(Stimulus 3)
The second thing I notice is that these little circles in the squares look like three-dimensional metallic objects with shiny paint on them. Like thumb tacks, or blobs of paint? They have little highlights on their edges. Which gives the illusion they're sitting out from the surface. They probably actually are. (8.6)

Texture was described in terms of an "activity", a "quality", and an "illusion". Texture was also equated by three informants with a kind of "pattern".

It ranges from a very, very, very soft focus in the center, to an almost bark-like texture pattern of the intertwined branches, to the smooth edges of the petals of the flowers, and the pattern texture on the leaves. (1.2)

Color

In the initial descriptions of images before prompting, only the two art educators used such color terms as "analogous", "complementaries", "primaries", and "secondaries".

All informants were prompted to describe color in terms of "palette" or "scheme" and "color theory". Four informants were unsure of the meaning of the term "palette" itself.

One informant used the term "palette" to describe a *color scheme* in stimulus 1 - "so that we have a palette that

ranges in analogous colors from yellows through greens" (1.1) - and used the same word to describe color in terms of the artist's *intention* in stimulus two - "the palette seems to deal with color in both naturalistic and more imaginative forms" (1.2). Therefore "palette" appeared to have two different meanings. Most informants responded to prompts regarding the palette used in images by identifying local colors of specific areas, which created a third meaning. One informant objected to the use of terms like scheme and palette altogether.

> Not a color *scheme*. I hate that word, anyways. I often run across that word used to talk about color, and by a dictionary it's in use, but "scheme" by definition does not have any relation to the way people use color. "Scheme" would be more like a design intention. (6.8)

"Color" was generally perceived as a kind of artistic vehicle for generating response. Color was frequently identified with "excitement", "vibrancy" and "fun". It was also used frequently as a cue that signaled edges or a change of shapes, as well as a depth cue.

> (Stimulus 1)
> The depth is that the color in this figure is colorful, and the background is no color, except for this line on the side. So this appears to be a figure that is flat, against a field. So it's a figure on a ground. (6.2)

"Cool" and "warm" colors were also used as depth cues by two informants.

> (Stimulus 3)
> Because of the use of the color, the warm colors, the cool colors on the face, the cheeks do appear to be three-dimensional. (8.7)

Two informants in computer graphics emphasized color processing in the reproduced images.

> Printing only has four colors that it can represent... when they do printing, they do it like Pointillism. So when you look at it up close, you can see the dot pattern - but when you get far away it's like Pointillism, it blends. Your eye is made to do the blending. (7.2)

These informants emphasized that the human eye is never limited to seeing "color schemes" or even compartments of local color, since any color is made up of many colors.

> There's way more... there's about a million colors in that, if you really look at the second one. Whereas in the first one there's maybe ten. I'm talking about shades of a certain color. That's the way you see in any given time. You might see in millions of colors. (8.5)

Therefore identification of color depended on the degree to which a color is pure or made up of different color dots.

> Irregardless of how they were made, if you did a color analysis of the range of colors in both

> of them, they're both there. There's just as much *color* in here, it's just that the appliqué of the third one is flat color, larger areas. (7.8)

Tone

Tone was frequently described in terms of "focus". It was also perceived as a result of lighting, and as a cue for depth.

> (Stimulus 1)
> Someone's taken the time to make a tone. From the neck to the head, for instance, there's a tone under the neck to give the illusion that she may actually have a chin protruding outwards. One shoulder is in shadow, and there does seem to be a shade going up one side of the body, like there's a light source over here. (8.1)

Tone was also identified in terms of color contrast, which again was used as a depth cue. In two-dimensional images, contrast was perceived to create flat layers that enabled the perception of shapes. In three-dimensional imagery, color contrast was related to the integration of spatial "grounds".

Summary of elements

Shape

The term "shape" itself was rarely used. Two-dimensional shapes were called "spaces", "areas" or "regions" in all four stimuli. Three-dimensional shapes were referred to as "objects" or "forms" or by their names, such as "flower" or "chair". In both cases, the term "dimensional" was not used in relation to shapes.

Line

Lines created by continuums of pixels were compared to "stitches", and differentiated by their regularity, flatness, and spacing. "Inconsistency" in terms of "jaggedness" was not a factor in differentiating, but variations of hand pressure were. Other than in terms of hand-pressure, informants were unable to rationalize a dislike for mechanical, electronic lines. Informants perceived implied lines *if* they were part of global patterns, or if they contributed to illusions of depth.

Pattern

Pattern was most noticeable, and termed "pattern", when it was global. The term pattern was most frequently used in descriptions of stimulus 2, which had a radiating, receding global pattern. Informants described local pattern in terms

of repeated elements, but did not tend to use the actual word "pattern".

Texture

Informants distinguished between texture as a physical surface and as an illusion. The term texture was most frequently used in descriptions of stimulus 3, an oil painting. Texture was perceived as an "activity" or "quality". Informants were particularly aware of nuances in the physical surfaces of pictures, such as "impasto". The word texture was also used to describe or replace "pattern".

Color

Most informants did not understand or relate to color as a "scheme" or "palette" in the formalist sense of "analogous" or "complementary" schemes. Color was generally described in terms of local color, and used as a cue to discern edges of shapes. Color was identified globally with "excitement", "vibrancy", and "fun". It was pointed out that since any one color "contains" all other colors in both visual perception and in four-color printing, the perception of color is a matter of *degree* on a continuum, rather than a categorization.

Tone

Tone was frequently described in terms of "focus". It

was perceived to be a result of global lighting, and as a depth cue. In two-dimensional images, changes in tone enabled the perception of shapes. In three-dimensional images, tonal contrasts were related to the integration or the contrast of different planes. Thus tone was perceived as a global element, as was pattern.

Formal principles

Formal balance

The four informants who referred to "balance" used the term in the context of "symmetry". By "symmetry" they meant the centering of space and objects. The idea of centering was related to the picture plane.

> In terms of the image on the ground that I'm looking at, it's organized in almost a totally symmetrical way, in that it's centered in the picture plane. (1.2)

Seven informants did not respond to prompts regarding the asymmetrical positioning of the vertical line on the right in Stimulus 1.

> It's pretty straight forward. She looks as though she's right in the center, very symmetrical. Very composed. It's anti-Baroque. Classically oriented. It's a formal positioning of things. (5.2)

Informal balance

One informant disagreed, and found the asymmetrical line to be an important compositional element.

> The line really does make a lot of difference. Otherwise the pattern-like quality of the form would be entirely isolated from the format. (4.3)

"Asymmetry" generally was perceived in terms of deliberate manipulations to make images "irregular" by three

informants. "Asymmetrical" images were also considered as "balanced" by two of these informants.

> (Stimulus 2)
> I'd say it was asymmetrical... it's a type of spiral, but there's a lot of work put in there to make it look asymmetrical. And yet balanced at the same time. (8.5)

Unity

Another informant discussed the "unity" of stimulus 2 on the basis of its continuously reducing depth of field. Four informants attributed unity to the radiating global pattern.

> The vines are like the flowers. They're weaving in and out of the foreground. I see more of a circular pattern, a serpentine pattern, whereas the flowers are definitely part of this giant radiation. (2.4)

Concepts about composition and unity were therefore strongly related to global patterns within the format, especially in response to stimulus 2.

Variety

Variety between elements was perceived by all informants to be a purposeful manipulation by the artist to keep the viewer's interest. Variety was discussed in terms of perceptual interest as well as conceptual, although the

emphasis was on the conceptual.

> (Stimulus 2)
> The elements work together, in order to create enough diversity, to keep you interested, to keep your eye moving through the space... to give a hint of something more happening than first appears, that keeps your mind working through, and tries to work through what is really going on with it. (1.3)

Clarity of image

Clarity of image was the most prevalent theme identified in the interview data. Informants were concerned that the techniques, styles, and mediums in all imagery be consistent, and that the composition be symmetrical. Five informants found stimulus 4 "cluttered", "too busy", and a "mish-mash of styles and surfaces". One informant had "the urge to run to my paper cutter and cut this up into at least six different areas" (2.10). Another informant was visibly distressed.

> I'm objecting to the mish-mash of styles and surfaces. Like, what is this yellow thing? What is that? The elements of this picture drive me nuts. It's like one of those pictures of, "Do you make these mistakes in your art?" (6.10)

Informants were concerned that lighting be uniform, not inconsistent; that edges of shapes were defined; and that

expected evidence, such as the detail on leaves in stimulus 2, be consistent with the detail on flowers.

Repetition

In stimulus 2, repetition was seen in terms of the replication of a *single* piece of imagery, rather than a series of alike or similar elements.

> They look like they've been done on a computer. The way the shapes, once they've been done once, can repeat endlessly off. (3.4)

Informants described this kind of repetition in terms of "images copied", "recursion", and "duplication".

Particularly in response to stimuli 3 and 4, the word "repetition" was used to describe different elements that shared a feature which made them more alike than dissimilar.

Proximity of elements

The "success" of an image was evaluated by one informant in terms of continuity of eye movement in the format. He believed that an implied diagonal line created a sense of proximity of elements in stimulus 4.

> It's successful because of its structure, its composition, its color. There's a diagonal line that starts in the lower left by the horse's foot, going up through the head to the top right. Good structure, good composition. (7.4)

Emphasis

Individual elements were rarely described in terms of emphasis. Terms such as "focal point" and "isolation" of elements were not used. "Emphasis" in stimulus 1 was equated with the symmetry of the image; in stimulus 2 with the "pervasive" and "merged" pattern of the vines and flowers, as well as the composition of what was described by four informants as the "vortex".

In stimulus 3, emphasis was equated with the narrative aspects of what was described as a "circus" theme by four informants; and in stimulus 4 with the conceptual "game" between the artist and the viewer. Therefore, formal principles such as balance and emphasis as well as cognitive themes like "carnival atmosphere" or "art historical game" were perceived to be emphasized, rather than specific elements within compositions.

Lighting

Lighting was perceived as something that should be continuous throughout an image; that is, as a global, unifying device that should affect all parts of an image equally. Evidence of inconsistent lighting was described as "cosmic", "false", "indeterminate", and "confusing".

Three informants referred to traditional painting as

something that doesn't have lighting, it "just is". Other informants perceived the concept of "lighting" as something that an artist does on purpose, and discussed it on the strength of its "naturalness". Lighting in both traditional art images and computer art was compared to natural light effects.

> (Stimulus 2)
> There are some things that are missing here that are in reality. And I would say that that is the lack of a light source, overall. If there were any light coming from the side, there would be shadows we would experience in reality. (6.5)

Lighting was cited as a cue for "perspective" or depth by all informants.

Informants felt that it was important that lighting be "continuous" if it were used at all, and affect all parts of an image equally in the way that chiaroscuro once did.

> For example, the old idea of chiaroscuro, of modeling, that would have to be done by going back into it, and playing with each individual one. (5.4)

The definition of continuous included the ideas that there be only one external light source, and that it cause regular effects such as shadows.

> There'd also be a spotlight casting light on

> it... a light source, like the sun behind you, and casting shadows. There's no obvious apparent source of light [in stimulus 3.] (3.8)

Three informants were concerned by the lack of shadows in what they otherwise described as a very "realistic" image, stimulus 2.

> Where these things overlap there's no sense of shading or shadow-casting. They're so strongly lit there are no cast shadows, nor incidental shadows. So that's kind of false. (6.5)

Five informants commented on the irregularity of the light source in stimulus 2. The irregularity was perceived as a result of procedures that "pasted" or "patched" the image together from one or more sources.

> The light often seems to be coming from all directions at once. And that's probably caused by the cutting and pasting and rotating of a single image to make an image like this. (8.3)

The fact that computer images are created on a screen was perceived by one informant as affecting the way light and color are used in the final image.

Format

The format itself was perceived as a kind of "container" for eye patterns or structural patterns.

> The composition always does depend on the format, not on the positive space. It happens

from the edge of the piece. (4.4)

Three informants noticed the cropped edges of the image in stimulus 1.

> The toes are missing, and the very top of the head is sort of clipped off, like it's either been photocopied or something, as would be the usual thing that would produce that sort of clipping. Or looking at an image that's not quite fully displayed on a computer screen. (3.2)

Two informants commented on the scale of the computer format in terms of its impact on the viewer.

> The scale is different in these images too. Everything's down to magazine size. (5.11)

One informant pointed out that the experience of the computer image is different in hardcopy than it is on screen. The colors on the monitor may not match the colors which will be output by various hardcopy devices. He pointed out that the computer artist has to be aware of potential variables that occur during electronic reproduction, while a traditional artist has control over his image from beginning to end.

Summary of formal principles

Balance

The idea of balance was related to that of global, symmetrical organization. Asymmetry was equated by most informants with irregularity, or deliberate manipulations of local areas for particular effects.

Unity

Unity was perceived as a global effect resulting from consistency in depth of field, such as consistent reduction of forms or focus, or from global patterns such as a radial composition of elements.

Variety

Variety was considered by most informants to include conceptual and perceptual information, though the manipulation of ideas was referred to as a technique to maintain the viewer's interest.

Clarity of image

The importance of clarity of image was the most prevalent theme in all interviews. Informants looked for evidence that techniques, styles and mediums were consistent in each image, and compositions symmetrical.

Repetition

The term repetition was used equally as much in two

different senses: the replication or copying of a single element, and a series of elements which were more alike than dissimilar.

Emphasis

Informants perceived emphasis as a kind of global organization. Informants referred to allover "pervasive" or "merged" patterns, as well as unifying cognitive themes like "carnival atmosphere". Thus emphasis was equated with notions about each artist's overall intention or purpose, rather than with the idea of emphasized elements.

Lighting

Lighting was also perceived as a global, unifying device, and informants looked for consistency. Informants distinguished between art styles which stressed decorative effects and therefore ignored conventional light sources, and artworks which sought to transcribe or incorporate natural, illusionistic lighting.

Effects of lighting were used as depth cues to determine irregularities in the original surface of artworks; to verify consistency in three-dimensional illusions; and to verify the "naturalness" of simulated realism.

Format

Format was perceived as a kind of "container" for structural patterns and imagery. Format is not only "magazine scale" in computer graphics, but may also be different in hardcopy than on the screen.

CHAPTER V

COMPONENTIAL ANALYSIS

Introduction

All of the data from the literature search, domain analysis, comparative taxonomies, and the interpretation of interviews was compared and contrasted. The componential analysis has three parts.

First, design vocabulary used in art education and computer graphics is listed. These terms are derived from the literature review and from the interviews. Many terms are comparable (Tables 4 - 7) and significantly expand formalist concepts. They are further discussed. Other terms have no counterpart, and appear unique to one field of image-making or the other; these terms are listed following the comparison tables.

The second part is a componential analysis of elements and principles in traditional art and in computer graphics.

In the third part, many issues raised in the literature search are correlated with problems identified in the domain analysis and by informants during interviews. These include similarities, differences, and dichotomies between formalism and computer graphics.

1. **Design vocabulary**

The componential analysis of design vocabulary is presented in four tables: in Table 4, vocabulary used to *designate* design elements as well as parts of design elements, such as "corner" in traditional art and "vertex" in computer graphics; in Table 5, vocabulary used to describe *characteristics and properties of* design elements, such as "organic" shapes and "freehand" polygons; in Table 6, vocabulary used to describe the *image as a whole*, such as "symmetry" or "global regularity", as well as vocabulary used to describe positions or locations of design elements within the format; in Table 7, terms that describe *procedures and techniques* for structuring images.

The componential analysis of design vocabulary seeks to compare differences in terminology, and in this study, to describe areas where traditional concepts have been expanded to accommodate material derived from data-gathering. Each table has two columns so that design vocabulary in the two fields can be compared side-by-side. Computer graphics terms are highlighted to represent conceptual areas which appear to *expand* meanings in formalist theory. An outline of how these terms expand traditional art theories follows each table.

TABLE 4

Design vocabulary: elements

Art education	Computer graphics
element	primitive
mark, point	pixel; dot-per-inch
line, path, continuous mark, moving point	row; segment; vector
contour line	silhouette line
cross-contour, interior contour line	contour line
connecting line	segment; vector
corner	vertex; node, handle
edge	bounding side
pattern	default, selected, or created patterns; area fills; hatch patterns
allover, continuous pattern (local)	fill, opacity map, texture map
surfaces	materials
plane	bitmap; polygon
two-dimensional shape	polygon
three-dimensional shape, 2D projection	solid object; polyhedral
illusion	simulation
projection	extrusion; loft
plastic shapes	extruded polygons
area	region
positive shape	region; polygon; polyhedral
negative shape, space	bitmap; void
soft-edge shadow	penumbra, fall-off
highlight	specular highlight
value	contrast

Conceptual expansions of terminology for design elements, Table 4

mark, point < pixel; dot-per-inch The computer graphic terms expand the notion of "mark" to emphasize different forms of *output*
line, path, continuous mark, moving point < row; segment; vector The computer graphic terms emphasize the *result* of working in different spatial environments
corner < vertex; node, handle The computer graphic terms indicate the *generative* potential of shapes. Shapes have no "fixed" corners.
pattern < default, selected or created patterns; area fills allover, continuous pattern (local) < fill, opacity map, texture map In computer graphics, patterns are ready-made.
surface < material In traditional analog media, the surface of an object in a picture is the same thing as its side or face. In computer graphics, the surface, called "material", can be manipulated independently of faces, called "facets"
plane < bitmap; polygon "Bitmap" and "polygon" clarify notions of plane as *either* a surface or a shape
three-dimensional shape, 2D projection < solid object, polyhedral The computer graphic terms clarify the notion of 3D shape as a 360° form in an environment

TABLE 5

Design vocabulary: characteristics and properties

Art education	Computer graphics
character	regularity
characteristics	properties
curve	arc, semi-circle, spline
diagonal	slope
on an angle	skewed
broken	angular
dashed or dotted	hatched
zigzag	broken
jagged edges	jaggies, steps, staircase effect
soft edge	dithered, feathered
hard edge	bounding sides
decorative	planar
organic, biomorphic	freehand polygons
turned	rotated
distorted	irregular
concrete	visible
symmetrical	duplicated and flipped
simple	regular
busy	noise
mirrored	ping-ponged
repeated	duplicated, copied; swept; replicated; arrayed; instanced
actual	positive by default
negative	reverse
opaque	solid
matte	flat light
glossy	shiny, reflective; illuminated

weight	intensity, thickness
bold	thick
delicate	thin
local or objective color	selected color
optical color	spotlight color
shade	lightness
intensity	saturation
overlapping	co-planar

Conceptual expansions of terminology for characteristics and properties, Table 5

characteristics < properties The notion of "properties" credits characteristics to the element, rather than to the format or the element seen in context
diagonal < slope The term "slope" allows a perception of diagonals as "grades" interacting with each other, rather than with the format
hard edge < bounding sides The term "bounding sides" emphasizes the idea of space around the shape rather than the shape
busy < noise The computer term "noise" expands the perceptual response to include cognitive reaction
repeated < duplicated, copied; swept; arrayed; instanced The computer graphic terms emphasize the notion of exact equivalents copied in a series
intensity < saturation "Saturation" indicates the measurable extent, on a scale of 1-100%, to which a color can be intense in computer graphics.

TABLE 6

Design vocabulary: Imagery

Art education	Computer graphics
design, graphics	two-dimensional graphics
picture	rendering
three-dimensional space; illusionism	void
format	hardcopy; environment
pictorial analysis	disaggregation
multiples	hardcopies; replications
surface	image
picture plane	screen; matrix; bitmap
grid	bitmap; wireframe
matrix	bitmap
mosaic	block-pixed bitmap
composition	structure
position	location
depth devices	depth cues
lighting	ambient lighting
axis	intersection
symmetry	global regularity
direction	orientation
radial balance	rotation; mirroring
allover pattern (global)	continuous pattern
density	resolution
perspective	field of view
point of view	camera placement
palette	color resolution
color scheme	color tables

Conceptual expansions of terminology for imagery,
Table 6

picture < rendering In a computer rendering, features of the picture such as point of view, field of view, and lighting can be manipulated independently of the objects in the picture. In traditional analog media, these features are inseparable from the content of the picture.
three-dimensional space; illusionism < void The computer term "void" expands the notion of a three-dimensional space from a surface to an environment
format < hardcopy; environment "Hardcopy" expands the notion of one unique original, and "environment" expands the notion of the format as a surface plane
pictorial analysis < disaggregation In "disaggregation", elements are perceived in terms of a process of *reduction*, rather than of integration or addition
multiples < hardcopies; replications The computer terms emphasize the idea of a digital rather than an analog original
picture plane < screen; matrix; bitmap The computer terms refer to the location and orientation of areas rather than to the idea of a "window"

matrix < bitmap mosaic < block-pixed bitmap The computer terms allow matrix-based traditional art to be seen in a spatial tradition *unlike* the picture plane
composition < structure "Structure" emphasizes the notion of *building* rather than designing or arranging
symmetry < global regularity "Global regularity" focuses on the composition of a *unit*, rather than areas that "match"
density < resolution "Resolution" emphasizes the *distribution* of the medium on the surface rather than the depth
perspective < field of view The computer term places the viewer within the field of view, rather than establishing the viewer as an external observer

TABLE 7

Design vocabulary: procedures and techniques

Art education	Computer graphics
techniques	procedures
mediums	program capabilities
pigment	pixels of light; dots of ink
draw	use coordinates, geometry
freehand	paint
image development	interpolation
experimentation	generation
graphic design	interaction
perspective systems	coordinate systems; geometry
chiaroscuro	flat shading, polygonal shading
modeling	continuous shading
atmospheric perspective	degrees of atmospherics
aerial perspective	degrees of transparency
scaling of pattern or texture	procedural modeling
scaling	resizing
outlining	framing
repetition	replication, copying, duplication; sweeping; iteration; recursion

Conceptual expansions of terminology for procedures and techniques, Table 7

mediums < program capabilities "Program capabilities" afford interaction between mediums which are physically impossible in traditional art
pigment < pixels of light; dots of ink The computer terms indicate expansions in the properties and qualities of color
image development < interpolation "Interpolation" emphasizes transitions between images as an averaging process, rather than a hierarchical succession
experimentation < generation "Generation" emphasizes the idea of machine intervention in the creative process, using such intermediary devices as conversion to digits and algorithms
graphic design < interaction "Interaction" emphasizes the role of the computer in affording a partnership during the creative process
perspective systems < coordinate systems; geometry The computer graphic terms indicate new capabilities of perspective systems in art, such as using a 3D void to create 2D output
repetition < replication, duplication, copying; sweeping; iteration; recursion The term "repetition" is not expansive enough to accommodate differences in the meanings of these computer graphics terms.

The following art education terms do not appear to have any comparable meanings in computer graphics.

motif
rhythm
calligraphic
variety
emphasis
focal point
weight
center of interest
dominant
subordinate
approximate symmetry
monochromatic color scheme
analogous color scheme
complementary color scheme
triadic color scheme
shallow space
dynamic
passive
intuitive
expressive
color "temperature"
advancing or receding color
ambiguous
organic/biomorphic
color field
passage
harmony
proximity
balance
unity

The following computer graphics terms do not appear to have any comparable counterparts in traditional art.

iteration
recursion
fractals
mathematically "grown" images
transformation
morphing
digitization
randomness
stochastic variation
mkray tracing
self-illuminating
effects filters
hidden line algorithms

2. **Elements and principles**

A comparison of similarities and differences between elements and principles in traditional art and equivalent elements and principles in computer graphics afforded the following componential analysis of expansions in meaning or usage.

1. Two-dimensional space

Procedures for computer graphics are linked to different kinds of two- and three-dimensional space. In

two-dimensional object-based systems, the idea of "co-planar" shapes replaces formalist ideas of "overlapping" shapes, and expands formalist ideas about design as an "arrangement" with computer graphic procedures for coordinate systems. Bitmap systems in computer graphics may be equated with matrix-based forms of art.

2. Two-dimensional shape

Formalist ideas about two-dimensional shapes as geometric, "decorative" or planar, with characteristics like "soft" and "hard" edges, are similar to the concept of polygons or planes in computer graphics. The idea of shape in computer graphics also includes *spaces, areas, regions,* or *surfaces*. Two-dimensional shapes in computer graphics have different intentions, depending on the kind of space in which they are created.

3. Three-dimensional space

The idea of three-dimensional space in traditional artwork is constrained by the fact that images are flat areas on a picture plane. In computer graphics, three-dimensional space is a void in which 360° objects are placed, and subsequently manipulated through such techniques as scaling, orientation and lighting.

Traditional perspective systems involve treating images

in 3D space as 2D projections from a fixed viewpoint. Computer procedures afford the expansion of traditional concepts about perspective through the use of coordinate systems and geometry; interactive points of view and depth of field; and special procedures for transparency and illumination.

4. Three-dimensional shape

In computer graphics, three-dimensional shapes are entities or objects which interact in actual geometric relationship to each other. This concept expands the formalist idea of three-dimensional shapes as illusionistic organizations of tone or contrast on a surface.

5. Line

Line in formalist theory is perceived as an element with expressive characteristics, while in computer graphics line is literal. Lines in computer graphics are generated via the computer, using different mathematical systems. A number of perceptual and conceptual characteristics of computer lines, such as aliased lines, lines with precise hatch patterns, or vectors on a z axis, expand the formalist dimensions.

6. Pattern

A wide variety of procedures are used in computer

graphics to create local patterns similar to those of traditional art. Global, unifying procedures in computer graphics can also organize local elements. Global pattern is created in computer graphics with procedures such as recursion or "mirroring".

7. Texture

Rather than a surface quality, texture in computer graphics is defined as a form of rendering, such as bitmaps or bumpmaps. These procedures simulate reality but are applied uniformly, despite procedural modeling which increases illusionistic effects by "wrapping" texture around three-dimensional objects to give a perceptually-correct perspective. Computer-driven procedures give a uniformity to texture that equates it more with formalist ideas of pattern.

8. Color

Formalist notions of color "schemes" may be replaced with response to color brightness, key or intensity, value contrasts, and color saturation, since four-color separation and computer program palettes emphasize these kinds of qualities rather than schemes. The perception of color appears to be a matter of perceiving degrees on different *continuums*, rather than a categorization process. Color is

therefore perceived in relationship to variables of value or purity within each color.

9. Tone

The concept of tone in computer graphics is primarily concerned with uniform global effects rather than local contrast. It is determined by such global features as lighting, color intensity and resolution. The use of tone in terms of *focus* in computer graphics, through such procedures as illumination and transparency, also expands the formalist concept of tone as shading and modeling. Local effects are achieved through the application of different kinds of shading procedures, as they are in traditional art.

Tone was found to serve as an aid to the perception of shapes, edges, and texture. Tone also aids in the integration of planes.

10. Formal image

Procedures play an important part in expanding the idea of an *abstract* "language". Evidence of techniques and selections may be perceived as recognizable elements or "signifiers", whether they are techniques in art or algorithmic procedures in computer graphics. Appropriated art historical signifiers also appear to be an important

part of artistic language. The formal image can no longer be perceived as referring only to itself, with "permanent or residual aesthetic value".

Computer graphics demonstrate more precise ideas about "space" in images than have been defined in traditional art. Ideas about space may be organizing principles rather than elements, as different kinds of artistic and mathematical spaces determine the kinds of activities which can occur in them.

Generative and interpolative procedures in computer graphics, as well as the replicability of the same image in different output modes, beg notions of what is original or "unique" in art.

11. Balance

Ideas expressed by the informants about balance, symmetry and asymmetry in computer graphics tended to be described as local. However, the formalist principle of "balance" is related to that of global pattern in computer graphics.

12. Unity

Concepts of resolution and lighting in computer graphics expand the number of formalist fundamentals which are believed to contribute to "unity". The computer image

is unified by equivalency of color, medium, and resolution, and the degree to which lighting effects are consistent.

13. Variety

Formalist ideas about variety depend on the dominance or subordination of sensory elements such as color and shape, and on contrasting characteristics of sensory elements such as hard edge/soft edge, matte/glossy, or patterned/solid. Variety was not found to be an important principle in computer graphics. This study also found that variety is generally perceived in terms of conceptual theme variety rather than perceptual effects.

14. Clarity of image

Clarity of image was found to be a significant factor in the perception of the image as a whole, whether traditional art or computer art. Procedures in computer graphics afford consistency in techniques, styles and mediums.

15. Repetition

The formalist idea of repetition as a series of elements which are more alike than dissimilar is expanded by computer graphics to include the idea of replicating or duplicating a single element. The latter form of repetition creates a kind of fill, iteration, or equivalency of

elements in a similar sense to that of modernist and minimalist art structure.

16. Lighting

In traditional art, the paint itself (or other media) is used to create the illusion of light. The content (i.e. objects represented in a 2D artwork) and the effects of lighting (i.e. the modeling) are inseparable. In computer graphics, objects and lighting are created separately and can be manipulated independently.

In both traditional art and computer graphics, however, lighting can be a global, unifying device that creates both consistency and regularity between elements. As such, lighting is a compositional element.

17. Format

The "magazine" scale of 8 1/2 x 11" computer graphic hardcopy questions the assignation of formalist values to relationships between the scale of the visual content and the scale of the format, as well as the values assigned to scale in contemporary artworks.

Traditional concepts of perspective are expanded as the field of view in computer graphics seeks to *enclose* the image content, while traditional perspective *directs attention to* diminishing and receding elements.

Conclusion

In conclusion, this conceptual analysis of elements and principles of art indicates that while some elements may be principles, some principles may be global elements.

Principles do not appear to be laws, criteria, or rules. Images are perceived as units, with regular, irregular, consistent, or inconsistent features within those units. Global elements such as tone, pattern, resolution or lighting aid in the consistency or regularity of images. The interior consistency or constancy of design elements is unlike formalist notions of harmony, which assume exterior criteria.

3. **Componential analysis of image-related issues**

The componential analysis of issues related to the visual structure of images is organized in three parts. First, conceptual similarities between computer graphic images and formalist images are described. Second, differences between them are reviewed. Third, conceptual dichotomies are created as a result of certain distinctions between formalist images and computer graphic images as well as distinctions in aesthetic response.

Similarities

1. Computer graphics and formalist images rely on similar elements of art: line, point, pattern, texture, and shape.
2. Computer graphics and formalist art share rational organization.
3. "Formal roots" give traditional art "universality", while the international use of specific software programs causes a kind of "cultural colonization" (Ettinger, 1988).
4. Traditional art has schematas, or conventions for representation, as does computer graphics.
5. The idea of "signifiers" in both traditional images and computer images includes concrete evidence of specific techniques, selections, and procedures as much as an "abstract language".

6. Traditional art is concerned with perceptual structures, such as modeling, pattern, or texture. In a similar vein, computer graphics use algorithms for perceptual structures.
7. In aesthetic study, visual and tactile characteristics (among other properties of artworks) can be discriminated and categorized (Broudy, 1966). In computer graphics, visual and tactile characteristics are recognized and described.

Differences

1. In aesthetic study, discriminations among sensory elements are visually perceived (Smith, 1972). In computer graphics, many elements are hidden from view or embedded in such procedures as hidden-line algorithms.
2. Aesthetic study of conventional 2D images is premised on the fact that the structure is static, and has a typical consistency. The underlying structure in computer graphics is fluid, and may be hidden, manipulated, cut and pasted, or transformed.
3. Formalist images are often described in terms of anthropomorphic qualities of character and personality, while characteristics of computer graphics are literal.
4. The formalist image is material and fixed. In computer

graphics, the digital data is subject to transformation during output reproduction.

5. Formalist art postulates an idea of permanent or residual value, while computer graphics are interactive and transformable.

6. Formalism seeks to *integrate*, while computer graphics seeks to *correlate*.

7. The formalist image is considered to be unique and original, even when it appears as a multiple, as in printmaking. In computer graphics, the image is one of multiple interpolations or modification. It may also be the result of commercial software or public domain shareware. In these cases, the programmer as author has, by writing the program, constrained the user's originality; as Hickman and Wright pointed out, the programmer may even be seen as the artist, who makes art by offering an array of possibilities to others (Hickman, 1991; Wright, 1989).

Dichotomies

1. Traditional artworks frequently contain evidence of handcrafted marks and "errors". The surfaces of computer graphics tend to be pristine, regular, and uniform.

2. In traditional art, elements are worked with, using

principles. In computer graphics, principles are worked with, using elements.

3. Traditional formalist theory emphasizes the significance of dominance and subordination, emphasis, and focal point, with elements interacting to create balance, harmony, or rhythm. In computer graphics, elements are downgraded into the kind of "visual fodder" described by Wright (1989), which creates an equality and consistency between elements.

5. Computer graphics seek to introduce chaos into order (in the mathematical sense) as a generative process, to circumvent the orderly and mechanical nature of the medium. Conversely, formalist design seeks to bring order out of chaos (in the literary sense).

6. Formalist theory postulates subjective external aesthetic references such as "balance", "harmony", or "beauty". Computer graphics that simulate scientific referents in the fields of biology or astronomy are externally-directed and have objective criteria against which they can be evaluated.

CHAPTER VI

IMPLICATIONS FOR ART EDUCATION

Introduction

During the past ten years, the field of art education has been influenced by models which equally emphasize studio practice, response to art, and the art historical context of artworks. The J. Paul Getty model for Discipline-Based Art Education has been particularly influential in North America.

Studio practice is concerned with the techniques and theories involved in the creation of art. Two modes of response to art are encouraged: aesthetic response, particularly "scanning" for sensory elements and principles; and art criticism, or an evaluation of art in the context of aesthetic models and value systems. In art historical analysis, artworks are discussed in the context of chronological, cultural, and personal influences on artists throughout history.

The findings of this study reveal implications for art educators in these four areas.

Implications for studio practice

1. Space as an integrating principle

This study has revealed that the idea of space is very important in determining both the media used in traditional art and the kinds of systems used in computer graphics. Ideas about space in computer graphics allow precise and detailed understandings about the construction of elements and the kinds of environments in which they operate. Concepts of space in computer graphics may serve as models for the organization of elements and principles when creating artwork, in the same way they served as an organizational framework for the comparative taxonomies of concepts about elements and principles in this study (Appendix E and F).

In traditional studio courses, it may be useful to encourage students to begin not with emphasis on exploration of a medium, but instead, with the emphasis on investigation of spatial properties and relations. Elements in artmaking may be considered as correlated to spatial properties. Shapes, for example, can be evaluated not only in terms of type, but position, area or structure, surface, and edges in the context of different kinds of two and three-dimensional space.

2. Cognitive factors

Formalist theory places great emphasis on affective experiences that result from working with elements. This study has confirmed the degree to which artmaking and artviewing are cognitive experiences, with artworks resulting from generative procedures as much as experimentation. In studio practice, for both groups of informants, expressive intentions were found to be balanced with attention to *how* and *why*. For example, techniques and procedures for making "textures" were well-articulated, particularly in computer graphics. *Reasons* for making "textures" were particularly well-articulated in traditional art. The emphasis in both traditional art and computer art was on media as intermediaries for thought.

The language used to express formalist theory was also found to be very affective and often anthropomorphic in intent when compared to design vocabulary in computer graphics. This study has investigated the extent to which such non-affective or objective ideas as schematas, "signifiers", and simulations affect both art making and art viewing.

3. The sequence and significance of elements

A great deal of emphasis was placed by both the

informants and the literature on the "man-made" mark, and issues surrounding the values implicit in this. Many textbooks and course outlines traditionally begin with the element of "line", which reinforces the apparent importance of line, gesture and mark. However, there appears to be no reason, other than habit, why "line" should be the first element of art to be taught and applied in studio courses. The element of "line", as well as other elements, may not even be an important part of many art forms, *including* traditional two-dimensional art. For example, "line" was found not to be an important component of either matrix-based art or of color fields. Based on the number of mentions, in computer graphics the element of line was found to be sixth in frequency in terms of informant reports. It may be fruitful, refreshing and disarming to change the sequence in which elements are taught in studio courses. It may also be appropriate to consider the relative significance of different elements and principles to different art forms.

Implications for aesthetic response

1. <u>The interrelationship of techniques and elements</u>

   Arbitrary separations of "studio techniques", "sensory

elements", and "formal principles" in recent aesthetic models encourage the separation of processes or techniques from visual evidence and structure during aesthetic scanning. However, this study determined that not only are processes an important part of elements, but elements are also a vital part of processes. For example, the idea of "signifiers" in both traditional images and computer images includes evidence of specific techniques, selections and procedures as much as "abstract language". Computer graphics in particular enable techniques and processes to be read in terms of both elements and principles, since mathematically-defined operations often leave specific kinds of visual evidence. Algorithms unique to particular programs may be universally recognizable and form a kind of "cultural colonization" of computer imagery. In this sense, the findings of this study are reminiscent of recent studies which have explored the relationship of aesthetic frameworks to artwork that is bound to cultural and socioanthropological traditions.

2. Sensory discriminations

The "language" of art is often taught as if elements and principles have clear distinctions, and as if discriminations can be made between them. Discrimination,

however, may be more complex than this. In this study, many sensory elements were found to be operating as formal principles, while formal principles often occurred as elements. For example, space, pattern and tone were found to be organizing and unifying characteristics as much as sensory elements of images. The textural quality of pixel/needlework surfaces was found to be uniformly pervasive, rather than locally isolated. Conversely, asymmetry and repetition were often local elements as much as principles.

3. Standards of response

Ideas about "space" and "color" are in particular need of reevaluation by educators. Renaissance and/or photographic perspective continue to be used as standards for responding to space in artwork. It would be useful to examine other concepts of space with students, including different forms of "artistic" space.

Ideas about "color schemes" in formalist theory were formulated at a time when the range of both traditional studio pigments and reproductive pigments was relatively limited. Color "brilliance" relied on such effects as juxtaposed "complementaries". In teaching color theories, educators should account for the greatly expanded range of

colors developed in all mediums (including many new ones) during the past twenty years, as well as the degrees of brilliance and intensity available in contemporary mediums. Visualization technologies which exhibit color through light add another new dimension to the standards and terms by which the element of color is discussed. The highly sophisticated use of color in computer technologies further underscores the gap between formalist descriptions of color and contemporary applications.

4. The relevance of formalist terms

Mention has previously been made (p. 160) of 31 formalist terms that were found to have no comparable meaning in computer graphics. It may be useful for art educators to evaluate other art forms such as images resulting from visual technology, animated art, site and environment art, performance art, and modernist artworks generally, to determine whether formalist terms are appropriate or relevant in other cases as well. Rather than assuming that formalist terms are always applicable to all artwork, as was suggested by Malcolm (1972), Lauer (1979), and Ocvirk et al (1975), regardless of medium, function or intent, aesthetic inquiry might more meaningfully be directed to contextual/situational analysis, in which, as

Weitz (1962) suggested, each art work is evaluated in terms that are relevant to it.

This study emphasizes the fact that formalist theory is only one of many aesthetic models. It appears to be applicable to artwork which has formalism as its *intention*. It is misleading and confusing for teachers to discuss artwork in paradigmatic terms that are antithetical to the purposes and processes that governed the creation of the work in the first place. A paradigm can be justified only inasfar as it expands and enhances the perceptual and cognitive experiences of the viewer. This study has sought to describe ways in which computer terms and concepts are both similar and dissimilar to formalist terms, and to suggest ways in which the knowledge of concepts unique to computer graphics may expand and enhance an appreciation of traditional art as well as computer graphics. For example, educators might consider discussing traditional art in computer terms. Such traditional media as weavings and mosaics have many things in common with pixel graphics (Appendix E, p. 217). Two-dimensional, flat planes in traditional art have much in common, in terms of concept, types, shape structure, surface, and edges, with polygons in two-dimensional graphics (Appendix E, p. 219).

Implications for art criticism

1. Aesthetic paradigms

Computer graphics have traditionally sought to simulate traditional art. Early Constructivist-oriented computer art emphasized formal relations of elements and principles of design. Recent programs prioritize procedures for illustration and simulation, using effects-filters to simulate even the appearances of traditional art mediums such as watercolor or pastel and styles such as Pointillism.

An "aesthetics" of computer graphics has not been well-articulated. An aesthetic model for computer graphics ideally would account for the constraints and strengths of the medium, the potential of mathematically-based "elements" of art, the "marriage" of geometry and visible evidence, and the values implicit in simulation and appropriation.

By teaching the history of computer graphics and focusing on emerging issues that distinguish computer graphics from traditional art, educators can help students to become more discerning consumers and producers of both.

2. The importance of terminology

It is difficult to discuss computer graphics without a knowledge of the terminology. Thirteen computer graphic terms (as noted on p. 161) were found to have no comparable

meanings in traditional art, and 31 art education terms (as noted on p. 160) were found to have no comparable application in computer graphics. One hundred and twelve art education terms were found to have meanings that do have a correlative in computer graphics (Tables 4-7). However, 57 of the computer graphic correlatives represent concepts which expand the meaning of traditional art education terms, or change the nature of its application (as noted in Conceptual expansions of terminology, Tables 4 - 7).

Unlike traditional design vocabulary, language is very *specific* in computer graphics. Educators should encourage art students to learn and apply proper computer terminology to computer images. An evaluation of art education textbooks may be necessary to determine the degree to which they incorporate appropriate terminology.

3. Judging art

This study found that even without knowledge of computer terminology, informants had strong and well-articulated opinions about computer graphics used as stimuli. Stimulus 2, a recent 3D computer graphic, provoked both the greatest quantity and the highest quality of discussion about visual imagery. This graphic enabled intense and detailed examinations of issues, elements and

principles, as well as techniques, in both fields. Many issues described in this study, such as the value of the human gesture versus the mechanical mark, can serve as provocative starting points for discussing computer images.

Implications for art history

1. The history of aesthetics

This study found that art historical references are an important part of art appreciation, and that most informants could "read" images in terms of traditional art history. However, none of the informants "read" the two computer graphics in a historical context. While relatively short, the history of computer graphics is fascinating and has many correlatives with traditional art.

For example, computer graphics have been produced as an art form for more than thirty years. During this time, different approaches have been taken that are linked to traditional art historical styles. Pioneer efforts have also been made in simulating pure aesthetics, by computer-generating the characteristics of landmark artworks and pivotal art historical styles. Notions about "ideal" aesthetic structures formed an important part of early computer graphics. A historical study of aesthetic

explorations in computer graphics would enhance students' understanding of both the field of computer graphics and fine art.

2. The history of studio practice

As an art form, computer graphics has been led by developments in electronic capabilities. In this sense, the history of computer art could be studied together with traditional art forms such as painting. Studio developments in traditional art, such as the development of oil paint, the notion of "portable" easel painting, and the creation of chemical pigments as well as entirely new mediums and grounds, have shaped output in traditional art. Similar events in computer graphics are worth studying.

The manipulation of color with a computer is subtractive on screen. All colors potentially exist on the screen and the user selects those which are appropriate, by manipulating the default palette. The traditional artist, on the other hand, is constrained to achieving color by aggregation. It would be interesting to examine palette potential in an art historical context. An art historical study could be made of developments in art resulting from artists' reactions to expanded palettes; of different color "schemes" used in fine and applied art during this century;

and the development of color palettes and finer resolution in computer graphics.

In conclusion: A personal note

Near the end of this study, I received a press release describing a series of traditional oil paintings as "offering random access to the viewer". The artist described her paintings as "layered information" on a "surface carrying synchronicity" as "elements of text interacted with the visual". It would appear that just as computer artists have appropriated visual art traditions, so traditional visual artists have begun to borrow both terminology and paradigms of thought from computer technology.

As an art reviewer, the dilemma of choosing paradigms for discussing art work may be resolved for me by the artists themselves. As an art educator, I feel there is much work to be done. Two large areas of concern have barely been articulated to date. The first is the need to develop a theory of art for computer graphics which will delineate its similarities to traditional art forms, while at the same time develop and articulate a philosophy that guides its differences. The second is the need to develop a

historical, practical, and theoretical curriculum for art education that embraces visualization technology.

Art educators currently believe that people should be guided in their approaches to making art, and informed in their responses to art. Computers cannot do this job for art educators. Computer graphic programs are highly "intuitive". They are menu-driven to teach the user *how* to use them, and interact with gestural input devices such as trackball or mouse to ease the learning process. However, they do not provide the kinds of structured knowledge about art that art educators themselves can offer, and do not guide the process of aesthetic inquiry.

Art education can make a valuable contribution to the field of computer graphics. Conversely, art education can benefit from the incorporation of this new medium. It is a question of evaluating the degree to which traditional knowledge and theories in art education are a good "fit" with computer technology. This study has evaluated one aspect of that process: a comparison of visual elements in traditional art images and computer graphics.

REFERENCES

Ackerman, J.S. (1966). The historian as critic. In Smith, R.A. (Ed.). Aesthetics and criticism in art education. Chicago: Rand McNally.

Ackroyd, S. and Hughes, J.A. (1981). Data collection in context. London: Longman.

Apple, M. (1988). The politics of pedagogy and the building of community. Journal of Curriculum Theorizing. 8 (4). 7-22.

Autodesk 3D Studio manual and tutorial.

Batty, M. (1987). Microcomputer graphics. London: Chapman Hall.

Binkley, T. (1989). The wizard of ethereal pictures and virtual places. Leonardo: Computer art in Context Supplemental Issue. 13-20.

Bixby, R. (1993). Corel DRAW! 3. New York: Wiley and Sons.

Broudy, H.S. (1966). The structure of knowledge in the arts. In Smith (Ed.). Aesthetics and criticism in art. Publisher?

Broudy, H.S. (1972). Enlightened cherishing: An essay on aesthetic education. Urbana: University of Illinois Press.

Chapman, L.H. (1992). Art: Images and ideas. Worcester, Mass; Davis Publications.

Crozier, W.R. and Greenhalgh, P. (1992). Beyond relativism and formalism: The empathy principle. Leonardo. 25 (1). 83-87.

Csuri, C. (1979). Computer graphics and art. In Booth, K. (Ed.). Computer graphics. New York: IEEE.

Elementary Fine Arts Curriculum Guide (1985). Province of British Columbia: Ministry of Education.

Ettinger, L.F. (1988). Art education and computing: Building a perspective. Studies in Art Education. 30 (1). 53-62.

Feldman, E.B. (1992). Formalism and its discontents. Studies in Art Education. 33 (2). 122-126.

Franke, H.W. (1985). Theoretical foundations of computer art. Computer graphics, computer art. Berlin: Springer Verlag. 153-167.

Freedman, K. (1991). Possibilities of interactive computer graphics for art instruction: A summary of research. Art Education. 44 (3). 41-47.

Freedman, K. and Relan, A. (1992). Computer graphics, artistic production, and social processes. Studies in Art Education. 33 (2). 98-109.

Friedhoff, R.M. (1989). Visualization. New York: Abrams.

Galassi, P. (1981). Before photography. New York: Museum of Modern Art.

Glasser, E.M. Abelson, H.H. and Garrison, K.N. (1983). Putting knowledge to use: Facilitating the diffusion of knowledge and the implementation of planned change. San Francisco: Jossey-Bass.

Gombrich, E.H. (1961.) Art and illusion (2nd edition). New York: Pantheon Books.

Greer, W.D. (1993). Developments in Discipline-Based Art Education(DBAE): From art education to arts education. Studies in Art Education. 34 (2). 91-101.

Hamblen, K. (1987). Approaches to aesthetics in art education: A critical theory perspective. Studies in Art Education. 29 (2). 81- 90.

Hearn, D. and Baker, M.P. (1986). Computer graphics. Englewood Cliffs, N.J.: Prentice-Hall.

Hickman, C. (1991). Why artists should program. Leonardo. 24 (1). 49-51.

Hobbs, J. (1993). In defense of a theory of art for art education. Studies in Art Education. 34 (2). 102- 113.

Inside MacIntosh, Volume I. (1985). Addison-Wesley: Apple Computer Inc.

Johnson, N.R. (1992). Metaphor and design. Studies in Art Education. 33 (3). 144-153.

Jones, B. (1989). Computer imagery: Imitation and representation of realities. Leonardo: Computer Art in Context Supplemental Issue. 31-38.

Kerlow, I.V. and Rosebush, J. (1986). Computer graphics for designers and artists. New York: Van Nostrand Reinhold Company.

Krathwohl, D.R. (1985). Social and behavioral science research. San Francisco: Jossey-Bass.

Lauer, D.A. (1979). Design basics. New York: Holt, Rinehart and Winston.

Lewis, E., Garneau, R., Holynski, M. (1989). Adaptive computer graphics for research in aesthetics. Leonardo. 22 (2). 251-254.

Lucas, R. (1986). Evolving aesthetics criteria for computer-generated art. Masters thesis, Ohio State University.

Malcolm, D. (1972). Design: Elements and principles. Worcester, Mass: Davis.

McCall, G.J. and Simmons, J.L. (Eds.) (1969). Issues in participant observation. Reading, Mass.: Addison-Wesley Publishing Company.

MacPaint manual. Claris.

Nadin, M. (1989). Emergent aesthetics - aesthetic issues in computer arts. Leonardo: Computer Art in Context Supplemental issue. 43-48.

Ocvirk, O., Bone, R., Stinson, R. and Wigg, P. (1975). Art fundamentals: Theory and practice (3rd ed.). Dubuque, IA: William Brown.

Pearse, H.P. (1992). Beyond paradigms: Art education theory and practice in a postparadigmatic world. Studies in Art Education. 33 (4). 244-252.

Pope, E.R. (1988). The significance of the computer in art. In Farley, F.H. and Neperud, R.W. (Eds.) The foundations of aesthetics, art, and art education. 321-336. New York: Praeger.

Sanders, W.B. and Pinhey, T.K. (1983). The conduct of social research. New York: Holt, Rinehart and Winston.

Spradley, J.P. (1980). Participant observation. New York: Holt, Rinehart and Winston.

Varro, T. (1992). Emerging roles for art educators: Toward the year 2000. BCATA Journal. 32 (2). 15-19.

Weitz, M. (1962). The role of theory in aesthetics. In J. Margolis (Ed.). Philosophy looks at the arts: Contemporary readings in aesthetics. New York: Charles Scribner's Sons. 48-62.

Wilson, S. (1991). Technological research and development as a source of ideas and inspiration for artists. Leonardo. 24 (4). 433-440.

Wright, R. (1989). The image in art and computer art. Leonardo: Computer Art in Context Supplemental Issue. 49-53.

APPENDIX A

Literature used in domain analysis

Art education

Chapman, L.H. (1992). Art: Images and ideas. Worcester,Mass: Davis.

Elementary fine arts curriculum guide (1985). Province of B.C.: Ministry of Education.

Lauer, D.A. (1979). Design basics. New York: Holt, Rinehart and Winston.

Malcolm, D. (1972). Design: Elements and principles. Worcester, Mass.: Davis.

Ocvirk, O., Bone, R., Stinson, R. and Wigg, P. (1975). Art fundamentals: Theory and practice (3rd ed). Dubuque, IA: William Brown.

Computer graphics education

Autodesk 3D Studio manual and tutorial manual.

Batty, M. (1987). Microcomputer graphics. London: Chapman and Hall.

Bixby, R. Corel draw! 3.(1993). New York: John Wiley.

Csuri, C. (1979). Computer graphics and art. In Booth, K. (Ed). Computer graphics. New York: IEEE.

Franke, H.W. (1985). Theoretical foundations of computer art. Computer graphics,computer art. Berlin: Springer Verlag.

Friedhoff, R.M. and Benzon, W.(1989). Visualization. New York:Abrams.

Hearn, D. and Baker, M.P. (1986). Computer graphics. Englewood Cliffs, N.J.: Prentice-Hall.

Inside MacIntosh, Volume I (1985). Addison-Wesley: Apple Computer Inc.

Kerlow, I.V. and Rosebush, J. (1986). Computer graphics for designers and artists. New York: Van Nostrand Reinhold.

MacPaint Manual, Claris.

APPENDIX B-1

Sample of terminology in art education texts

Line Problems

Problem 1
The artist may combine expressive calligraphy and the representational characteristics of line in the same image (fig. 4.16).

> Select a few moderately complex subjects. Draw these experimentally in a continuous contour line, defining the subject but at the same time allowing the drawing instrument to roam freely, to make sudden changes in direction, and to overlap itself. The line should dwell in some areas, moving steadily, improvising as it moves, and moving directly from one area to another. Try drawing quickly as well as slowly. The intention is to produce works that are at the same time definitive and spontaneous, expressive and disciplined. The line should have calligraphic qualities (*see Calligraphy* under "Definitions"; *see also* plate 18 and fig. 4.3).

Problem 2
Lines may vary according to their physical properties.

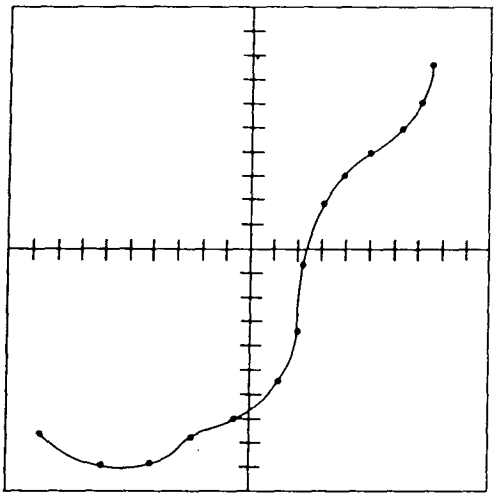
> a. In one or more frame shapes create interesting line arrangements in one medium. Vary the measure, type, direction, and location of the lines.
> b. Repeat the line arrangements in several other media and compare the resulting works for differences in character.

from
Ocvirk et al., (1975). Art fundamentals: Theory and practice (3rd ed)., page 50. (Emphasis mine).

Sample of terminology in computer graphics texts

floating point numbers. Computer graphics employs either integer or floating point numbers depending on whether the data being measured is discrete or continuous. ***Discrete*** data occurs in distinct units. Individuals, playing cards, and letters of the alphabet must all be represented by discrete data, as they cannot be divided and still retain their identity. Likewise, the pages of this book come in integer whole numbers and are not counted in fractional units.

Data is ***continuous*** if the axis or dimension that is measured has no apparent indivisible unit from which it is composed. Examples abound in our space-time-matter environment, such as weight, length, and temperature as well as an intelligence quotient or a readability index; no matter how precise the scale of measurement, a finer resolution always exists.



The continuous/discrete dichotomy applies to graphics as well as to Cartesian spaces. Both incorporate an origin, axes, and equal-interval scales. If the Cartesian space is floating point and continuous, then a location is expressed as a decimal number and called a ***point,*** which is an XY number pair. If the Cartesian space is discrete, a location is expressed using a pair of integers and is called a ***pixel*** (fig. 1-21). Pixels cannot be fractional.

The distinction between point (line) and pixel representations is analogous to the distinction between line copy and halftones in traditional graphics. Logos, diagrams, and type—objects with sharp edges and no continuous tone—are best represented as line copy, while photographs, paintings, and shaded color areas (benday) are best represented using continuous tone methods. Of course, it is possible to represent logos, type, and rules using halftone methods and to represent photographs using line copy techniques, but this crossover seldom improves visibility and is not recommended except to achieve a particular artistic effect.

Many aspects of computer graphics can be either discretely or continuously represented—time and color for example. Pixels and points are everyday tools that illustrate the fundamental differences between the two.

from
Kerlow and Rosebush, (1986). Computer graphics for designers and artists, page 14. (Emphasis mine).

APPENDIX B-2

Sample of terminology found in glossaries and lists (Art education)

Line
path of movement
active – passive
bold – delicate
flowing – light
straight – curved
thick – thin
dark – light
broken – continuous
geometric – organic
implied – actual
precise – irregular
contour – outline
calligraphy

from Chapman, L.H. (1992). Art: Images and ideas, p.40.

Sample of terminology found in glossaries and lists (Computer graphics)

- *Translation* and *rotation* of pictures and subpictures.
- *Windowing:* singling out a window-like area which can then be treated separately, for instance by coloring it or by zooming it.
- *Zooming:* the enlargement of subpictures or windowed structures;
- *Clipping:* the clipping of line segments which extend beyond the window border.
- *Locator Operation* for locating a point or a line.
- *Pick Operation:* the identification of a graphical element on the basis of spatial coincidence. The so-called choice simulation applies procedures of this kind, for instance when a digitizing table is being overlaid by a menu of light buttons. Since the computer using the pick operation is capable of recognizing the light button picked, it can also understand the associated choice.
- *Temporary Storage:* the stored pictures can be retrieved at any time during a design session.
- *Overlay Technique:* the overlay of storage levels.
- *Filling of Closed Polygons:* for instance by coloring, textures, etc.

from Franke, H.W. (1985). Computer graphics, p. 27

Sample of terminology found in indexes (Art education)

from Lauer, D. (1979). Design Basics, p. 239.

Sample of terminology found in indexes (Computer graphics)

from
Bixby, R. (1993). Corel Draw! 3, page 324.
(Emphasis mine)

APPENDIX C-1

Domain analysis of sensory elements

Art Education

line

- concepts
  - a mark
  - a continuous mark, a path of movement
  - a path, mass or edge where length is dominant
- measure
  - length
  - width
- type
  - straight
  - curved
  - angular
  - contour
    - *interior*, cross-contour
    - *exterior*, outlines
  - continuous
  - broken
  - connecting
  - repeated
    - rhythmic
  - simple/ consistent (thickness and value remain the same along the length)
  - complex
  - geometric
  - organic
  - precise
  - irregular
- direction
  - horizontal
  - vertical
  - diagonal
- value
  - light/distant
  - dark/ close, near
- weight
  - heavy
  - light
  - thick
  - thin, fine

line

presence
- implied
- actual
- *positive*
- *negative*

location

character (refers to medium)
- calligraphic, expressive
- dynamic, active, passive
- subtle, delicate
- intense, bold, powerful

shape

concept
- the idea of "plane" distinguishes 2D shapes from 3D shapes

two-dimensional shapes
- 2D shapes are single planes
- also called flat or decorative shapes
- have area but not volume
- surface may be modeled but without depth

three-dimensional shapes (sometimes referred to as "forms" because they simulate actual physical volumes)
- 3D shapes are made up of planes
- the edges of planes may not be obvious
- also called volumetric or cubic
- have area and volume (depth)
- may use value gradation/ contrast to indicate planes and/or depth
- interact in space but their interaction does not have mathematical precision

types
- outline/ contour
- solid
- *unclear boundaries*
- geometric: circle, square, triangle
- organic/ plastic/ biomorphic
- free-form
- concave, convex
- hard edge
- soft edge
- torn edge

shape

- ambiguous
- complete
- modeled
- *opaque*
- *transparent*
- negative/ ground/ void
- positive/ figure/ solid
- *location*
- *orientation*

space

two-dimensional

- flat shapes feel shallow
- shapes are against the picture plane
- outlines keep shapes closer to the picture plane
- depth can be suggested by
    - overlapping lines
    - overlapping shapes
    - converging lines
    - line weights
    - multiple views
    - arrangements of light and dark
- a picture plane covered only with patterns eliminates the feeling of space
- types
    - negative/ positive
    - open/ closed
    - filled/ empty
    - actual/ implied
    - interior/ exterior
- warm colors advance to the picture plane
- cool colors recede from the picture plane

three-dimensional (illusionistic)

- picture plane has *levels* of depth
    - deep
    - shallow
- perspective systems
    - one-dimensional
    - two-dimensional
    - three-dimensional
    - aerial perspective (lessening of value

space

and value contrasts in the "distance" of the picture plane)
- atmospheric perspective (background becomes more opaque or bluer)
- *loss of detail*

lighting
- modeling
- chiaroscuro
- shadows

object relationships
- objects in the distance become smaller
- objects higher than others appear to be at the front end of the picture plane
- overlapped objects appear to be at the front of the picture plane
- shapes are solids existing in space
- forms and space interact, but are usually not mathematically defined

space can dominate form

shapes often appear to escape the boundaries of the picture plane

form (physical)

actual 2 1/2D (parts or areas of a flat picture plane are physically projected into space)

actual 3D (e.g. sculptures), not illusory

mass
- volume
  - opaque
  - transparent
- weight

planes
- surfaces
- surface directions

structure
- geometric
  - spheres, cylinders, cones, cubes, pyramids
- irregular
- solid/ closed
- penetrated/ open

pattern

- motif
- repetition
- type
  - border
  - allover/ continuous (systematic organization)
  - *distorted/ variant*
  - *localized*

texture

- surface quality
  - even/ uniform
  - uneven
  - smooth
- *type*
  - natural/ actual/ "tactual"
  - invented/ man-made
    - engraved
    - embossed
    - impasto
    - relief
  - 2 1/2D
  - *illusory/ simulated/* visual/ trompe l'oeil
    - *modulation of bits or areas*
    - illusion of texture
      - *variable line measure*
      - *variable line direction*
      - *variable line type*
      - *variable brush techniques*
- *balance*
  - distributed
  - unified
- *luster*
  - matte
  - shiny
  - semi-gloss, glossy

color

- limited palette
  - monochromatic
  - complementary (employing simultaneous contrast of colors that are opposite on the color wheel)
- unlimited palette

color

- hue (name of color: e.g. yellow). May also be neutral. Color interactions and simultaneous contrast are a result of hue.
- value (lightness or darkness of a color)
  - tint (a high-value color produced by adding white pigment)
  - shade (a low-value color produced by adding black pigment)
- intensity/ chroma/ saturation (brightness of a color)
  - high key/ low key
  - bright/ dull
- theory
  - primaries (red, yellow, blue)
  - secondaries (orange, green, purple)
  - tertiaries (intermediates, e.g. blue-green)
- harmony (color schemes based on the position of hues on the color wheel)
  - monochromatic
  - analogous
  - complementary
  - triadic
- innate qualities
  - depth
    - receding
    - advancing
  - temperature
    - cool
    - warm
  - description
    - local/ objective
    - optical (as affected by light conditions other than "normal" daylight)
    - arbitrary
    - symbolic

tone

- *flat*
- *even*
- *contrasting*
- chiaroscuro/ shaded
- hatching
- passage

APPENDIX C-2

Domain analysis of sensory elements

Computer Graphics

line

concepts
- in Draw mode, a linear location with no thickness between available pixels (a mathematical model rather than an actual graphic element on the screen)
- in Paint mode, a continuum of adjacent pixels (2D lines with x,y coordinates)
- in 3D graphics, vectors (3D lines with x,y,z coordinates between width, height and depth)

measure
- length
- width
- location

type
- straight: horizontal, vertical, diagonal
- curved: arcs (have a start, end, and radius); semi-circles; or curves (wander)
- "jagged" diagonal curved lines, often as a result of output resolution
- silhouette (designate outline)
- contour (designate the height of areas, as in contour maps)
- hatch patterns (dots, dashes, etc.)
- connecting (vectors)

direction
- horizontal
- vertical
- diagonal
- slope (degree of grade or the orientation of a line on a plane)

value
- variable line widths
  - can be zero
  - can be cued to show depth
  - result from pen modes

line

- result from pen sizes
- some programs support pressure-sensitive drawing with a stylus on a tablet
- variable line intensities
- can be cued to show depth
- thick and thin lines resulting from time-sensitive tablets

presence

- positive by default
- reverse/ negative

location

- designated area of a pre-determined format (eg. Paint programs)
- mathematically defined in space (vector or object-oriented graphics)

shape

two-dimensional shape

- mass of pixels
- has area
- types of edges
- horizontal
- vertical
- hard-edge
- Cartesian coordinates x,y
- polygon (a closed shape formed by lines; a sequence of connected lines)
- two-dimensional/ flat/ planar
- has corner points (vertices)
- sides (edges)
- has surface area
- can be filled (with coloring, textures, etc.)
- types
- freehand
- regions (an irregular set of bits)
- may be two dimensionally concave
- may be two-dimensionally convex
- consists of one or more areas
- can have "holes"
- selected (defined by an arbitrary

set of points)

shape

- rectangles/ rounded rectangles
- ovals
- wedges
- resized
- duplicated
- rotated
- flipped
- distorted
- inverted
- types of edges
  - invisible
  - hard-edge
  - horizontal
  - vertical
  - angled
  - curves
- coordinate systems
  - Cartesian coordinates x,y
  - local coordinate system
  - two-coordinate systems, x,y and r,c
- geometric
  - using pre-selected shapes
  - using pen tool
- organic
  - using freehand tool
- positive
  - filled
  - transparent
  - opaque
  - region (a low-level routine, i.e. a figure as a collection of regions)
- *negative*
- location
  - designated area of a bitmap (predetermined format)

three-dimensional shape

- wireframe display
  - has area
  - has volume, with Euclidean x,y,z coordinates
- polyhedra (a volumetric solid object, like a cup or tree)

- three-dimensional

shape

- has bounding edges
- each face is a facet
- has area
- has volume, with Euclidean x,y,z coordinates

- types of edges
  - hard-edge (solid shapes or wireframe)
  - blurred or "feathered " edge

geometric

- using pre-selected shapes
- using points and vectors

organic

- 2D shapes can be extruded into 3D

positive

location

- objects in relation to space
- objects in relation to other objects in space
- opposite of conscious formatting

orientation

- described by a face normal (not a coordinate or position, but a direction: e.g. how a polygon is angled in space)

space

two-dimensional space (conscious formatting)

- pixel-based graphics (methods analogous to using a traditional brush and paint)
  - base of a mathematical hierarchy
  - Cartesian coordinates x,y
  - manipulations occur on the picture plane, by shuffling or replacing intensities or colors in the bitmap)
- 2D object-based systems
  - above pixel-based graphics in a mathematical hierarchy
  - depth suggested by:
    - overlapping lines and shapes
    - line thickness (not "weights")
      - size
      - near/far
    - shadows
    - contrast (arrangements of light

and dark)

space

- perspective

three-dimensional space (3D graphics or 3D object-based systems)

- concept: although illusory (since it is taking place behind the computer screen), 3D graphics is more similar to the idea of physical "form" in art than to 3D space
- space is infinite
- objects can be located and intersected
- objects can be treated as things with physical properties (dependent on the program, objects can be assigned properties such as mass, gravity (weight, inertia), subjected to stress testing, etc.
- objects can be subjected to transformations
    - joined
    - broken into multiple objects
- objects can be subjected to procedural modeling (a mathematical procedure in which the surface texture or pattern, called "image", does not stay relative to itself, but changes in proportion to the object)
- lighting
    - omni (ambient)
    - spotlights (have a source and focus)
    - specular highlights (need a viewer: the other end of the "z" in x,y,z)
    - the automatic creation of
        - shadows
        - transparency (usually in degrees of 100)
        - self-illuminated
        - reflective

pattern

default

selected

- pen patterns
- brush patterns
- area fill patterns

created

- bitmaps

- texture maps

pattern

- opacity maps
- bump maps
- fractals

texture

surface rendering
- smooth
  - blend
  - graduated fill
  - detailed (details used to make smooth transitions between areas or objects)
  - polygonal shading
  - continuous shading
    - Gouraud
    - Phong
- uneven
  - block-pixed
  - manipulated intensity values
- edges
  - aliased ("jaggies" or "staircase" effect)
  - anti-aliased

color

monochrome (black and white)

limited palette
- can be dithered to suggest gradations between colors
- pseudocolor (limited color palette applied to black and white images)

unlimited palette
- 8-bit (each pixel has 1 of 256 simultaneous intensity values or colors, "chosen" from 16,000,000)
- 24-bit (each pixel has 1 of 16,000,000 possible intensity values; "true color")

pixel format resolution (the number wide by the number high) has an equitable volume of intensity values. There is a correlation between quantity of pixels and quantity of colors. Generally, the higher the resolution (without extra hardware), the lower the number of colors.

hue (position of color on the color wheel)
color

value/ brightness (amount of black in the color)
saturation (100% intensity without white)
lightness (amount of black or white in the color)
theory
- primary colors red, green, blue
- secondary colors cyan, magenta, yellow
- black is the absence of all three primaries
- white is all three primaries in full intensity
- gray is all three primaries in equal intensity
Note: Program example in 3D Studio
1-100 Red Hue 1-100
1-100 Green Luminance 1-100
1-100 Blue Saturation 1-100

tone
matte surface (flat)
chiaroscuro
- polygonal shading/ "flat shading"
    - color graduated surfaces
continuous shading
- Gouraud
- Phong

APPENDIX D-1

Domain analysis of formal principles

Art education

concept

- image as a whole
- an artwork is a concrete image, like hardcopy, but without an identical abstract self
- an original, unique
- the content is part of a discrete environment
- passive contents, bound to form
- artworks contain signifiers
- the vast majority of works employ several formal methods simultaneously

balance

- horizontal
  - assumes a central vertical axis in the format
  - assumes a distribution of visual structure on either side
- vertical
  - assumes vertical balance with weight at bottom
- symmetry
  - symmetrical
    - elements are similar
  - asymmetrical
    - contrast of
      - value
      - shapes
      - texture
      - position
  - approximate symmetry of elements
- dominance
  - dominant
  - subordinate
- tension
  - opposition
- radial balance
- allover pattern/ crystallographic balance

variety
visual theme and variation
contrast
- large against small
  - light against dark
  - cool against warm
  - color against color
  - defined edges against space

scale (size)

proportion (relative size)
actual/ natural/ realistic/ life-size
monumental/ miniature
distorted/ exaggerated/ idealized

emphasis/ focal point/ center of interest/ weight
by size and by contrast of elements
- one element differs from others
- interrupts an overall pattern

by converging lines or elements
by isolation of elements
placement of elements
degree of emphasis
- restraint in emphasis
- absence of focal point

unity/ harmony/ consistency/ integration
whole pattern is predominate over the parts
distinction between intellectual or conceptual unity and visual unity
proximity
- of elements
- of figure to ground
  - dividing
  - separating
  - organizing
- of format to content
- of color distribution
- of palette
  - warm
  - cool

surface resolution/ uniformity of surface

repetition

repetition of characteristics (holds overall design together)

rhythm or continuance

- regular
- irregular/ progressive, through increasing or decreasing elements in a series:
  - small to large
  - light to dark
  - smooth to rough
  - patterned to solid
- alternation

continuation

dominant path of movement

line, edge or direction continues from one form or element to another

- vertical
- horizontal
- diagonal
- curving

field of view

enclosed

cropped

lighting

APPENDIX D-2

Domain analysis of formal principles

Computer graphics

concept

- image as a whole
- object-oriented graphics and 3D graphics have an identical abstract self
- image may be part of a discrete environment (2D bitmaps) or part of a continuous environment (3D graphics)
- may not be an original
- except in hardcopy, contents are dynamic and interactive
- artworks contain signifiers
- the vast majority of works employ several formal methods simultaneously, although hierarchically arranged according to mathematics and procedures

hierarchical assemblage

- pictures or systems ("universals") are a hierarchical assemblage composed of parts or elements ("primitives")
- "primitives" are often incorporated into procedures or sub-routines
- "universals" can be decomposed or disaggregated into their constituent parts
- primitives are assembled with additional synthesizing elements; i.e. the sum is greater than the parts

balance

- regularity (relates to the traditional concept of symmetry)
  - local
  - global
- complexity (local and global)
  - shape variety
  - color variety
  - *business*
  - *noise*

unity

low color variety

resolution

- image is affected uniformly by the resolution of the output

temporal priority

- what is written first stays written until it is overwritten: the order of commands is maintained
- can be used by the artist to structure his work; e.g. landscapes: one thing leads to another

lighting (3D graphics)

reflection (the amount of reflected light varies according to the relationship between the angle of incidence and the angle of view)

- matte or diffuse (dull, flat light)
- shininess
- specular (highlights)

refraction (uses ray tracing to cause reflections to adapt to a new surface)

can reveal transparency

atmospherics (such as fog: can be set for % near, % far, and color)

luminescence (self-illuminating)

shadows

- hard-edge
- transparent
- penumbras
  - blending tools
  - shadow map resolution

emphasis

windowing

- isolation of regions in 2D graphics
- zooming (enlargement of sub-pictures or windowed structures)

repetition

recursion/ self-similarity

- parts that reflect the whole
- detail is produced by the same procedure that produced the overall structure (i.e. fractals)

repetition

replication/ recursion
- one of the greatest strengths of computer graphics

ability to replicate detail in great abundance
representations are quantitatively rich/ precise
both regular and broken symmetries can be manipulated

variety

randomness
- random choices of local details temper repeatability and sameness

experimentation
- the necessity of improving the quality of programs and picture structure through interactive use

APPENDIX E

Comparative taxonomy of sensory elements

ELEMENTS	ART EDUCATION		COMPUTER GRAPHICS	
TWO-DIMENSIONAL SPACE 1. Matrices	concept	matrix-based forms of art (eg. needlepoint, weaving, mosaics, hard-edge abstract grid paintings)	concept	pixel-based graphics (eg. Paint programs)
		two-dimensional space		bitmap
		discrete environment		discrete environment
		conscious formatting		conscious formatting
		shapes are composed of individual stitches, tiles, sections, etc.		shapes are intensities of color selected in a bitmap
		each shape is one layer deep		bitmap manipulations (changing intensities or colors by replacing them)
		shapes are areas of a matrix (grid)		shapes (called regions) use Cartesian coordinates x,y
	depth devices	(generally not applicable)	depth cues	the illusion of layered lines and areas
				line thicknesses
		contrast		contrast
		color gradations		color gradations
TWO-DIMENSIONAL SPACE 2. Designs	concept	arrangements on a picture plane	concept	2D object-based systems
		two-dimensional space		2D graphics
		discrete environment - not consciously formatted		discrete environment - using Cartesian coordinates x,y - using a local coordinate system - using a two-coordinate system
		flat shapes feel shallow		
		shapes are against the picture plane		
		picture plane manipulations		selections and procedures
	types	negative or posisitve	types	positive by default
		open or closed		open or closed

ELEMENTS	ART EDUCATION		COMPUTER GRAPHICS	
2D Space: Designs		filled or empty		filled or empty
		actual or implied		positive by default
		interior or exterior		
	measure	scale	properties	scale
		spacing		positioning
		position		location
	depth devices	overlapping flat shapes ("layered" shapes)	depth cues	layered shapes
		converging lines		perspective
		line weights		line thicknesses/intensities
		arrangements of light and dark		drop shadows
		color theory - warm colors advance to the picture plane - cool colors recede from the picture plane		color coding
TWO-DIMENSIONAL SPACE 3. Continuous fields	concept	soft-edge abstracts, photographs, washes, etc.		
		two-dimensional space		
		continuous environment		
		not consciously formatted		
TWO-DIMENSIONAL SHAPE 1. Area of a matrix	concept	area of the matrix design	concept	- region of pixels - set of bits
	types	positive/figure	types	region (a figure is a collection of regions)
		negative/ground		bitmap
	position	not explicit ("upper right", "lower left" etc.)	location	designated area of a bitmap in a predetermined format
		not explicit ("to the right" or "left of")		mathematic orientation to other shapes
	area structure	positive - regular - irregular	region structure	positive (irregular only) - may be 2D concave - may be 2D convex
		consists of one or more areas		consists of one or more areas
		positive types may have "negative spaces"		may have holes
	edges	hard-edge	sides	hard-edge by default

ELEMENTS	ART EDUCATION		COMPUTER GRAPHICS	
				"staircase"effect; jaggies
TWO DIMENSIONAL SHAPE 2. Plane	concept	flat surface	concept	a polygon (a sequence of connected lines)
		essentially two-dimensional		two-dimensional
		"decorative"		flat/planar
		relationships with other shapes give the illusion of a third dimension (eg. overlapping)		relationships with other shapes give the illusion of a third dimension (eg. layering)
	types	created	types	- selected - created
		may be repeated		- may be duplicated - may be swept (a procedure which repeats a shape)
		inverted		inverted
		turned		rotated
				flipped
		open or closed		closed
		filled		filled
		empty		outline
		actual		shapes
		implied		hidden shapes
	shape structure	geometric (circle, square, triangle) - using tools - freehand	polygon structure	geometric (circle, ellipse, square, rectangle, triangle, polygon etc.) - using pre-selected 2D shapes - using pen tool and 2D line segments
		organic/plastic/ biomorphic/freeform		organic using freehand tool (pixel-based brush in Paint layer)
		sizes are not explicit ("of different proportions")		may be resized
	surface	may be modeled (without intending an illusion of depth)	fill	can be filled with coloring or textures but not modeled
		may use value gradation		may use value gradation
		may use value contrast		may use value contrast
		opaque/solid		opaque/solid
		transparent		transparent

ELEMENTS	ART EDUCATION		COMPUTER GRAPHICS	
2D Shape: Plane		outlined/contour		framed
	edges	hard-edge	sides	hard-edge by default
		corners		vertices (corner points)
		freehand		freehand in Paint mode only
		soft-edge		may be "feathered" (a procedure which dithers the pixels)
		N/A		invisible
TWO-DIMENSIONAL SHAPE 3. Formless	concept	an area of a continuous picture plane (eg. a watercolor wash)		
		two-dimensional		
	types	positive/"form"		
		negative/ground		
	position	not explicit ("upper right", "lower left" etc.)		
	area structure	often called a "form" or "formless shape"		
	edges	soft-edge		
		blended		
THREE-DIMENSIONAL SPACE	concept	picture plane has levels of depth (described as "deep", "shallow")	concept	3D graphics copy laws of physics
		simulates a continuous environment		- continuous environment on screen - discrete environment in hardcopy
	perspective	linear - one-dimensional - two-dimensional - three-dimensional	environment	space is infinite
	depth devices	atmospheric perspective	depth cues	degrees of atmospherics
		aerial perspective		degrees of transparency
		lighting		- ambient lighting - spotlights - specular highlights
		shading/modeling		modeling
		shadows		- cast shadows - ray tracing

ELEMENTS		ART EDUCATION		COMPUTER GRAPHICS
THREE-DIMENSIONAL SPACE		- objects in the distance are proportionately smaller - higher objects appear farther back - overlapping objects appear to be in front		objects are in geometric relationship to others in space
		space may be used to dominate form		
		cropping		
		framing		
THREE-DIMENSIONAL SHAPE 1. Wireframe	concept	3D art forms such as wire sculpture, rather than 2D art	concept	wireframe display
		actual three-dimensional form		- three-dimensional grids in a void - two-dimensional hardcopy
		non-mathematical		has volume, with Euclidean x,y and z axes
			sides	hard-edge (lines)
				structure and sides are the same thing (no surfaces)
		may be concave		may be concave
		may be convex		may be convex
THREE - DIMENSIONAL SHAPE 2. Illusion	concept	a 2D projection	concept	a polyhedral
		a volumetric or cubic 2D shape		volumetric (3D) in a void
		illusion of three dimensions		- illusion of three dimensions in hardcopy - solid object in the void
		has area on the picture plane		- has area in hardcopy - has area and volume with x,y and z axes in the void
		3D illusion from a fixed 2D viewpoint		- objects behave and are treated more like actual 3D forms - fixed viewpoint only in hardcopy

ELEMENTS	ART EDUCATION		COMPUTER GRAPHICS	
3D Shape: Illusion	position	positioned on a picture plane	location	objects are in mathematical relation to space (not consciously formatted on a matrix)
			orientation	described by the direction of face normals (the facets oriented to z, the viewer)
	depth devices	shading/modeling	depth devices	modeling
		shadows		cast shadows
				ray tracing
	image structure	made up of planes (surface directions)	object structure	made up of facets (each face is a facet)
		planes may be blended		facets may be smoothed
		geometric (sphere, cube, pyramid, cone) - using tools - freehand		geometric (sphere, cube, pyramid, cone etc.) - using preselected volumetric shapes - using extrusion or surfaces of revolution - using points and vectors
		organic/biomorphic (2D)		freehand polygons (2D)
		plastic (3D)		organic (2D freehand polygons can be extruded into 3D)
			object properties	objects may be assigned "mass" and act as if they display space (also gravity, weight, inertia etc., and may be stress-tested)
				may be subjected to transformations (joined, broken into multiples objects etc.)
				objects may be intersected
				objects act as if they have physical surfaces (eg. reflective surfaces)
				may be subjected to procedural modeling (the surface texture or pattern changes in proportion to the subject)

ELEMENTS		ART EDUCATION		COMPUTER GRAPHICS
3D Shape: Illusion	surface	solid	image (in 3D, refers to the surface texture or pattern)	bitmapped
				may be transparent
				may be self-illuminated
				may be reflective
		devices like modeling are used to simulate an appearance of depth		has actual volume (z) in the void
	edges	hard-edge	sides	bounding edges
		soft-edge		dithered, blurred or feathered edge
		may be open (passage) or closed		
		may be penetrated (interaction between shape and space)		
FORM	concept	2 1/2 D or actual 3D (eg. a real object, sculpture, assemblage, mobile, etc.)	concept	3D output
	object properties	mass		
		weight		
		planes (surfaces and surface directions)		
	object structure	geometric		
		irregular		
		solid/closed		
		penetrated/open		
	surface	opaque		
		transparent		
LINE	concepts	- a mark - a point	concepts	- a pixel (on screen) - a dot-per-inch (in hardcopy)
		a path, mass or edge where length is dominant		- a continuum of adjacent pixels - a row

ELEMENTS		ART EDUCATION		COMPUTER GRAPHICS
Line		a continuous mark		- 2D segments with x,y coordinates (go between width and height or between local coordinates) - 3D vectors with x,y,z coordinates (go between width, height and depth)
				a invisible linear location (a mathematical model rather than an actual graphic element on screen)
	types	- freehand - geometric - organic	types	follow grid patterns on screen and in hard copy
		straight - horizontal - vertical - diagonal		straight - horizontal (x) - vertical (y) - diagonal/slope (x+y)
		curved - geometric - freehand		curved - arcs (have a start, end and radius) - semi-circles - curves (Bezier, quadratic and Fournier are equations that describe the mathematics of the curves between the defining points) - freehand in Paint mode
		continuous		continuous
				jagged diagonal and curved lines (a result of output resolution in 3D graphics)
		contour lines/ cross-contour lines (exterior outlines)		silhouette lines (designate the outline)
		cross-contour (designate surface changes)		contour lines (designate height of areas)
		connecting		- 2D lines/segments - 3D vectors

ELEMENTS	ART EDUCATION		COMPUTER GRAPHICS	
Line		repeated		iterated
	measure	direction - horizontal - vertical - diagonal	properties	orientation - horizontal (x) - vertical (y) - 2D diagonal line or slope (degree of grade on a plane, x+y) - 3D diagonal vector (z)
		weight - heavy/ dark/ wide/ thick - light/thin/fine		intensity - thick (a result of pen mode or sizes in pixel or 2D graphics) - thin (a result of pen mode or sizes)
		value - dark - light		value - resulting from pressure or time-sensitive tablets - can be zero (+)
	depth devices		depth cues	2D or 3D lines
		dark or heavy lines appear close/near		lines can be cued to show distance by using variable intensities (thick, thin etc.) or colors
		light lines appear distant		lines can be cued to show distance
	structure	- broken - dotted, dashed	structure	hatch patterns (dots, dashes, etc.)
		angular		broken (ie. silhouette lines)
		simple/consistent		simple/consistent by default
		complex (eg. sketching)		
				patterned
	presence	- implied - actual	selection	- invisible - positive
		positive (dependent on contrast of media to ground)		positive by default (dependent on contrast)
		negative (dependent on contrast)		reverse
				erased
	character	a result of media	regularity	- variable widths as a result of time- or pressure-sensitive drawing tablets - result of pen patterns

ELEMENTS	ART EDUCATION		COMPUTER GRAPHICS	
Line		active or passive		
		precise/regular or irregular		
		expressive or dynamic		
		calligraphic		
		subtle/delicate		
		bold/powerful/intense		
PATTERN	concept	a series of repeated elements or motifs	concepts	-default patterns -selected patterns - pen patterns - brush patterns - area fill patterns - bitmaps (eg. reflection map) - created patterns - fractals
	types	border	types	border
		allover/continuous		- fill/ opacity map/ texture map - reiterated/ duplicated - recursive
		distorted/variant		bump-mapped
		localized		- area fill - image-mapping
		grid		- bitmap
TEXTURE	concept	surface quality	concept	surface rendering
		may have surface depth or layering		single layer output
	types	natural/actual	types	
		invented/man-made (engraved, embossed, impasto, relief etc.)		
		illusory/ simulated/ visual/ trompe l'oeil		simulated
	surface	even/uniform (distributed or unified)	image (3D)	- bit-mapped - opacity mapped
		- uneven modulation of bits or areas - illusory variables: - line measure - line type - line direction - brush techniques		uneven 2D - block-pixed - manipulated intensity values uneven 3D - texture mapped - bump mapped

ELEMENTS	ART EDUCATION		COMPUTER GRAPHICS	
Texture		smooth		smooth 2D - blend - graduated fill - polygonal shading smooth 3D - continuous shading - Gouraud - Phong
		luster/sheen - matte - shiny/ semi-gloss/ glossy		3D effects - luminance - matte - glossy - self-illuminating - reflection mapped
			edges	2D - "jaggies" or staircase" effect 3D - aliased or "jaggies" - anti-aliased
COLOR	concept	made of pigment, dye etc.	concept	- dots of ink in hardcopy - made of light on screen
		colors absorb or reflect light		- colors absorb or reflect light in hardcopy - colors are luminant on screen
	types	local/objective color	types	selected color
		optical color		as altered by color spotlights, etc.
		arbitrary color		arbitrary color
		symbolic colors used to generate aesthetic responses		symbolic colors used for coding in technical applications (eg. medical or engineering)
	palette	monochrome (black, white, gray)	palette	monochrome (black or white/ on or off)
		tints		pseudocolor
		- limited palette - full palette		palette -1, 8, 16, 24 or 32 bit

ELEMENTS	ART EDUCATION		COMPUTER GRAPHICS	
Color		palette is limited by the range of chosen or available pigments		the number of colors correlates to the pixel format resolution: the fewer colors, the higher the resolution (the more colors, the lower the resolution)
	color scheme	- monochromatic - analogous - complementary - triadic	color design	color tables
	color theory	additive	color theory	- additive in hardcopy - subtractive on screen
		primaries red, yellow, blue		- primaries cyan, magenta and yellow in hardcopy - primaries red, green, blue on screen
		secondaries purple, green, orange		- secondaries purple,green orange in hardcopy - secondaries cyan, magenta, yellow on screen
		black is the presence of all three primaries		black is the absence of all three primaries
		white is the absence of all three primaries		white is the presence of all three primaries in full intensity
	shade	gray results from adding black to any pigment	lightness	amount of black or white in the color
		a low-value color produced by adding black pigment		amount of black in the color
	intensity	brightness or dullness of a color - bright or dull - high key or low key	saturation	100% intensity without white
	hue	name of the color on the color wheel (eg. yellow-green)	hue	default name of color (eg. yellow)
	value	lightness or darkness of a color	brightness/ contrast	gray is all three primaries in equal intensity
	depth	receding color		
		advancing color		
	temperature	cool or warm		

ELEMENTS	ART EDUCATION		COMPUTER GRAPHICS	
TONE	concept	qualities of light and dark	concept	shading and shadows
	types	flat, even	types	matte
		chiaroscuro (treatment of light and shade)		- 2D chiaroscuro - 3D flat shading (polygonal shading)
		modeling (shading in tones of light and dark)		continuous shading - Gouraud - Phong (includes specular highlights)
		modeling (shading with color gradiants)		- color is mapped onto shading - Gouraud shading creates gradiants of color
		hatching		
		passage		
		shadows - cast - hard-edge - soft-edge		shadows - cast - hard-edge - penumbras - drop

APPENDIX F

Comparative taxonomy of formal principles

PRINCIPLES	ART EDUCATION		COMPUTER GRAPHICS	
FORMAL IMAGE	concept	image viewed as a whole	concept	- hardcopy image - screen or digital image
		matrix forms		digital medium in Paint snd 2D object-oriented systems
		analog forms		continuous medium in 3D graphics
		concrete		- concrete in hardcopy only - dynamic on screen
		image is stable		only hardcopy is stable
		one original		three originals - digital data - multiple screen originals coexist in pixel-based, 2D or 3D graphics - hardcopy graphics
		printmaking multiples		hardcopy multiples
	content	content is created in a discrete environment called a format	content	- 2D bitmap content is created in a discrete (matrix) environment - 2D object-oriented content is created in a discrete (coordinate) environment - 3D graphics content is created in a continuous environment
		contents are passive		contents are passive only in hardcopy
		contents are bound to form		contents are bound to hardcopy
		artworks contain signifiers (the "language" of art)		contain signifiers (evidence of selections and procedures, such as "sweeping" or a partical procedure)
		several formal principles may operate simultaneously		formal principles are applied hierarchically
	structure	formalist images are composed of parts called "elements" of art	structure	pictures ("universals") are hierarchical assemblages of parts or elements called "primitives"
		elements of art can be further broken down (ie. motif + repetition = pattern)		primitives are often incorporated into procedures or subroutines

PRINCIPLES		ART EDUCATION		COMPUTER GRAPHICS
Formal image		the formalist image can be subjected to "aesthetic scanning" for individual elements of art		universals may be decomposed or disaggregated into their constituent parts
		the sum is greater than the parts (due to visual and conceptual relationships between elements)		the sum is greater than the parts (due to additional synthesizing elements)
	procedures	formal principles result from working spontaneously with media and elements of art	procedures	formal principles are hierarchically arranged in both mathematics and procedures
		spontaneity		have temporal and mathematical priority
		dynamic		dynamic
		interactive		interactive
		the image has no identical abstract self (the result of a mental model)		the image has an identical abstract self (a mathematical model)
FORMAL BALANCE	horizontal	- assumes a central vertical axis in the format or object - visual structure is distributed to either side	horizontal	regions, polygons or objects may be subjected to Flip Horizontal procedure
	vertical	the "weight" of the image is at the bottom	vertical	regions, polygons or objects may be subjected to Flip Vertical procedure
	symmetry	balance of the same elements	global regularity	duplicated and flipped
	radial balance	design elements radiate from a central point	rotation	objects rotated around a circle
	allover pattern	repeated motifs (eg. lines, geometric or organic shapes) distributed uniformly across the surface	continuous pattern	a result of procedures for iteration or recursion (eg. fractals)
INFORMAL BALANCE	asymmetry	off-balance contrast of - value - shapes - texture - position	broken symmetries	- regions, polygons or objects may be transformed with Rotate, Slant, Stretch or Distort procedures - randomness of local details
	approximate symmetry	symmetry using two or more different elements to intuitively balance the design		

PRINCIPLES		ART EDUCATION		COMPUTER GRAPHICS
VARIETY/ CONTRAST	shape variety	dominant		
		subordinate		
		proportion (relative size) - actual/natural/realistic - distorted/exaggerated/ idealized - miniature - monumental - mannered		scale
	theme variety	- perceptual - conceptual		
	tone variety	- light against dark - defined edges against space		
	color variety	- variety of hue - variety of tint - cool color against warm		
UNITY/ HARMONY 1. Visual Unity	concept	unity of visual elements		
		the whole pattern is predominant over the parts		
	clarity of image	complex	graphic form variables	complexity - local - global
		simple		regularity - local - global
		busy		"busyness" "noise"
				randomness
	repetition	repetition of characteristics	repetition	- duplication - replication - iteration
		rhythm/continuance - regular - irregular/progressive (increasing or decreasing elements in a series, eg. from small to large, light to dark)		recursion/self-similarity - details and parts reflect the whole - detail is produced by the same procedure that produced the overall structure (ie. fractals)

PRINCIPLES		ART EDUCATION		COMPUTER GRAPHICS
Unity/ harmony: Visual	proximity of elements	continuation (a line, edge or direction continues from one element to another) - vertical - horizontal - diagonal - curving		
		figure to ground - dividing - separating - organizing		
		format to content		
		color distribution		
	color scheme	- monochromatic - analogous - complementary - triadic		color "look-up" tables
	gradation	- color gradation - texture gradients - perspective	gradients	- gradients - ping-ponged
	surface	uniform density (image is affected uniformly by reflected light on media)	a graphic/ an image	uniform resolution (the image is affected uniformly by the resolution of the output)
UNITY/ HARMONY 2. Conceptual	concept	intellectual/conceptual unity (resulting from "meanings" of parts of images)		
EMPHASIS	concept	focal point(s)		
		center of interest		
		"weight" of the picture		
	types	degree of emphasis	types	
		restraint in emphasis		
		absence of focal point		absence of focal point
	structure	isolation of elements	structure	isolation of elements
		placement of elements		placement of elements
LIGHTING			types (3D graphics)	reflection (the angle of incidence and the angle of view can be manipulated) - matte or diffuse - shininess - specular
				refraction (uses ray tracing to cause reflections to adapt to a new surface)

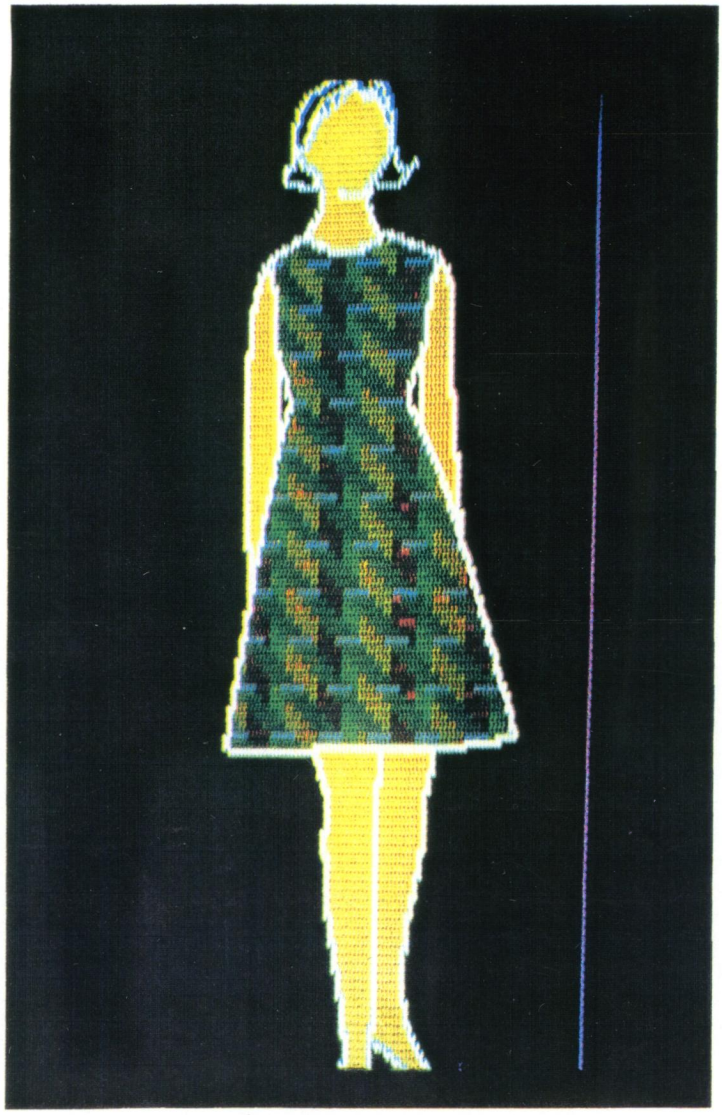
PRINCIPLES		ART EDUCATION		COMPUTER GRAPHICS
Lighting				transparency of images (can be revealed and adjusted with lighting)
				luminescence (self-illuminating)
				shadows
FORMAT	perspective	directed	field of view	enclosed
		cropped		can be - selected (pixel graphics) - windowed (2D graphics) - cropped (3D graphics)
	scale	the scale of the format in relation to the scale of the visual content		
		the scale of the format in relation to conceptual content		
	orientation of format to content	horizontal : "earthly"	view	horizontal by default ("portrait")
		vertical: "spiritual"		vertical may be selected on some programs ("landscape")
		circular		
		irregular		

APPENDIX G

Stimulus 1

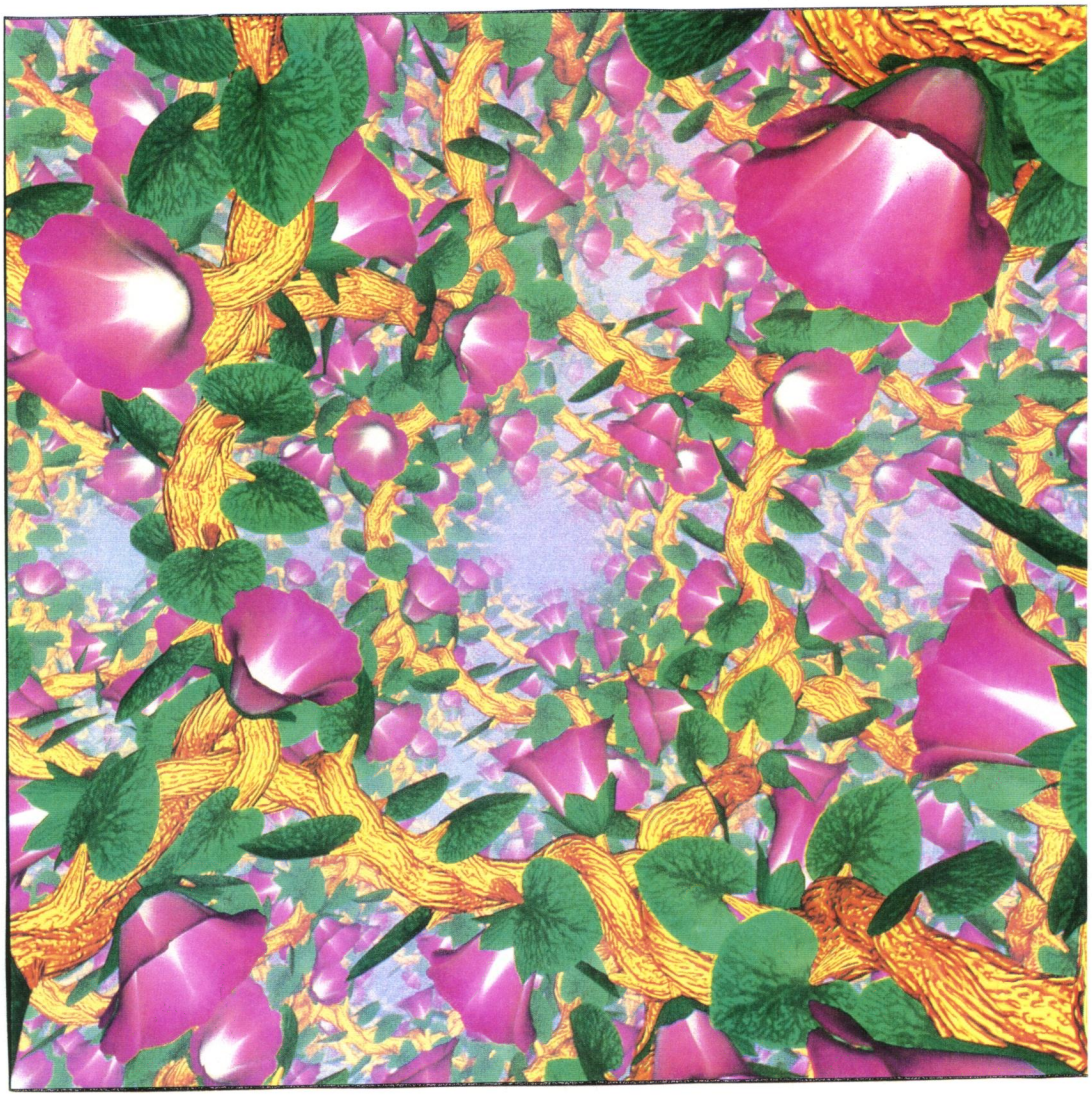
Untitled, Pixel graphic

Tosiyasu L. Kunii, Tokyo University



Stimulus 2

Peonies, 3D graphic
Ned Greene, New York Institute of Technology

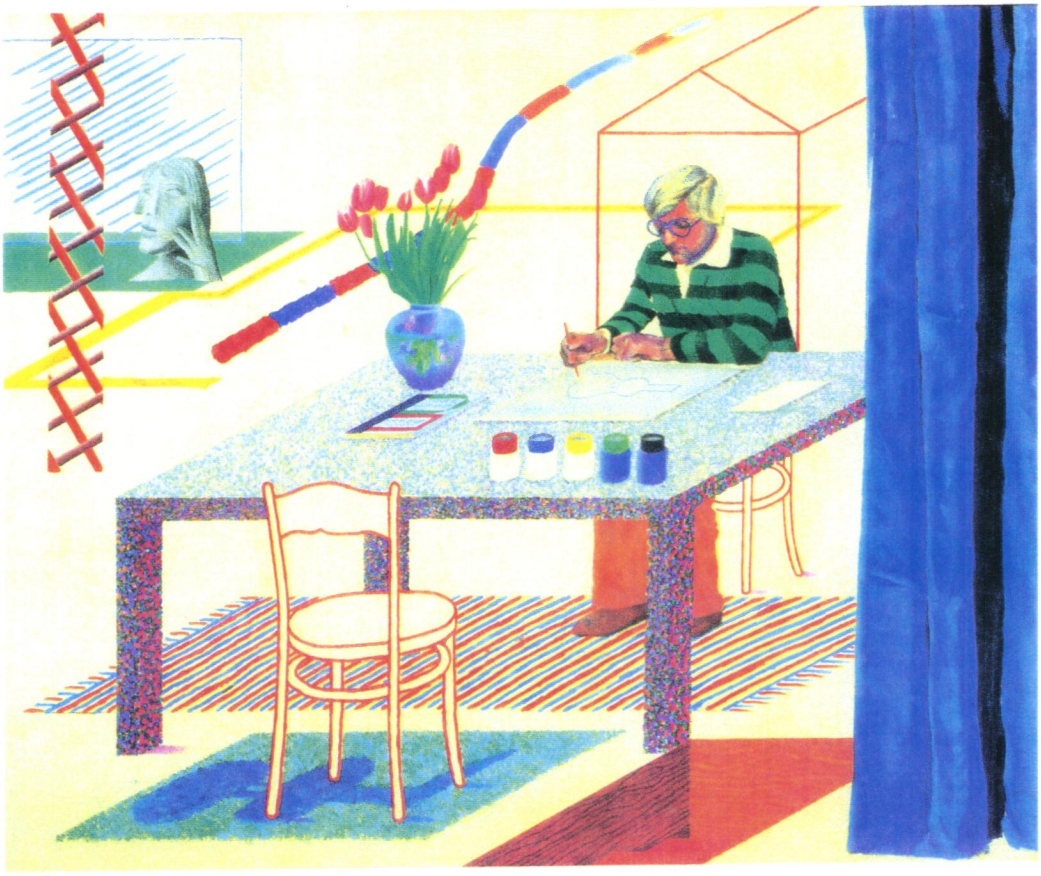


Stimulus 3

Presenting George Littlechild and His Horse
George Littlechild, Mixed media on paper, 30 x 30"

Stimulus 4

Self-Portrait with Blue Guitar
David Hockney, Oil on canvas, 152.4 x 182.9 cm.



APPENDIX H

Description of stimuli

Stimulus 1: *Untitled*, Pixel graphic. Tosiyasu L. Kunii, Tokyo University

Elements of art

line
- uneven contour/ silhouette, jagged
- vertical, horizontal, diagonal
- negative/ reversed

shape
- two-dimensional
- geometric, organic
- solid, outline

space
- two-dimensional
- matrix, bitmap
- positive and negative

pattern
- localized (dress)
- allover, invariant (dress)

color
- limited palette
- analogous
- cool

texture
- illusory
- even/ uniform/ invariant (pixel pattern)
- localized (figure)

tone
- flat
- contrast

Principles of art

unity
- format to content

- unified palette
- proximity of figure to ground: separated

repetition - regular pattern (on dress)

emphasis - isolation of element (pattern on dress)
- outline/ silhouette line

balance - horizontal

scale/ proportion - actual

lighting - diffuse reflection

uniformity of surface - low resolution "jaggies"
- contrast (pixel texture against solid)

field of view - almost enclosed (cropped feet)

Stimulus 2: *Peonies*, 3D graphic. Ned Greene, New York Institute of Technology

Elements of art

line - broken
- interior/ cross-contour (designate changes in surface of bark)

shape - 3D
- organic

space - 3D
- object-based system
- one-point perspective
- atmospheric perspective

- loss of detail

pattern
- allover
- variant/ irregular
- decreasing

color
- limited palette
- complementary color scheme (red and green)

texture
- natural (the bark is an algorithm derived from plaster casts of actual bark)
- mapping (flowers and leaves were modeled as grids of fine polygons then colored by texture mapping)
- smooth/ even

tone
- even
- continuous shading (Gouraud)

Principles of art

unity
- recursive imagery
- proximity of figure to ground: organizing

repetition - irregular

emphasis
- placement and scale of elements
- vanishing point

balance
- approximate symmetry
- radial balance

scale/ proportion - actual/ natural

lighting
- diffuse reflection/ no shadows
- atmospherics

uniformity of surface - high resolution

field of view - cropped

Stimulus 3: *Presenting George Littlechild and His Horse*, George Littlechild, mixed media on paper, 30 x 30".

Elements

line
- bold
- continuous
- irregular contour
- positive and negative

shape
- 2D/ flat
- layered
- face is semi-3D due to contour lines

space
- 2D (overlapping)
- 3D (modeling on face)

pattern
- motif/ repetition
- allover/ continuous (spots)
- border (squares)

color
- unlimited palette
- tints

texture
- invented/ man-made
- impasto

tone
- contrasting

Principles of art

unity
- proximity of figure to ground: dividing
- repetition: irregular (decreasing)

repetition - repeated shapes
- repeated motifs

emphasis - contrast (scale)

balance - symmetrical and asymmetrical
- horizontal and vertical

scale/ proportion - distorted/ unnatural

lighting - diffuse reflection
- no shadows

uniformity of surface
- even (impasto: brushwork of a similar scale)
- low resolution

field of view - enclosed

Stimulus 4: *Self-Portrait with Blue Guitar*, David Hockney, oil on canvas, 152.4 x 182.9 cm.

Elements

line - delicate
- contour/ silhouette lines
- repeated diagonal perspective lines

shape - some 3D
- some 3D (both outline and modeled)
- geometric and organic

space - 2D
- 3D projection
- isometric projection

pattern - localized
- allover/ continuous
- distorted/ variant

color - unlimited palette
- primary colors

texture - illusory/ simulated
- smooth
- modulated areas

tone - chiaroscuro/ shading
- flat
- contrasting

Principles of art

unity - proximity of figure to ground: organizing
- conceptual unity

repetition - repeated lines/ angles/ styles/ colors

emphasis - isolation of elements
- placement of elements
- degree of emphasis

balance - symmetrical
- horizontal and vertical

scale - actual/ natural

lighting - inconsistent

uniformity of surface - non-uniform
- both flat and impasto
- high resolution

APPENDIX I

Interview questions

1. To begin, could you tell me about this picture?

2. I would like to know how you would describe the different parts of this image.

Prompts:

Stimulus 1

Could you describe the different areas of this figure (dress, limbs, face, etc.)?

Could you describe the edges of this figure?

Could you describe the background?

Stimulus 2

Could you describe the different areas in this picture (flowers, leaves, vines, etc.)?

Could you describe the edges of these areas?

Stimulus 3

Could you describe the different areas of this picture (face, horse, background, border design, etc.)?

Could you describe the edges of these areas?

Stimulus 4

Could you describe the different areas of this image?

Could you describe the surfaces of different areas and objects?

3. I would like to know what you think about the image as a whole, in terms of its composition or arrangement in space.

Prompts:

Stimulus 1

Could you describe the colors or the palette of this picture?

Could you describe the way the different areas are organized in a composition or in space?

Stimulus 2

Could you describe the colors or the palette of the picture?

Could you describe the way these different areas are organized in a composition or in space?

Could you describe the lighting in this picture?

Stimulus 3

Could you describe the colors or the palette of this picture?

Could you describe the way these different areas are

organized in a composition or in space?

Stimulus 4

Could you describe the perspective of different objects?

Could you describe their location in space?

Could you describe the colors or the palette of the picture?

Could you describe the lighting in this picture?

4. On the basis of its visual structure, do you think this is a successful image?

5. Do you think there are any connections between the way computer artists and traditional artists (or computer graphics educators and art educators) might talk about this image?

APPENDIX J

Subject contact letter

THE UNIVERSITY OF BRITISH COLUMBIA

Faculty of Education
2125 Main Mall
Vancouver, B.C. Canada V6T 1Z4

Room 2115, Scarfe Building,
Department of Visual and Performing Arts,
Faculty of Education,
2125 Main Mall,
University of British Columbia.
May 27, 1993.

Dear _____,

I am a graduate student in the Faculty of Education at U.B.C. currently conducting a study for my M.A.

I am doing a study of the terms used by computer graphicists, artists and art educators to talk about art images. I will be interviewing eight subjects who work in one or more of these areas.

Your name has been recommended to me as a person who might be interested in responding verbally to four art images. The interview will take between twenty minutes and one hour, at the location of your choice and at a time convenient to you. The results of the study will be published in a Master's thesis. Your participation will be anonymous and confidential.

I hope to hear from you at your earliest convenience.

Sincerely,

Mia Johnson
822-5325 (office) or 222-2117 (home)

Faculty Advisor: Dr. Ronald MacGregor (822-5340)

APPENDIX K

Subject consent form

THE UNIVERSITY OF BRITISH COLUMBIA

Faculty of Education
2125 Main Mall
Vancouver, B.C. Canada V6T 1Z4

Consent form: Responses to visual images

Investigator

Mia Johnson
Visual and Performing Arts in Education,
Faculty of Education,
University of British Columbia.
822-5325 or 222-2117
Faculty Advisor: Dr. Ronald MacGregor (822-5340)

Purpose of the project

To examine the kinds of terms and concepts used by computer artists and educators to describe and discuss the visual structure of art images, and to compare them to terms and concepts used by art educators. An interpretation of the interview data may be used in a Master's thesis and in journal articles.

Procedures

Subjects of the study will be shown four reproductions of traditional and computer art and asked to describe the images in their own words. Subjects will also be asked to comment on connections between the fields of computer and traditional art.

The identity of the subjects will be confidential and subjects will be identified by number. The total amount of time required will be no less than twenty minutes and no more than one hour. Longer interviews will be dependent on the interest and agreement of the subjects.

Any inquiries concerning the procedures in order to ensure they are fully understood by the subjects will be answered. The subject has the right to refuse to participate in the study or to withdraw at any time.

I understand the purpose and procedures of this study and agree to be a subject under the above conditions. I have received a copy of this consent form.

_____ _____

subject name date

APPENDIX L

Sample interview transcript

Subject 4

To begin, could you tell me something about your background as an artist, and in computer graphics?

(S4) My background as a visual artist, as a painter, would most likely be the most extensive one. But like yourself, I'm interested in any two-dimensional surface, whether it be a television screen, or a computer printout, or a Xerox machine, or a photograph. In that way, I have been expert in *looking* at the two-dimensional surface, which is a most fascinating surface for me. Right now, and in the past couple of years, my interests have been involved in computer graphics. I would still use the computer as a tool.. as an experimental tool. I like experimenting with it... and I would certainly approach my computer work in a similar way I would approach my painting. And the similarity would be that I would let the image lead me into another image, rather than knowing what the image is going to look like in its final stage. So that's where the experiment comes in. It might mean that I would combine the computer image with my own drawing. I would certainly allow that to happen. So sometimes a cooperation of the computer and my own work... or it might be that I translate my own work into the computer. Although at times it even takes longer, some of the images that I'm after. But again, it's how familiar you are with the computer. Although it's a little bit like painting, you learn the techniques and then you strive for something more - you want to communicate on different levels. So there's this departure from an illustration which describes in a narrative, to something that deals with my emotions.

As I explained, I'm interested in your ways of describing visual images, or how you would explain them to someone else. I have four images. I'd like to show you each one in turn, then if you want you could comment on connections. Feel free to go back as we go through them. This is the first.

(S4) Certainly. Let's see... Nice color print. We're definitely dealing with a figurative image...

Could you describe the different areas of the figure?

(S4) Yes. Simply by the separation of the color field. There's a dress, there's pattern in the dress, the figure has a flesh tone, which is certainly evocative of the figurative. It's a female. There's a vertical line on one side which tends to fluctuate with tonality. It's lighter in the center and gets cool towards the each end. There isn't much in the negative space of this image except that one line. Other than that, I would look at it as a fairly raw image, or at least it's at a fairly raw stage by just simply the linear work. Most of the lines that are outlining the shapes have a certain similarity. I know that there that can certainly be a variation of the linear structure. Why does the outline of the dress have to be the same as the outline of the legs? I would be a little more sensitive to certain issues of the line itself.

Why do you think that line looks like that?

(S4) Well it's the same line that runs through the dress as it does throughout the figure. The only difference in the line is this line here, that vertical line. It's the only one that is quite a bit different from the rest of the image.

How do you think those lines were made?

(S4) Those lines were made... let's see... I'm trying to figure out what kind of program it could have been...

Do you think it was a computer image?

(S4) By the pixels...you know, a computer screen is a little bit like a stitch work. Like when you're sewing. It has every point. So it could very well be something that has been sutured, or weaved through. You know, computer printouts are always deceiving. It's more, what's reminiscent of this, the head does look very much like a computer image. Also this flatness of the negative space... it's so *nicely* flat. To have this positive space part of that negative space, it seems like a computer image. I could probably draw this image on my computer. But it seems like it been cut off, or shaved off, at the bottom. Maybe the printer, or something got in the way. But definitely the pattern, it's definitely a repetitive form. I could figure it out from a quarter of an inch. It's a repetition that tens to multiply itself. In the legs... it really does look like a material-like fabric. But there's not much difference. It could be an illusion... you know you can make computer look like fabric or you could make fabric look like the computer. The early stitching, they look like early computer drawings. You know, the early computer writing looks like stitching, like "Home Sweet Home", you know. The lines don't have that roundness though... it's a pretty raw program, because you can certainly get that much finer lines, or that difference between the lines. They could be much more evident. Light to dark... It definitely is a color Xerox.

Do you think this is a successful image, on the basis of its visual structure?

(S4) Yes... it could be successful... successful always depends on how it's utilized, what it's for. I could see it in enlarged in a window display, with some garments.

In terms of its composition?

(S4) Well, there are few elements with which to deal with. I like the simplicity of it. With the computer though I'd be tempted to deal with some other issues as well.

What would those be?

(S4) They might be dealing with the negative space, so that the negative space somewhat would be part of the positive space of the female figure. There might be some integration. It seems like I could just take scissors and cut out this figure and put it on a green paper. I really like this line. If the line wasn't there, it would really read as an isolated image, almost as an island. The line brings this negative space, like the black is not so isolated. There's an attempt at making the format. You know, the composition depends always on the format of the piece, reading it from the corner, or from the center. The line really does make a lot of difference. Otherwise the pattern-like quality of the form would be entirely isolated from the format. And the composition always does depend on the format, not on the positive space. It happens from the edges of the piece.

Let me show you the second image and see what you think. Can you tell me about this?

(S4) Oh, right... So this is a very illusionistic image. I do get the sense of a foreground, the middle ground, the background. It's not a figurative image. That's an excellent print of that...

Could you describe it to me? What are you looking at right now?

(S4) Well, without getting really specific, we're dealing

with organic imagery of flowers, branches, and certainly that sense of space... It seems like the images that are forward, or the foreground, are collected on the edges of this particular piece. The foreground happens in almost a circular manner. As we move toward the center, as a vortex, it moves through the middle ground into the extreme depths of space in the center. Again, I read it as a fairly symmetrical image because the center of the depth of field is so symmetrical.. But I do also get that sense of the spiral. And then there's the flowers, which are done with warm colors, and the leaves, which are done in cool colors. We're really aware of the contrast between the cool and the warm.. And those cool colors of the branches... they serve as a linear form... but they seem like a multiplication of a form.. It seems like somewhere along the line there is some kind of pattern I could figure out... I really do get that strong sense of a spiral coming from the center towards the edges. Of course, at the edges the images are far sharper, so in that sense it's creating a sense of the foreground. It gets sharper both in the flowers and the branches. That sense of contrast is being greatly reduced as we move through the middle ground into the background. Whether it was black or white, or that mauve color being diluted with the whiteness. There's certainly a gradation. Is it a computer image?

How do you think it was done?

(S4) I was trying to figure out the actual segment which was reproduced... on the edges, it doesn't seem like it was reproduced but turning to a few things I can see some reproduction. It could be collage. I've worked with an image that I have rotated and multiplied, with the computer. Because of the softness of some of these colors it also has an airbrush quality or a watercolor quality, but, that can also be done on the computer without too much trouble. But if it is a collage... there is a collage that exists from the early nineteenth century, the Dadaists were probably the

first people who dealt with the collage in a most extensive way... so whether it's collage done on a two-dimensional surface or collage done on a computer... Before computers the Xerox machine was a great device. What happened is that it would make six or a dozen Xeroxes of that same image, and go through a painstaking process of juxtaposing one against another to create one image from maybe a dozen similar images...

Why would you want to do that?

(S4) Well, for us, as visual investigators! you always want to go into the unknown, or somehow deal with your own image. I remember when the Xeroxes came out, I remember my Dad in 1968, who was the first guy on the block who got a Polaroid camera... You would take pictures, you know, instant gratification, then the Xerox machine that would also capture an image... inevitably you're going to come up with two or three images. These images that are kicking around in your studio somehow make their way into your work. Art, in my vision, is that mystery of art , sort of like the mystery of love... Being a Surrealist, the attraction is that mystery, that sensation of being alive, that is the reflection of your work without any aesthetical judgment. Often when artists get these materials that are new to them, like back then, whether they be tattered pages, or whether they be crumbled pages, whether you bring them out from the ashes and start gluing them, somehow they would make their way into your work. So again, this seems like a multiplication. It doesn't have the flatness like the previous image. And of course you know I'm a sucker for the flatness of an image. I do a lot of "seeing" the flatness, I can relate to the flatness, because of the physical manifestation of that two-dimensional surface.

Is this second image flat to you?

(S4) No, this image does not read flat to me. I certainly

do feel a depth.

Can you describe the things that create that sense of depth?

(S4) Yes, the contrast... that's the old academic school for illusionism: images that possess contrast will appear that they're coming forward. The reduction of contrast will create the illusion of space. And this is exactly the formula I'm seeing here.

Is there anything besides contrast?

(S4) Yes, the size can also create that sense of depth, that is probably the most obvious one. The reduction of size: the flowers in the foreground are larger, and as we move towards that depth of field the size of these objects is being reduced. We're reminded that we're dealing with then same object, the flower that is being reproduced throughout, but it's being reduced in size quite a bit as we move towards the extremity of that depth of field. As I'm looking at this longer, because it's pretty tricky, I've already found the original image, I think.

Could you describe the lighting in this picture.

(S4) Well, the lighting. You mean as far as the tint is concerned, of the color? I think if I were to examine this a little longer... I'm already starting to get the sense of the original, which has been twisted around... I feel that all the color that has been painted in this image, the original colors that existed here, the original pigments involved, the pink, the mauves - I doubt if they were just a single color - as you move into the middle ground, and the background, the reduction of contrast has been reduced by a single-color wash, rather than a multiple wash. The images were subject to either a wash, a white color, that makes it appear like a mist.

Why don't we look at the next one? You've gone into a lot of detail on this one, here.

(S4) Okay. Oh well, yes! I just had a show with this guy, in Prague!

Looking at the visual structure, how would you describe the third image?

(S4) In looking at the other images, totally flat... I must say I like this artist, I really do... First of all, he's dealing with the flatness of the shape, he's dealing with the materials... it doesn't look like a computer drawing. He's dealing with the sensation of color, and brush, shapes, to a certain extent even pattern. I love this controlled messiness, which is so difficult to do with the computer. To get messy with the computer, it's one of the most difficult issues to deal with. Controlled messiness... a good example would be Francis Bacon. They're loose, and yet there's an incredible amount of control. That mess, dripping, texture... you know, with a computer you can get texture but it's always a multiplication of that texture. This image has irregularity. I can "read" his handwriting. I call it handwriting, but I mean his brushwork.

When you say you "read" it, what do you mean by that? What are you reading?

(S4) Oh! I'm just reading the way you would deal with various planes. I like the way he's sensitive to color. For the computer to actually get that brush stroke, to actually get that sensation of form... because for a brush stroke, you have to go *around* these shapes. There's a great irregularity. There isn't that regularity that I would see in a lot of computer images. And then there's that whole sense that it's not an image that is perhaps derived from life. It's an image derived from the imagination, although it's still a figurative image. We see a horse, a face with

a crown... it reminds me of an old theater it's got lighting, it's got spotlights, it's got curtains, it has a stage. It's isolated, it is almost like a theatrical set. It's got a king, a big-headed king on this horse.... I could certainly say that if this is a computer painting, then I would like to know how this is done. Because this really has a sensation that is very evocative of a painterly manner. There's a great order in this as well, there's more to this than just the image.

What kind of order are you talking about?

(S4) I think, when we were talking about composition a little bit earlier, you know, the way he's taken care of organizing this image... who knows what came first or what came next - although probably you could figure it out - but there's been great care taken in presenting the image that tends to be worked out most in the head.

Could you describe the color scheme?

(S4) Yes, it's a pretty good color Xerox. There's that repetition, and knowing this is a painter, you tend to work out the problem of the color within the painting itself. You would mix a certain color, like perhaps this Thalo green with this Thalo Blue and some white, which would describe the horse... you would add a little bit of white... the same cool color might be represented in the crown and some of the evidence we have around that image.

You're pointing toward the...

(S4) I'm pointing toward the border that he's created with these rectangle squares and circles inside... so if I were to examine it a little bit longer, I would find there might be only five or six colors, and then they're mixed in various ways. And not like the first image, the figure... easily this head could have been dealt with in a symmetrical

way. He's not trying to be symmetrical. Left doesn't mean that it also has to be right. And then we were discussing the line. There's more to line... every line is different. One line is a sheer color. The next line is supported with a red line on the inside. Here it's supported with an orange, he's mixed some of his orange with it. When orange gets into blue, you're going to get this muddy color. And that muddy color was a result of what happened maybe in the nose. If you just go around, if you start looking at this structure, this is a line he's working on not in a systematic manner...

What would you call this line that goes around?

(S4) If it's an exterior line that deals with the outer shell only, it could be referred to as a contour line, or it could be referred to as an outer shell. Here the line is weaving in and out of the image. See here it starts out as a red line, it moves into the ear, it's still red, as it moves into the horse the line goes black, into white... there isn't that consistency. He's not working with borders in this image. There's paint involved. And a painterly manner. He's not trying to disguise the paint like we often would with a graphic design, that you have the flatness of the image and you can't really get away from pattern-making.

Would you say this is a 2D or a 3D image?

(S4) It's a two-dimensional image. It doesn't want at all to be a 3D image. Of course there's that overlap, we get that sense of a theatrical mask, or a theater, the horse is on top of something, but there's no illusion of space at all. It looks like Matisse would deal with that sensation of overlap, or how some people would deal with it in a collage. But it's a direct painting.

Do you think this is a successful image, on the basis of its visual structure?

(S4) Yes, I do. I like this image very much.

What makes its structure work?

(S4) There are various things, and this may be my personal outlook. Some images are really read as... the reason I would feel close to this image... it doesn't look anything like my work, it doesn't reflect what I'm working on. The words I'm going to say may be very abstract... because to say that it's not pretentious is a very abstract term. I would feel that this artist is working with images that are not derived from life, that these images are being explored from inside, and then manifested through some mean. Call it "magic", or call it mystery... the subject matter has not stood in front of this artist. He had to make this work from the very beginning of that image. He could not rely on a still life or on a tangible world to arrive at this image. I'm interested in that kind of work, whether it's from 4000 B.C. or today. Those images that come out of our mind, I'm always intrigued by them. Some of them tend to work... this could be tragic, or happy... but it is a *lived-through* experience rather than a rendering of an image.

Let's look at the last one. Again you've given me a lot of information!

(S4) Right! This is David Hockney.

Are you familiar with his work?

(S4) Oh yes, of course.

Can you tell me something about the different areas?

(S4) Right. You're giving me again work that I can relate to! In my youth, he was my mentor! I liked this stage of Hockney, when he was applying various methods.

Could you describe some of the various methods you see there?

(S4) Yes. One is simply working with the flatness, and the linear work, and then again, dealing with the illusion of space or texture... a little bit like in a collage, but in the chairs here, he's just dealing with linear structure, he's just dealing with lines. In a way it could have been a homage to Picasso. Even though it was a very surreal thing to have an artist painting their own work.. So it's a self-portrait, and when you actually draw your self drawing, there's a whole... it's a long discussion! There's an image of an image... Dali kind of did it in a cheap way - I'm crazy about Dali's work - but he's painted himself several times, holding the brush.

Do you think that's what going on here?

(S4) Well, here's David, and he's sitting in front of this table, and he's certainly drawing something... it seems like it may be a guitar. But the thing is, it may be a combination of that flat world, and that dimensional world. We can sense the dimension of that table, we can deal with the perspective, and then we can move on to other areas if we move below the table, we're dealing with the carpet. We're not dealing at all with an illusion of space there, we're only reminded of the geometric design of the parallelogram... but there's no depth of field here. There are the flat straight lines. He's applying different methods here: you're aware of various sides of the table, you can discuss him as an artist sitting at a table, and we can discuss the source of light... The light looks like it is coming from the top, because his chin has darker shades, and the shadow's a little bit under his hands, and the light is hitting the flatness of the table, but the sides of the table would be dark. Moving towards this curtain, you're almost getting into that illusionistic way of working with

the material. The way it's created, it seems it's really in the foreground. It seems we are dealing with the material in a way that is totally separate from the way he has handled the chairs. And then that little Picasso vignette of a head, it's again has a source of light, it's coming from the same side as it would on him, coming form the left. And there's that inevitable sense of an overlap... but I still don't get that sense of a dimension. In a lot of ways he's working with positive and negative space. I don't get that sense of dimension like I would with the flower image, where I'm really reminded that that image goes a long way back. Again it's more a sensation of overlap rather than an illusion of space. It's a very limited space. The only illusion of space in the entire piece is this line that drops behind this flower and starts going back, behind the house here. It's like the flower piece: contrast will look like it's forward, reduction of contrast will look like it's going really far back. The tail of that image certainly looks like it's going further back than the beginning of it, which is right almost under the Picasso head. There are kinds of suggestions that are not necessarily being derived from life. The chair sitting on top of a nice green carpet... the shadow of the chair does not correspond to the chair itself... it might be a design of the carpet, but it's still part of the chair. So there's still some Cubistic element involved, like the leg dropping or being extended into the carpet. And being more aware of the positive and negative space, and what happens in that area, rather than being true to life. He's also boxing himself in, he wants to be important. He's created a border around himself, he's got to stand out. It's a nice piece... There are various ways of dealing with a pattern. It's an effective component when it's part of that negative space. This is an absolutely marvelous piece as far as negative and positive spaces are concerned, because if we're constantly looking at the image, if we're constantly looking at the colors, or the chair, or the artist himself, well, that's nice. But I'm also looking at various abstract images that are created by

the negative space, like between the table, or spaces some people would just consider as white areas. Because knowing his work, I know that he was just so conscious of what happens in the whole structure, negative and positive.. In some places he tends to slow down the eye where he works with detail, then he gives it some sort of quiet area where there is less descriptive form. But again there is, talking about the methods, the way he presents himself in a fairly realistic manner, shadows included, and puts himself sitting on a bunch of lines... the chairs are lines, and the table becomes a very Impressionistic structure, sort of like someone like Seurat might be drawing on this table. Again, it's a totally marvelous piece.

Well, I'd like to ask you one last question. Can you see any connections between the way traditional artists and computer artists might talk about these images?

(S4) Traditional artists, you mean like artists who paint on canvas and that kind of thing...

Right.

(S4) Oh, yes. There would be similarities. If I were to be using a computer, and I would start to discuss an image, I would be using a similar language as I am using here, except that I would be talking about nods and angles and pixels... but I would still be talking about positive and negative space, I would still be talking about depth of field and composition...

So you feel you would be referring to the same kinds of things but using a different vocabulary...

(S4) Right. And I could be referring to such language as photography... or...

So you think that the language to describe art could be used

for computer graphics?

(S4) Yes. The English language is very good for that. I like discussing visual arts in English because there is an extensive way of portraying verbally a visual image.

Do you think that there are any terms or concepts in computer graphics that are useful for talking about traditonal art?

(S4) Oh yes, in the future I see absolutely no doubt. I mean it's already happening to a certain extent in my work. I can see no doubt that there would be some kind of a merging, or some way of dealing with a computer image. But there's a difference. I don't mean to call it graphic design. Graphics often deals with that world we call illustration. And a computer design deals with slightly different issues, because they're not responding to a graphic design... they're just responding to the computer. They don't have to create some *thing*. And usually when we're dealing with a graphic design, it's usually a logo, or an image, or someone sets up a situation, or it's a narrative. But once the computer design gets into... the only difference I can see in painting and computer design is the approach to the work. It's the way you would approach your painting...

You mean the procedures that you use in making it?

(S4) Yes, the procedures... but again it's how you extend the program, because just like painting, computers are also limited. The capability of a program is very important. But I still believe you can create something out of nothing. So if I were to be given a program just with a straight line, and maybe a curved line, I could come up with a great image.

Great, let's stop on that note!