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Linking visual and linguistic composition : a study of cognition using computer microworlds.

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LINKING VISUAL AND LINGUISTIC COMPOSITION:
A STUDY OF COGNITION USING COMPUTER MICROWORLDS

A Dissertation Presented

by

HILTON ABBOTT

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This work is dedicated to

MARK AND PEG

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I wish to express thanks to my students upon whose work this study is based, my committee whose guidance was crucial, and my family whose patience was essential. Special recognition goes to Howard Peelle for his ability to guide without directing, to Richard Konicek for his contagious enthusiasm, and to Robert Mallary for his aesthetic acumen. My thanks also goes to Raymond Lazzana who introduced me to visual grammars.

ABSTRACT

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FEBRUARY 1992
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This study is devoted to investigating links between the mental processes of visual composition and those of linguistic composition. The study has two components, each of which compares visual / verbal pairs. First is a comparison of visual and verbal features in picture books created by students. These books are alphabet books created in the tradition of "ABC" books for children and produced using standard desk-top publishing techniques. Drawn letters are compared to their accompanying text by measuring features of each. Second is a set of case studies of students' visual and linguistic compositions. These compositions were constructed within the constraints of computer based microworlds designed by the researcher. A positive correlation between visual and linguistic composition is demonstrated. This study accentuates the importance of the computer as a tool for generalized composition, perhaps the most important role for computers in education.

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CHAPTER 1
INTRODUCTION

1.1. Background

The computer has become an important tool for my teaching and it seems to give students power of a new kind. One aspect of this new power is the computer's effect on the processes of both visual and linguistic composition. My teaching experience leads me to believe that the ability to create structure may be generalized, implying that increasing competence in the use of one medium enhances skill in other media. Computer applications such as CAD (Computer Assisted Design) packages offer well-defined sets of tools. When a picture is composed using such a package, the "quality" of this composition might be established in terms of the frequency and diversity of the use of CAD features. Limited computer environments ("microworlds") suggest new techniques for investigating the construction of compositions. Some computer applications keep records of user input. The Logo DRIBBLE command, for example, allows this kind of record keeping. Records such as this can provide information about the process of creation. A record of an informal creation is likely to be a morass of process steps, making analysis difficult and tedious. There are alternatives to such exhaustive records. Lists of instructions-to-the-computer called scores[1] are more formal and much shorter records of process. Sometimes computer compositions are generated by scores. When using a score, the composer has to create at a level of abstraction above the composition itself. The score (instruction list) is closer to the process of creation than the composition itself, but it is easier to analyze than a complete record of the process.

In this study, some compositions will be analyzed in terms of traditional criteria for good design, whereas others will be analyzed at the score level.

The basic thesis of this study is that compositional skills of an individual may be applied generally, whether the medium of expression is visual or linguistic. Parallel features in visual and linguistic composition are established and correlation of feature-pairs is investigated.

A search of the literature seeks answers to the question of what has been written about mental linkage between pictures and words. A need to get to the basis of contemporary thought about learning and epistemology became evident early in the investigation. Chomsky, Pinker, Goodman, and Piaget have made lasting impressions.

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1. Not to be confused with musical scores

Noam Chomsky's work with generative grammars made an impact which extends far beyond linguistics. Of particular interest is the application of his ideas in the visual arts, from Stiney's shape grammar and Lazzana's rule systems for generating drawings in the style of Kandinsky to Cohen's robot art. As editor and writer, Steven Pinker has contributed much to my knowledge of current work in visual cognition. His (1988) book, *Connections and Symbols*, makes the case that connectionism and its neural net model do not preclude the need for symbols in cognitive processes. Nelson Goodman convinced me that humans create reality by constructing symbol systems which order their world; and Jean Piaget, in his book *Structuralism*, linked many disciplines arguing that subjects as diverse as anthropology and mathematics share similar underlying order.

This research is devoted to investigating links between the mental processes of visual and linguistic composition. The study has two components, each of which will compare visual-verbal composition pairs.

The work of students in the researcher's *Computers & Society* class at Springfield Technical Community College has been used for this study. Student work was saved during the semester for later analysis. One component of the study is based on an assignment to "publish" an alphabet book using standard desk-top publishing techniques. The second part of the study explores composition in more depth. Students compose pictures from a visual vocabulary of shapes, by writing computer programs. They also compose paragraphs using a limited vocabulary and a restricted grammar, using computer list processing techniques. Each assignment uses computer software developed by the researcher. Special purpose learning environments such as these are often called "microworlds". Both microworlds used in this study are similar in that they each contain a vocabulary of objects and a set of rules for modifying and relating the objects.

This study is important because it is a step in the investigation of links between visual and linguistic mental development. Support of a visual-linguistic connection recommends some types of educational activities which are not generally recognized as having important links to intellectual development. In particular, both visual art and computer programming may deserve more attention in school curricula. Although written composition is emphasized in school, visual composition is generally considered a "frill" which is culturally important but intellectually irrelevant. This study suggests that compositional skill crosses the visual-verbal boundary, and points to a need for reassessment of the priority given to nonverbal composition in school curricula.

1.2. Statement of the Problem

Much of the life-of-the-mind centers on the construction of symbol systems.[2] Educators should provide more opportunities for students to learn new symbol systems, to innovate within their confines, and eventually to create new systems. For example, education at large has the problem of ignoring cognitive value in the visual arts. A person's ability to compose in visual media may relate to his or her ability to create compositions in linguistic media. This study seeks to ascertain whether such a correlation exists. Does an individual's level of performance in one symbol system relate to performance levels in other symbol systems?

1.3. Purpose

This study seeks to establish that an individual's ability to create within the confines of one symbol system is related to that person's creative ability in another. For the investigation of learning as symbol system mastery, systems which can yield to analysis must be found or made. For comparison a pair of systems must be found which, although quite different in vocabulary and grammar, are similar in complexity and structure. If systems meeting these criteria can be found, and learner responses in both systems can be obtained, then questions about general symbol system mastery can be investigated. This study uses systems meeting these criteria. The creative media used in the study are all environments which may be thought of as small symbols systems. One system is a restricted design problem which has both visual and verbal components. The researcher has also built two closed computer microworlds, one verbal and one visual, for further study of symbol system mastery.

1.4. Significance of the Study

This study is important because it is a step in the investigation of links between visual and linguistic mental development. This study indicates a visual-linguistic link, suggesting that compositional skill in each may be supported by common mental processes.

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2. See for example, Howard Gardner's book *Art, Mind, & Brain* (1982).

Since individuals who create visual compositions of high quality generally tend also to produce verbal compositions of high quality, further investigations of transfer between visual and verbal cognition are in order. The visual-verbal connection suggests to educators that visual art in school curricula deserves attention, not only as culturally important, but as a discipline which nurtures the intellect.

1.5. Limitations of the Study

This study is exploratory in nature and seeks to support the basic thesis that compositional skill is general and not tied to particular media of expression. It is not an experiment and does not attempt to establish causality. This study struggles neither with issues of mental process, nor with the transfer of learning. It seeks only to show a consistency, across the visual-verbal boundary, in the quality of individuals' compositions. The study is weakened by the fact that the variables, measuring instruments, and analysis schemes --all designed by the researcher-- have not been used by others. It is hoped that the results are convincing enough to encourage more study of generalized composition. Although beyond the scope of this exploratory study, the ideas and procedures developed here could be used in experiments for more generalizable results.

1.6. Definition of Terms

Action:
The visual equivalent of a verb. Action commands change the (Logo) Turtle's position or orientation.

Attribute:
The visual equivalent of a adjective. Attribute commands change the texture or size of the shapes drawn by the Turtle.

Composition:
In this study the meaning of composition is specific and restricted. Composition (verb) is the construction of coherent structures out of parts. A composition (noun) is a complex expression in either visual or linguistic media. Verbal compositions might be words composed of letters, sentences composed of words, paragraphs composed of sentences, or

even libraries composed of books. Visual compositions might be drawings of windows composed of panes, walls composed of windows and doors, houses composed of walls and rooves, or villages composed of houses. The nested nature of composition implies that a level or set of levels must be selected by the artist. In the first part of this study, verbal composition will be investigated at the sentence level, i.e. words will be considered the vocabulary from which sentences are composed. Drawn letters of the alphabet are the visual compositions which will be studied. CAD tools; curves, segmented lines, and a set of shadings form the visual vocabulary from which these letters are composed. In the second part of this study, composition is investigated in the context of more formal systems with limited vocabularies and specific rules of grammar. Programmed compositions will be evaluated in terms of their content and their form. Content is taken to consist of the quality and quantity of vocabulary selected for the composition whereas form is to be found in the relationships between parts.

Creativity:

In this study creativity necessarily has a restricted meaning. Creativity here refers to the ability to construct compositions. A high level of creativity is implied by a high quality composition. Quality of composition is evaluated in terms of measurable features. The more potent aspects of creativity like a juxtaposition of alien elements in new relationships, a shift of metaphor into a new domain, or a discovery of new contexts are not be considered here.

Grammar:

Grammar is a component of both visual and linguistic expression. It is the underlying logic of a language and it is expressible as a rule system.

Lexicon:

In contrast to a visual vocabulary, a lexicon is a collection of nouns, verbs, and adjectives which may be used in linguistic expressions.

List Processing:

List processing is a scheme for handling information in which the basic data structure is the list. The elements of a list are words or other lists. Information is processed by moving it in and out of lists. For example, the first word in a list may be retrieved by the Logo command FIRST (The LISP equivalent is CAR).

The FIRST of the list [REAL HOT STUFF] is REAL.

Logo:
Logo is a computer language, based on the language LISP, and developed with children in mind. It has three characteristics which make it a suitable language for this study. It was created for use in education and it is quite friendly, it has list processing capability, and it has a good graphics package.

Microworld:
A microworld is a limited learning environment. The two microworlds used in this study are realized in computer software. Both these microworlds invite exploration and are ultimately used as creative media.

Notation:
A notation is a discrete set of symbols which allows the representation of a work as a score. Each character in a notation can have only one meaning. This makes possible multiple true copies of a score and multiple true performances of a work. A good notation can serve as a "tool of thought" and thus be a flexible medium of expression.

Score:
A score is a composition expressed in the symbols of a notation. The compositions which are objects of this study are generated by sequences of computer commands. These lists are scores, rules for building sentences or drawing instructions for the "turtle". A score is notation acting on vocabulary.

Shape:
A shape is the visual equivalent of a noun. Shape commands instruct the Turtle to draw one of the basic shapes in the visual vocabulary.

Symbol System:
A symbol symbol consists of a set of symbols called the vocabulary and the rules relating them called the grammar.

Turtle:
The Turtle is an abstract creature which moves around the screen at the command of a Logo programmer.

Turtle Graphics:
This is undoubtedly the most well known and widely used feature of Logo. It is a geometry based on local referencing. Distances and angles are both measured with respect to the current position of the "Turtle".

Verbal Language:
To differentiate it from visual language, verbal will be used to denote language in the usual sense.

Visual Language:
In this study, a visual language is taken to be a system for expression consisting of a set of visual elements (its vocabulary) and a grammar for combining them. Pictures, built from the vocabulary and constructed by the rules of the grammar, are the "sentences" of a visual language

Visual Vocabulary :
A visual vocabulary, analogous to "vocal" vocabulary, is a collection of shapes, actions, and attributes which are available for use in visual compositions.

Work:
A work is a completed composition. A work may be visual or linguistic. The computer-compositions, which are the subjects of this study, are works which have been expressed as scores.

CHAPTER 2
THEORETICAL BACKGROUND

2.1. Introduction

The building of sentences and the composition of pictures are generally treated as very different arts. A case in point is the emphasis, in American education, on verbal activities for the training of the mind. The perception of a deep verbal-visual dichotomy has been strengthened by a popularized image of mind which splits brain function into "Left Brain" and "Right Brain". Basically, it identifies the left brain with language and logic, the right brain with art and emotion. A careful look at the research indicates that this view is not only simplistic, it can be misleading as well. The integrating role of the corpus collosum, and the importance of the right hemisphere for semantics must be appreciated. If visual and verbal processes are highly integrated, the implication for educators is substantial. In spite of the popular adage that "a picture is worth a thousand words", the visual arts are assumed to be less important for intellectual development. The rationality in visual art is being overlooked and its importance for cognitive development is underestimated. The verbal-visual dichotomy is drawn too sharply.

It is the goal of this study to show that verbal and visual expression may be understood as having a common basis. Structuralism sets the philosophical stage for this research. It has provided a common paradigm for disciplines as diverse as anthropology, mathematics and linguistics. In structuralist thought, universality of the human use of symbol systems is a recurring theme. A symbol system consists of basic "atomic" elements, often called its vocabulary, and a set of rules, or a grammar, which governs the combination of these elemental parts. Of particular interest in this study is the fact that Chomsky's work with generative grammars in linguistic composition has been applied by visual artists to visual compositions. The development of competence in the use of and creation of symbol systems is a crucial, if not primary, goal of education. Symbol systems such as Algebra or Latin, traditional parts of school curricula, are too large to be considered here. Smaller systems called microworlds will serve this study. Microworlds are symbol systems designed to serve as small environments for human learning. Microworlds, as envisioned by Paper (1980), are well-defined frameworks for learning. This research about learning uses computer microworlds for the exploration of mental processes. Since computer microworlds can put visual and verbal composition on common ground, they are particularly well-suited for this study.

2.2. Philosophical Foundation

The dichotomy of empiricism and rationalism is ancient and persistent. It is based on a split of attitudes concerning the acquisition of knowledge. The empiricists say that

knowledge is acquired primarily through sense perceptions of the world and that truth is basically relative. Rationalists emphasize the role of inherent genetic capacities of the mind and basic a priori truth. The difference extends to the beliefs about human potential for control of self and world. Psychologists who view the course of human development to be deterministic, in the sense of stimulus response mechanisms, are given the empiricist label. Those who believe that the human mind has structures which put it in control of its own processes are called rationalist. The disagreement is still essentially the controversy of free-will vs. determinism, which has been a theological debate for centuries. Empiricism, having had recent popularity, is now challenged by a renaissance of rationalism. Behaviorist psychology, typified by the work of Skinner, has been challenged by the ideas of structural linguists such as Chomsky. The focus of this chapter is on contributions of these opposing schools of thought to the clarification of epistemological issues.

Allan Paivio is an empiricist who is of particular interest here, in that he has developed a theory which includes both verbal and visual mental representations. He summarizes his "dual coding" theory as follows:

> According to dual coding theory, meaning consists of the relations between external stimuli and the verbal and nonverbal representational activity they initiate in the individual. Three levels or types of relations are assumed: *representational*, referring to the relation between familiar linguistic or non linguistic units and the corresponding verbal or non-verbal representations that the stimuli activate; *referential*, referring to the relations between verbal and nonverbal representations corresponding to the conventional relation between non-linguistic events (objects, properties, action) and their names; and *associative*, the relation among different verbal representations on the one hand and among different nonverbal representations on the other. No other entities such as abstract conceptual representations are assumed. Concepts are defined entirely in terms of the representational units and relations specified by the theory. Control processes are assumed in the theory but these, too, are defined in terms of the same classes of representations and relations. Referential activity, as in naming an object or imaging to a name, is a probabilistic reaction influenced by the verbal and nonverbal context, including such highly constraining events as verbal instructions to name an image; and similarly for associative activity. (Paivio, 1986 p. 214)

The current tendency among empiricists, stimulated by growing understanding of brain hemispheric asymmetry, (Springer and Deutch, 1985) is to assume some approximation to Paivio's hypothesis of dual coding. A dichotomy of brain function has developed: one component is taken to be essentially sequential and the other synchronous. These functions are generally identified as operating in the left and right hemisphere respectively.

The left hemisphere is believed to usually support language and to deal with the discursive aspects of thought, while the primary function of the right side is to handle visual imagery.

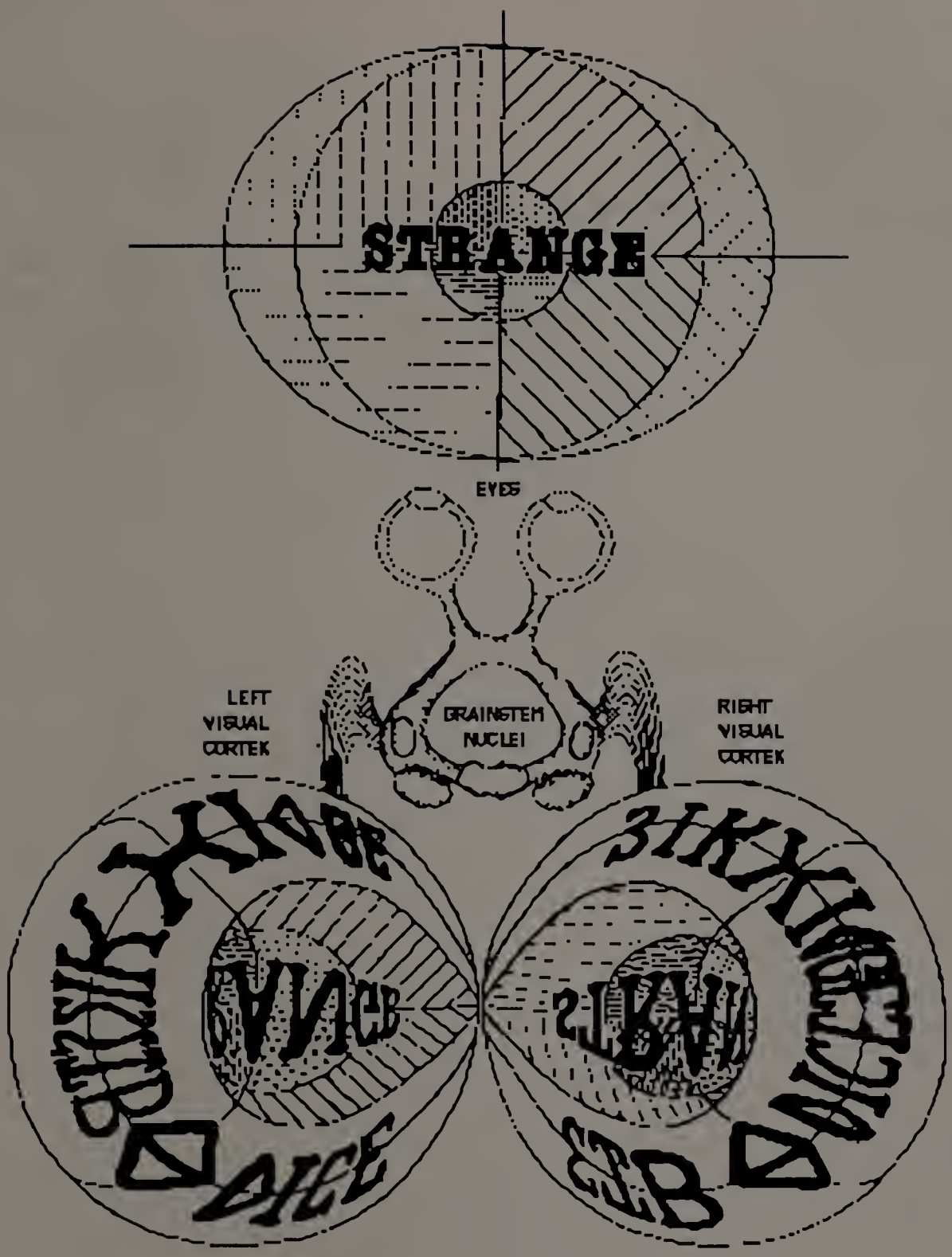
The relative cognitive importance of these two modes is debated. Kaufmann, for example, thinks that Paivio "... has pressed the case for imagery too hard at the expense of language". Kaufmann believes that imagery is secondary.

> In our theory imagery is regarded as an ancillary symbolic function within linguistic representation. From this basic theoretical premise it follows explicitly that imagery has the potential of providing an additional amount of processing, thus increasing the general level of operativity. Taking the semantic nature of imagery into consideration, it also seems reasonable to claim that imagery as a symbolic instrument is particularly well suited for the execution of the kind of flexible transformational activity that is needed in tasks possessing a high degree of novelty. (Kaufmann, 1980, p. 45)

Duality of mind is clearly an over simplification and undoubtedly inadequate. The case is being made, by Fodor (1983) and others, for mental modularities with more than two components. Paivio recognizes an auditory component. The existence of somatic maps in the brain has been well established, as has retinotropic mapping. Figure 2.1 is an illustration of a retinotroptic map from Cook (1986, p. 38). Although association of brain function type with either left or right hemisphere is a compelling simplification, it is clear that more than dichotomy is necessary to model thought.

In contrast to the empiricist's dependency on "experimental" data and the development of reasonable fits, the rationalists are committed to the creation of logical models. They prefer schemes which are based on sets of propositions and logically developed into formal systems.

The rationalist approach is likely to be computational, with computer modeling a current preference. The work of Noam Chomsky has been pivotal in rationalism's swing back to credibility. Interesting for this study, relating the visual and verbal, is the fact that his work in generative grammars for language has inspired the use of a generative grammar approach in the study of pictorial representation. One rationale for studying generative grammars is the assumption of innate brain structures with the potential for producing sentences and pictures. In reference to generative grammars, it is important to mention the term "Generative Aesthetics", a computer-based approach to art and aesthetics espoused in Germany during the early sixties by an interdisciplinary mix of scientists who were prescient in perceiving the enormous potential of the computer and computer graphics for art and the creative process, and for research in the linguistic and syntactic aspect of visual art.



Retinotropic Map
Figure 2.1

Robert Mallary, discussing the genesis of Serial-Robotic art, credits the husband-wife team of Colette and Jeff Bangert with having been "... perhaps the first to apply the serial-robotic in the U.S.A...", but suggests that absolute priority should go to German pioneers in Generative Art (Mallary, 1990). Colette Bangert writes about the random and repetitive aspects of her drawing in relation to the capacity of computers for randomness and repetition.

> The subject of all my work has been landscape. The elements of both the computer work and my hand work are often repetitive, like leaves, trees, and other natural landscape elements are. There is sameness and similarity, yet everything is changing. Landscape yields both texture and form. The pictorial form is usually all-over, with nonessential properties of landscape. A field has no center, and is not really flat, so I use no flat areas. The form of grass as grass, leaves as leaves, is what I'm exploring. Landscape form is itself the subject. Line as form. Grass as form. Grass is also random and random is a ntural computer facility. Computer grass is natural grass. (Leavitt, 1976, p. 19)

Short commentaries and samples of the work of other early contributors to Serial-Robotic Art -Robert Mallary, Herbert Franke, Mandred Moher and Vera Molnar- are contained in Ruth Leavitt's (1976) book "Artist and Computer"

The picture in figure 2.2 was made by a robot[1]. Infinitely many different pictures of this type may be made by this robot. The rules for making them are simple and the picture reflects that simplicity. Most of the aesthetic control has been given to a random number generator, an audacious attempt to "humanize" the machine. There are many ways to improve the quality of a robot's work. If robot art is to please humans, "improvements" must involve the study of human preferences. Aesthetic principles built into robots must be reflections of aesthetic principles in a human mind.

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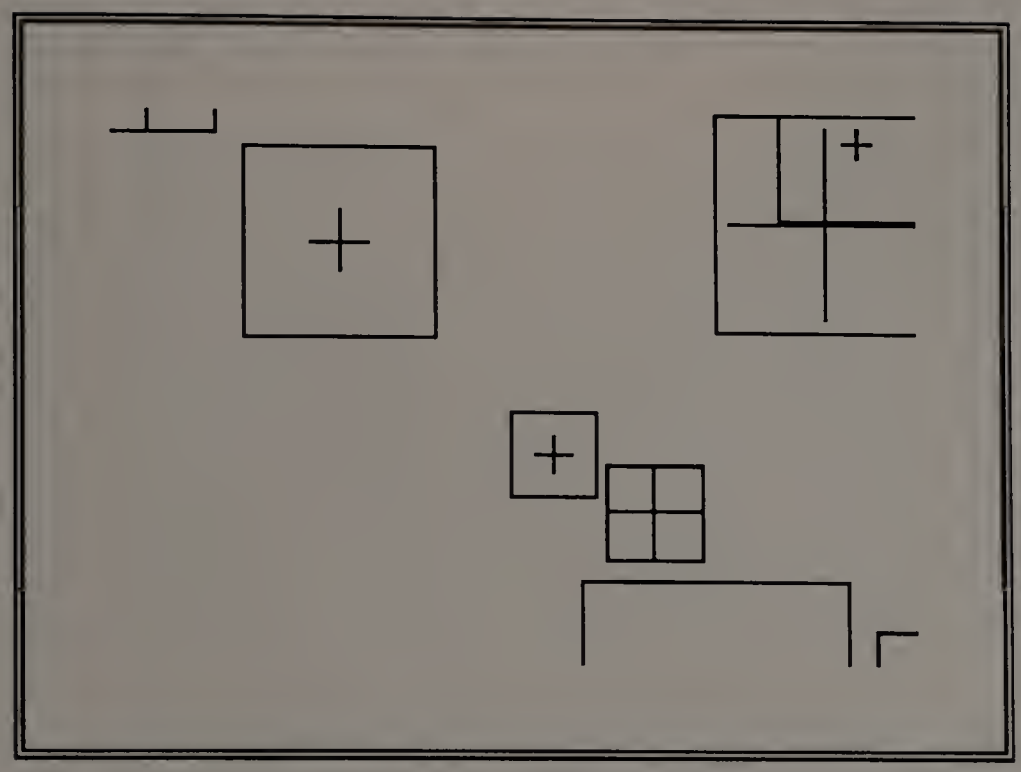
1. This robot is based on a programming assignment in Mallary's *Computer Graphics Workshop* at the University of Massachusetts



Robot-Art by CROSS
Figure 2.2

Harold Cohen has developed a very sophisticated robot artist called AARON. AARON does not draw pictures from a score. If it did, it would not in any sense create the art, but merely perform it. AARON consists of rules for image making. Dietrich uses the metaphor of human education to describe the development of this robot art generator.

> "AARON has gone through two distinctly different phases of drawing lessons. In the first period, AARON was taught the basic structure images and image making. In other worlds, AARON has learned image making strategies that comprise issues such as simple repetitions, the figure-ground problem, closure and various other related techniques. It also can find out where it currently is drawing, and locate empty space on the picture plane. All of the techniques have been analyzed by Cohen, formalized into rules and are now embodied within the program".
> (Dietrich, 1987, p. 323)

Recent versions of AARON incorporate a world-knowledge which helps produce more naturalistic pictures. Cohen has programmed AARON to draw according to a set of aesthetic principles which he believes to be artistically significant. Cohen's computational modeling rests squarely in the rationalist tradition.

Detail from a Composition by ARRON

Figure 2.3

Empiricism, which takes as grist the artifacts of human behavior, and rationalism, which searches for the grail of innate abilities, have been at opposite ends of the philosophical spectrum in their quest for understanding. This polarization has supported a belief that the fundamental human condition has but two alternatives, free will or determinism. So severe is this dichotomy that the battle has raged for centuries. Seeking a middle ground, which accepts the best of both philosophies, the *structuralists* have emerged.

Scholars in many different fields have found it useful to approach their study in terms of systems. Systems of rules which structure bodies of knowledge have become the primary objects of study. Levi-Strauss, studying primitive cultures, has focused on classification techniques used by the cultures under study. He considers the tendency to create structures, with which to relate objects at hand, to be an innate human inclination.

> Challenging the accepted wisdom that the primitive mind operated differently from the civilized mind, Lévi-Strauss accrued a mass of beguiling evidence to indicate that the principal feature of all minds in to classify and that primitives classify along much the same lines as do members of more advanced cultures. He described the classifying practices of primitive groups as a "science of the concrete". In a famous analogy, he compared the mind of the savage with the practices of a handyman, or *bricoleur:* in both cases, instead of starting with a preordained theory from which one makes deductions (in the manner of a trained engineer), the individuals work inventively with what is at hand (or in the ready accesses of their minds) in order to solve problems that happen to arise. Individuals devise concepts and comparisons not because they satisfy basic biological urges (not because they are good to 'eat with,' as a functionalist might argue) but rather because they satisfy cognitive constraints (they are good to 'think with'). (Gardner, 1982, p. 34)

Linguists have found it helpful to study languages as rule systems. The approach of linguists has shifted from the study of historical development to studies of concurrent (synchronic) relationships in language. The early work of the structural linguists focused on taxonomies of language. To this background work with the synchronic aspects of language, Noam Chomsky added a new level. He sought to formalize rules and create a generative device which could model language production.

> Chomsky started with the structuralist assumption that a language is (just) a set of structurally described sentences that happen to occur in a single speech community at a particular time. The structuralist insists that he, as a good behaviorist, studies what people do (what series of noises they actually make, a corpus), not what they think they are doing; further, distinguishing linguistics from behavioral psychology proper, the structuralist insists on just considering noise, not the generating source of the noise. But, given that a human language has an infinite number of sentences, and, hence, that enumeration and analysis of a corpus can neither amount to description of a language nor be related to such a description by straight-forward probabilities, Chomsky concluded that neither a corpus nor its language can be described except through the general, explicit, and formal specification of a generative device that meets goals of observational, descriptive, and explanatory adequacy. (Leiber, 1975 p. 65)

Seeing the importance of structures and systems in a broad spectrum of inquiry, Piaget felt that structuralism deserved consideration as a general principle. He summarizes:

> As a first approximation, we may say that structure is a system of transformations. Inasmuch as it is a system and not a mere collection of elements and their properties, these transformations involve laws: the structure is preserved or enriched by the interplay of its transformation laws, which never yield results external to the system nor employ elements that are external to it. In short, the notion of structure is comprised of three key ideas: the idea of *wholeness*, the idea of *transformation*, and the idea of *self-regulation.* (Piaget, 1970, p. 5) [my emphasis]

The relationships between the parts are the essence of a structure. The relationship between the elements of a structure define its form and must be comprehensive enough to make the structure cohesive. Piaget uses the set of integers and the rules governing their relationships as an example. "...the integers do not exist in isolation from one another, nor were they discovered one by one in some accidental sequence and then, finally united into a whole". (Piaget, 1970, p. 7) There are certainly integers that have not been seen, even though they are provided for in the structure.

What are the origins of wholes? Are they created complete, or made by adding blocks? Piaget suggests a third alternative.

> Over and beyond the schemes of the atomist association on the one hand and emergent totalities of the other, there is, however, a third, that of operational structuralism. It adopts from the start a relational perspective, according to which it is neither the elements nor a whole that come about in a manner one know not how, but the relations among elements that count. In other words, the logical procedures or natural processes by which the whole is formed are primary, not the whole, which is consequent on the system's laws of composition, or the elements.
> (Piaget, 1970, p. 56)

Piaget argues that not only do the rules of a system endow it with structure, but that they must also assure its wholeness and must themselves structure the system.

> If the character of structured wholes depends on their laws of composition, these laws must of their very nature be *structuring*: it is the constant duality, or bipolarity, of always being simultaneously *structuring* and *structured* that accounts for the success of the notion of law or rule employed by structuralists.
> (Piaget, 1970, p. 10)

Not only must a structure be a whole and contain a comprehensive set of rules which relate the elements which comprise it, it must also be self-regulating. Its boundaries must be stable, and it must not generate unruly elements. Structures are identifiable by their property of wholeness, their transformational character, and their self-regulation. The words *wholeness*, *transformation*, and *self-regulation* strongly suggest a connection between structuralism and General Systems Theory[2] (the science of systems) and with Cybernetics through its close association with General Systems Theory -- both of which are thoroughly holistic and inter-relational in their approach to the study of systems, including linguistic systems.

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2. See for example, von Bertalaffy. L. (1950) The Theory of Open Systems in Physics and Biology. *Science*, 3 23-29

"*Achilles:* Oh, I feel so rotten, I was REALLY HOPING to wish for a hundred wishes ...

Genie: Gee, I hate to see anybody so disappointed as that. And be sides, meta-wishes are my favorite kind of wish. Let me just see it there isn't anything I can do about this. This'll just take one moment--

(The Genie removes from the wispy fold of his robe an object which looks just like the copper Lamp he had put away, except that this one is made of silver; and where the previous one had 'L' etched on it, this one has 'ML' in smaller letters, so as to cover the same area.)

Achilles: And what is that?

Genie: This is my Meta-Lamp...

(He rubs the Meta-Lamp, and a huge puff of smoke appears. In the billows of smoke, they can all make out a ghostly form towering above them.

Meta-Genie: I am the Meta-Genie. You summoned me, O Genie. What is your wish?

*Genie:*I have a special wish to make of you, O Djinn, and of GOD. I wish permission for a temporary suspension of all type-restrictions on wishes, for the duration of one Typeless Wish. Could you please grant this wish for me?

Meta-Genie: I'll have to sent it through Channels, of course. One half a moment please.

(And, twice as quickly as the Genie did, this Meta-Genies removes from the wispy folds of her robe an object which looks just like the silver Meta-Lamp, except that it is made of gold; and where the previous one had 'ML' etched on it, the one has'MML' in smaller letters, so as to cover the same area.)

Achilles (his voice an octave higher than before): And what is that?..."

Meta-wish Dialogue
Figure 2.4

Douglas Hofstadter (1979) deals with many concepts related to structuralism in his book *Godel, Esher, and Bach.* In a chapter demonstrating nested "realities" he portrays a dialogue between Achilles and a genie (Hofstadter, 1979 p.111). An example of classic recursion, it is an adaptation of the age old hope for three wishes which might even expand to more. Achilles has just come to possess a magic lamp, and its genie offers him the traditional three wishes. A fragment of this dialogue is presented in figure 2.4. After the wish ascends the hierarchy of meta-genies, and the grant descends back down to the genie, Achilles' wish is granted. This whimsical tale is told, in part, to illustrate a principle formally demonstrated by Kurt Godel in 1931.

A consistent formal system cannot not be complete unto itself. A consistent system must contain statements which are undecidable within that system but may be demonstrated to be true by a higher (meta) system. Mathematics is not complete without metamathematics which is in turn not complete.

> Godel showed that *Principia* [Russell & Whitehead], or any other system within which arithmetic can be developed, is *essentially incomplete.* In other words, given *any* consistent set of arithmetical axioms, there are true arithmetical statements that cannot be derived from the set. (Negel and Newman, 1958 p. 103)

Any deductive structure like arithmetic will be incomplete and depend on a higher structure to decide some of its truths. This does not mean that a system cannot be whole. Systems must be incomplete only in that they themselves cannot prove all their own theorems. The wholeness of a system implies that its rules, which provide the relationships between the objects of the system, must <u>all</u> be present.

Jean Piaget saw, in children's development, the construction of mental structures. Looking at other areas of inquiry, Piaget saw that frameworks for knowledge were receiving considerable attention in many disciplines. Structural anthropology proposed that cultures rise from the human inclination to create structure. Field theory in physics gave the task, of realizing measureables, to systems of mathematical operators, and Gestalt psychology claimed that the mind is irreducible and must be understood as a whole. Structural linguistics led Chomsky to suggest that language might be modeled by a rule system which could generate the sentences of the language. At perhaps the the most fundamental level, mathematics was shaken by the work of Kurt Godel who showed that a formal system must contain relationships whose truth is undecidable within that particular system, but may be provable in the next higher system. Piaget saw structuring as something natural, usually commencing informally, but sometimes becoming formalized:

> ... from the structuralist perspective the logician's formal systems are wanting in at least two respects. In the first place, they are fabricated *ad hoc*, and, whether this be openly acknowledged or not, what structuralism is really after is to discover

> 'natural' structures - some using this somewhat vague and often denigrated word to refer to an ultimate rootedness in human nature, others, on the contrary, to indicate a non-human absolute to which we must accommodate ourselves instead of the reverse. But there is a more serious problem; a logical system, though a closed whole with respect to the theorems it demonstrates, is nevertheless only a relative whole; it remains 'open' with respect to those formulae which, though recognized as true when one goes 'up' to its metatheory, are nevertheless indemonstrable so long as one stays 'in' the system; and, since the primitive conceptions and axioms have all sorts of implicit elements, the system is 'open' at the 'bottom' as well. (Piaget, 1970 p. 270)

Piaget tried, justifiably and with substantial success, to keep one foot in the abstract formalism of logic and mathematics and the other on the ground of observable human behavior. This recognition of the need for a working combination of empiricism and rationalism may be seen as a major contribution of Piaget.

2.3. Symbol Systems

A symbol is an object which points to, or stands in for, another object. It can point to something concrete, an attribute, a relation, or an idea. The use of symbol is fundamental for abstract thought, and the growth of intelligence might be typified by the development of ability to navigate symbol systems. Howard Gardner believes that symbol systems are at the root of thought.

> To my mind, there is a crucial leap that a structuralist study of the mind must take. The leap involves a recognition that the basic unit of human thought is the symbol, and that the basic entities with which human operate in a meaningful context are symbol systems.... For me, intelligence is exemplified by the ability to cope with unknown worlds. To enter unexplored worlds, to learn the lexicon of symbols and the rules relating them, to function within this system, and ultimately to build new worlds. New worlds may be built from the stuff of a learned world or by the translation of elements of one world into another. (Gardner, 1982, p. 40)

Nelson Goodman's study of the types and functions of symbol systems led him to claim a very fundamental role for symbol systems in general. Two symbol systems of primary concern in this paper, and no less with Goodman, are art and discourse. He goes so far as to assert that art and discourse create reality.

> To a complaint that his portrait of Gertrude Stein did not look like her, Picasso is said to have answered, 'No matter; it will.'
> In sum, effective representation and description require invention. They are creative, They inform each other; and they form, relate, and distinguish objects.
> That nature imitates art is too timid a dictum. Nature is a product of art and discourse. (Goodman, 1976 p. 33)

Sentences may be seen as expressions constructed within symbol systems. A sentence may also serve as a symbol and, related to other sentences, may itself be part of a symbol system. Style derives in part from the inclusion of the same symbols in instances of a particular style. The phrases of a sentence may individually be symbols, related in a system by their location in the form of the sentence. Each phrase may consist of words, forming yet another subsystem. A sentence has associated with it a taxonomy which classifies the symbols from which it is constructed. The smallest parts of a sentence are taken here to be words. Words are the terminal (atomic) symbols in sentences. These terminal symbols, Goodman would call them characters, form the surface of sentences.

Pictures may also be seen as expressions constructed within symbol systems. A picture may serve as a symbol and, related to other pictures, may be part of a symbol system. Visual style derives in part from the inclusion of the same symbols in instances of a particular fashion. The figures of a picture may individually be symbols, related in a system by their position in the ground of the picture. Each figure may consist of parts, forming yet other subsystems. A picture has associated with it a taxonomy which structures the symbols from which it is constructed.

The smallest parts of a picture are the terminal (atomic) symbols in that picture. These terminal symbols form the surface structure of the picture. It would seem that the partitioning of pictorial symbols into sub-symbols could go on indefinitely. The attributes of the terminal symbols (characters) seem to scale with arbitrary fineness. Further, the positioning of figures in space seems completely adjustable. On the basis of these considerations, Goodman categorizes pictures as belonging to the set of syntactically dense schemes. This decision comes, no doubt, from experience with drawings and oil paintings. These media give one the impression of infinite control over picture syntax. Computer media, however, give a somewhat different impression.

The use of computers, for the generation of pictures, provides a new perspective. Experience with the limitations of memory size and screen resolution remind the computer artist that reality forces a syntactic limit on the detail of a picture. The size of the parts which can be depicted has a physical limit. Some might argue that this is merely an artifact of the digital computer, and that in different media the problem does not exist. Ned Block, in describing the attitude of pictorialist thinkers in general says that "... if the pictorialist view is right, the the human brain deploys representations (and processes operating over them) of a sort not found in digital computers (whose representations are paradigms of descriptional representations)". (Block, 1981, p. 4)

Symbol systems for picture making may indeed be chosen which come close to syntactic density, but must fall short. Limitations of the digital computer provide clues that pictorial symbols must be syntactically articulate (distinct). There are other clues. At the sensory level, the eye has a resolution limit. This limit is not imposed only by the fact that sensors in the retina itself are discrete, but also by the fact that finite size of the iris enforces resolution limit due to diffraction. The entrance pupil of any optical instrument limits its resolution. The resolution of double stars with a telescope is a classic example of this phenomenon. The image of a single star is not a point of light, but the smear of a diffraction pattern. Larger telescopes give smaller diffraction smears, making the images of two nearby stars more distinct. The largest of telescopes leave unresolved detail. There are limits to pictorial representability and in actual instances pictorial symbols must be discrete.

2.4. Notation

Goodman defines a set of criteria for the most formal of symbol systems which he calls *notations*. A notational system consists of a set of characters (vocabulary) and rules (grammar) relating the characters. The meaning of each character must be unique and all representations of a character must have the same meaning.

> What, first, constitutes a notational scheme? Any symbol scheme consists of characters, usually with modes of combining them to form others. Characters are certain classes of utterances or inscriptions or marks. (I shall use 'inscription' to include utterances, and 'mark' to include inscriptions; an inscription is any mark -visual, auditory, etc. - that belongs to a character.) Now the essential feature of a character in a notation is that its members may be freely exchanged for one another without any syntactical effect; or more literally, since actual marks are seldom moved about and exchanged, that all inscriptions of a given character be syntactically equivalent. In other words, being instances of one character in a notation must constitute a sufficient condition for marks being 'true copies' or replicas of each other, or being spelled the same way. And a true copy of a true copy of ... a true copy of an inscription x must always be a true copy of x. For if the relation of being a true copy is not thus transitive, that basic purpose of a notation is defeated. Requisite separation among characters -and hence among scores- will be lost unless identity is preserved in any chain of true copies. (Goodman, 1976, p. 131)

Goodman points out that notational systems are ideals, and most symbol systems violate at least one of the requirements for notationality. The English language, for example, contains ambiguous symbols; thus it fails to meet all Goodman's criteria for being a notation. Goodman summarizes the properties of notational systems.

> In sum, the properties required of notational system are unambiguity and syntactic and semantic disjointness and differentiation, These are in no sense merely recommended for a good and useful notation but are features that distinguish notational systems -good or bad- from non-notational systems. All derive from the primary purpose a score must serve and all are categorically required for any even theoretically workable notational system. A system is notational, then, if and only if all objects complying with inscriptions of a given character belong to the same compliance class and we can, theoretically, determine that each mark belongs to, and each object complies with inscriptions of, at most one particular character. [emphasis is mine]
>
> The five conditions are mutually independent in the usual logical sense that satisfaction or violation of one or more of them does not imply satisfaction or violation of any of the others. And although the conditions were designed to define notational systems, other important types of symbol systems are distinguished by violation of certain combinations of these conditions". (Goodman, 1976, p. 156)

A central point here is that each character in a notation is an atomic symbol which must have only one meaning. This implies a system of discrete symbols in which a score may be written which uniquely names what it represents. A score represents a work, and makes possible multiple true copies of the score and multiple true performances of the work. Goodman uses musical notation as the definitive example.

The work of Iverson provides an example of a "good" notation. Having developed a mathematical notation in the context of computer implementation (APL) he suggests that "... a good notation should embody characteristics familiar to any user of mathematical notation:

- Ease of expressing constructs arising in problems.
- Suggestivity.
- Ability to subordinate detail.
- Economy.
- Amenability to formal proofs". (Iverson, 1980 p. 445)

The identification of these qualities of a "good" notation expands the usefulness of the Goodman's definition. More than an instrument for writing scores which allow for the production of multiple true performances, a good notation becomes a "tool of thought". Iverson quotes Whitehead: "By relieving the brain of all unnecessary work, a good notation sets it free to concentrate on more advanced problems, and in effect increases the mental power of the race." (Iverson, 1980 p. 444)

Although they are symbol systems, neither language nor art fit all Goodman's required criteria to be notations. He considers representational (pictorial) systems to be dense symbol systems and thus not syntactically differentiated.

Descriptive (linguistic) systems are not dense and thus meet the requirements of syntactic differentiation; however they violate semantic differentiation. The overlap of meaning of words prevents language from being semantically differentiated. Notational subsets of language and art may be developed. Language and art may be modeled and constrained to fit into the limited resources of a computer system, in such a way that the symbol systems which represent these subsets of "language" and "art" may be considered notational. The scores which are the works produced within computer implementations of these notations do allow multiple true copies and multiple true performances. Furthermore, these notations function as tools of thought since they become the media in which compositions are created.

2.5. Grammars

In his seminal book *Syntactic Structures,* Chomsky demonstrated the capacity of formal grammar for modeling the syntax of natural language. He showed that finite-state grammars are inadequate for the task, that phrase-structure grammars can create the bracketing used by structural linguists, and that the addition of transformational rules enable the joining, deleting, and reordering of kernel strings produced by phrase-structure rules. Finally, to convert the terminal strings of the language into the sounds of speech, a set of morphophonemic rules was necessary to complete his scheme. Leiber summarizes Chomsky's early work.

> In summary, the grammar sketched in *Syntactic Structures* consists of three sorts of rules, which operate in sequence in generating the sentences of English and in providing them with phonological realizations in speech.
>
> 1. Phrase-structure rules which rewrite single, nonterminal symbols into, eventually, terminal symbols or words, in this manner creating a tree diagram or phrase-structure bracketing.
>
> 2. Transformational rules, which operate upon the phrase-structures produced by (1), deleting, reshuffling, and joining portions of such structures. Singular transformations, whose input is single phrase-structure (kernel) strings, are either obligatory or optional, optional transformations including passive, negative, and question transformations. Generalized transformations, which are always optional, join two or more kernel strings. As opposed to the phrase- structure rules, transformations are ordered, in that some must be applied after others -the passive transformation, for example, must apply *before* the transformation that makes the verb plural or singular, and so on, because it is the noun that is put into subject position by the passive transformation that determines the form of the verb.
>
> 3. Morphophonemic rules, which convert the output of (2), the sentences of the language form a syntactical viewpoint, into the actual sounds of speech. (These rules, of which no account has been given here, are similar to the phrase-structure rules. But they allow the rewriting of *more* than one symbol, and they are "context-sensitive" in that they may indicate that a symbol is to be rewritten in a

particular way *only* if certain symbols precede or follow that symbol. For example, the purely syntactical rules (1) and (2) will generate strings such as *take* + *past-tense;* the rule that will convert that segment into the sounds that we write as "took" is a morphophonemic rule). (Leiber, 1975, p. 107)

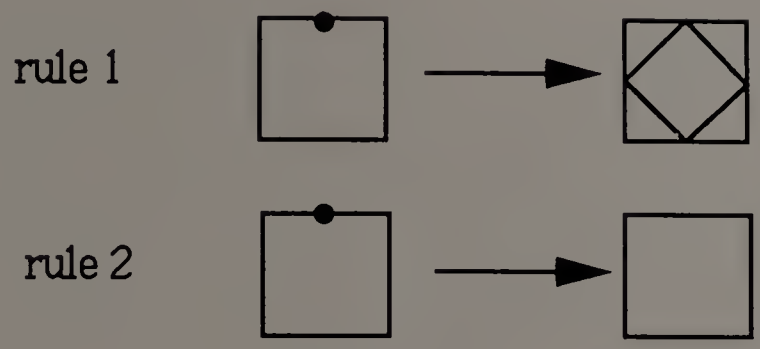
In *Syntactic Structures* Chomsky deals with syntax and leaves semantics for later work. His book *Aspects of the Theory of Syntax*, for example, begins to deal with the issue of the semantic component of language.

Although only a hint of Chomsky's thought is presented here, it should be clear that he is interested in understanding mental processes, and that he expected to find universally similar structures in human language which could serve as a basis for constructing cognitive models. His focus on innate ability and his assumption that this ability can be modeled added new life to a slumbering rationalism. Quoting again from Lieber;

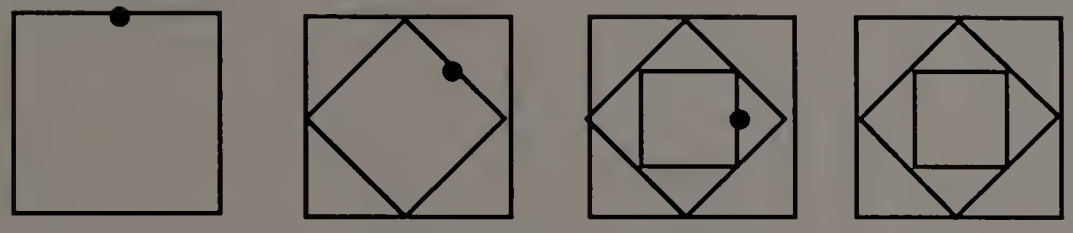
> ...It should be obvious by now that Chomsky's rationalism -his revival of the notion of universal grammar and innate ideas- and his claim that psychology has to make use of mentalistic concepts-can be thought of as a natural outgrowth of his linguistic work. To maintain that human beings have built into them language acquisition devices of considerable complexity is to maintain something like a modern version of the doctrine of innate ideas. The notion that the generative devices that are the grammars of the thousands of human languages may happen to have a very considerable number of common properties is *something* like the notion of universal grammar maintained by seventeenth-century rationalists.
>
> The mentalistic claim that it is, at least for the immediate future, inevitable and profitable for linguists and psychologists to study the software that is the mind, rather than confining themselves to observed physical behavior and dim hopes about brain physiology, is a claim that grants provisional support to the traditional rationalist views about the importance and independence of the mind.
> (Leiber, 1975, p. 68)

The work of Chomsky made an impression on scholars in many fields other than linguistics. It became apparent that other systems of denotation might be viewed as languages and that generative grammars could be created to generate the "sentences" of these non-linguistic symbol systems. We consider most of the objects in our worlds to be composite. Humans do search for atoms. Usually the objects we find are not truly atomic, but indeed have structure. Generally we pick a set of objects, at an arbitrary level, and define them to be the atoms of a system in which we can build composites. Taking words to be the atoms of natural language is arbitrary, but useful. The work of Chomsky which has been described above, takes words to be atomic and sentences to be the products of the language. Sentences are constructed; built of words by a generative grammar. Picture making can be viewed in a similar way.

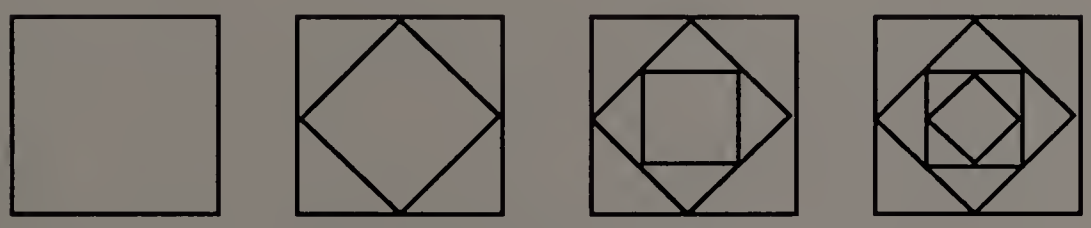
A) Vocabulary



B) Rules



C) Production of a Sentence



D) Sample Sentences

Shape Grammar
Figure 2.5

The art of picture making may be seen as having shapes as its atoms and pictures as its sentences. Pictures can be constructed from a vocabulary of shapes by the rules of a generative grammar. Generative grammars may have arbitrary complexity. Certainly grammars of great complexity are required to model the artistry of human artists.

A more formal shape grammar was outlined by Stiney (1980). Stiney's shape grammar is similar to the Chomskian phrase-structure model for language. A shape language has a lexicon (perhaps "visicon" would be a more appropriate word) of atomic shapes. There are nonterminal shapes which serve roles similar to labels for parts-of-speech (like Noun Phrase). Nonterminal shapes are labeled. The labeling is verb-like in that it establishes relationships (spatial positioning) between the terminal shapes. The terminal shapes are analogous to words in that they are the elements which appear in the final picture. Stiny uses nesting squares as an example of a simple shape grammar. Figure 2.5 is an adaptation of his example (Stiney, 1980, p.350). Vocabulary and grammar are shown along with some sentences of the language. Although Stiny's demonstrative example does not look much like what we think of as art, shape grammars can be arbitrarily complex and approach artistry.

The comparison of generative grammars for constructing pictures and composing sentences shows strong similarities in two areas of human activity which are often assumed to be very different and perhaps unreconcilable. Work on generative grammars, begun by Chomsky, typifies an approach to the study of the human mind which might be called *Contemporary Rationalism*. A contemporary rationalist view, that the innate structure of the human mind is in large part responsible for language, has transformed the way we think about learning, and teaching language. Work on visual grammars forces a fresh look at art and its relation to mental structure, learning, and teaching.

2.6. Mental Structure

The fact that the human brain has two distinct and nearly symmetrical halves, has stimulated much conjecture about brain function.

> "Over four centuries ago, the great French philosopher René Descartes concluded that the pineal gland, at the base of the brain, is the seat of consciousness. He based his conclusion on his belief in the unity of consciousness and on the pineal gland's being the only brain part he could find that was not double in structure. (Springer and Deutch, 1985, p. 254)

By the nineteenth century observations of brain injured patients were indicating that brain symmetry was not complete.

By the 1960's it had become popular to assign particular mental processes to either the left or right cerebral hemisphere. Springer and Deutch (1985, p. 237) have compiled a list, represented below in figure 2.6, of dichotomies which others have assigned to brain function.

Convergent	**Divergent**
Intellectual	**Sensuous**
Deductive	**Imaginative**
Rational	**Metaphoric**
Vertical	**Horizontal**
Discrete	**Continuous**
Realistic	**Impulsive**
Directed	**Free**
Differential	**Existential**
Sequential	**Multiple**
Historical	**Timeless**
Analytic	**Holistic**
Explicit	**Tacit**
Objective	**Subjective**
Successive	**Simultaneous**

Hemispheric Function
Figure 2.6

Findings from research with split-brained patients and hemispheric investigations with normal subjects have led psychologists and educators to review traditional ideas about personality and learning style. With the growth of experimental evidence, some researchers came to believe that the left brain was specialized not so much for language, but for a specific style of information processing. The left brain seems suited for mental tasks which involve sequential, temporal, or digital information. Some would say logical, or analytical tasks are best handled by the left brain. Robert Ornstein (1978) went so far as to link Western (rational) culture with left brain processes and Eastern (intuitive) culture with the right brain.

Paivio's characterization more is typical. He identifies two principal processing strategies which he names, perhaps too restrictively, verbal and non-verbal:

> ... the hypothesis being that the verbal system is specialized for sequential processing whereas the nonverbal system is specialized for synchronous or parallel processing of multiple representational units. The verbal system generates sequential structures and the nonverbal system generates synchronous (including spatial) structures, with the paradigm cases being their manifestation in speech and compound visual images respectively. These structures are defined by their functional properties (sequential constraints on processing, simultaneous availability of information, etc.).... . The processing mechanisms themselves are internalized derivations of the perceptual-motor activity involved in listening and speaking on the one hand, and observing and reacting to nonverbal perceptual information on the other. Thus, both processes include a motor component appropriate for generating the kinds of organized structures that characterizes verbal and nonverbal representations. (Paivio, 1986 p. 71)

The sequential processing generally attributed to the left hemisphere seems to dominate our (Western) culture. We emphasize "logical" thought in the training of our children and we even base the design of our mechanical brains on this model. The standard computer configuration has long been the von Neumann design which consists of memory and a single processor. Only recently has computer architecture begun to take advantage of a more "gestalt" approach.[1] Currently popular computer languages (Fortran, BASIC, and Pascal) have been built on a sequential model, one instruction following another, the second byte of data shifted after the first.

Although it has long been known that the left hemisphere plays a dominant role in language function, and is generally believed to have the major role in "rational" thought, impressions of the right hemisphere's function are less clear.

> ... let us pretend for the moment that we have in fact explained the major features of unilateral cerebral motor *dominance*. Still we are left with a difficult question: What is the right hemisphere doing while the left hemisphere is busy with the chores of linguistic communication? (Cook, 1986, P. 17)

Research with split-brain patients has given some indication of what the right brain may be doing while the left brain is talking. The dilemma of the split-brain patient is summarized by Springer & Deutch.

> When the word *teacup* is projected tachistoscopically on a screen, with *tea* presented to the left and *cup* to the right of a fixation point, a split-brained patient cannot read the whole word. Instead, the patient will say the word was *cup*, since the verbal left hemisphere saw what was to the right of the fixation (the right visual

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1. see for example: Hoffman, Paul (1988) *Archimedes' Revenge: The Joys and Perils of Mathematics*. New York: Fawcett Cress, 190-212

> field). The patient's left hand, under control of the mute right hemisphere, will point to the word *tea* in an array of worlds that includes *cup* and *teacup*. (1985, p. 264)

Jerre Levy and her colleagues (1976) have shown that when split-brain patients are given ambiguous instructions to match pictures, the left hemisphere matches by function and the right by appearance. This result indicates a "logical" left and a "visual" right hemisphere.

The visual-verbal split is compelling and has become highly popularized. However, as the study of mind continues, more sophisticated models emerge. Whereas rather low-level tasks, like simple word association, place language rather clearly in the left hemisphere, research with higher level language capabilities implicates the right hemisphere. The left hemisphere translates language literally and does not deal well with connotation and metaphor. The right hemisphere may stumble with language but find meaning anyway. Christine Chairello has investigated the roles of left and right hemispheres in lexical-semantic processing.

> Accessing knowledge about semantic relatedness, the linking of word meanings via association or semantic similarity, is an important aspect of language comprehension. If the hemispheres differ in how lexical-semantic relations are processed, this would also have consequences for "higher order" semantic operations which depend on the availability of this lexical knowledge. (Chiarello 1988, p. 59)

Chairello uses semantic priming to study processing differences in the hemispheres. In this technique a subject's task is to recognize a word after first being presented a priming word which is either related or unrelated semantically. The speed and accuracy of recognition are measures of processing quality. Her work, and that of others, indicates that semantic processing is different in left and right hemispheres.

> Thus, I am proposing that semantic processing in the LH [left hemisphere] operates in a *focal* manner with enhanced processing of relevant meanings, but suppression (inhibition) of meanings which, although related, are not currently relevant. In contrast, the RH processes semantic relation in a nonfocal manner with rather widespread facilitation of related meanings, but without selectivity. That is, within the set of meanings activated in the RH, one receives preferential processing at the expense of the others. (Chairello, 1988, p. 65)

This accessibility of semantic relations by the right hemisphere is in agreement with observations that patients with damage to the right hemisphere are likely to have difficulty with humor and metaphor. A review, by Hiram Brownell, of work bearing on the appreciation metaphor and connotation, indicates a general pattern of error in

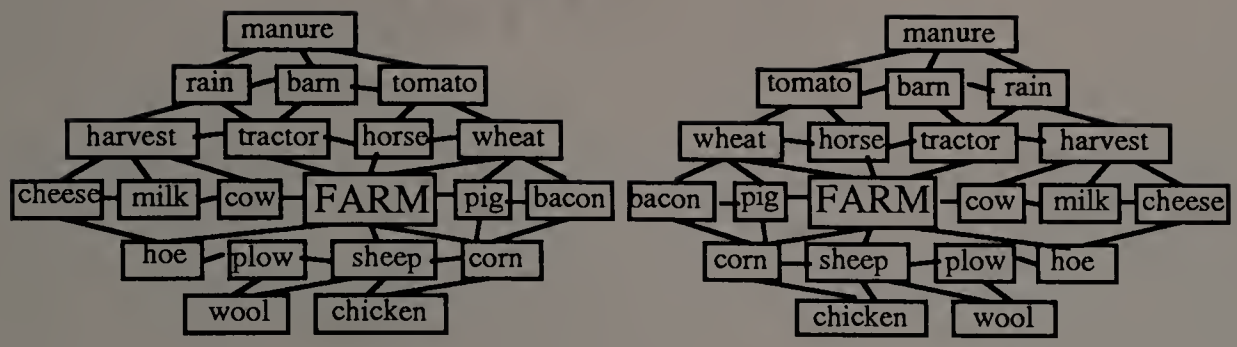
metaphoric response by patients with right-hemisphere-damage. He cites a study by Winner and Gardner (1977) in which brain damaged patients are asked-

> ...to understand familiar metaphors such as 'He has a heavy heart'. Subjects were read a phrase and then asked to select the corresponding picture from a set of four alternatives. The alternatives included (1) a depiction of the correct, metaphoric meaning, e.g., a man crying, (2) a literal foil, e.g., a man straining to carry an oversized heart, (3) a representation of the noun used in the metaphor, e.g., a picture of just such a heart, and (4) a representation of the adjective used in the metaphor, e.g., a picture of a lead weight. (Brownell, 1988, p. 23)

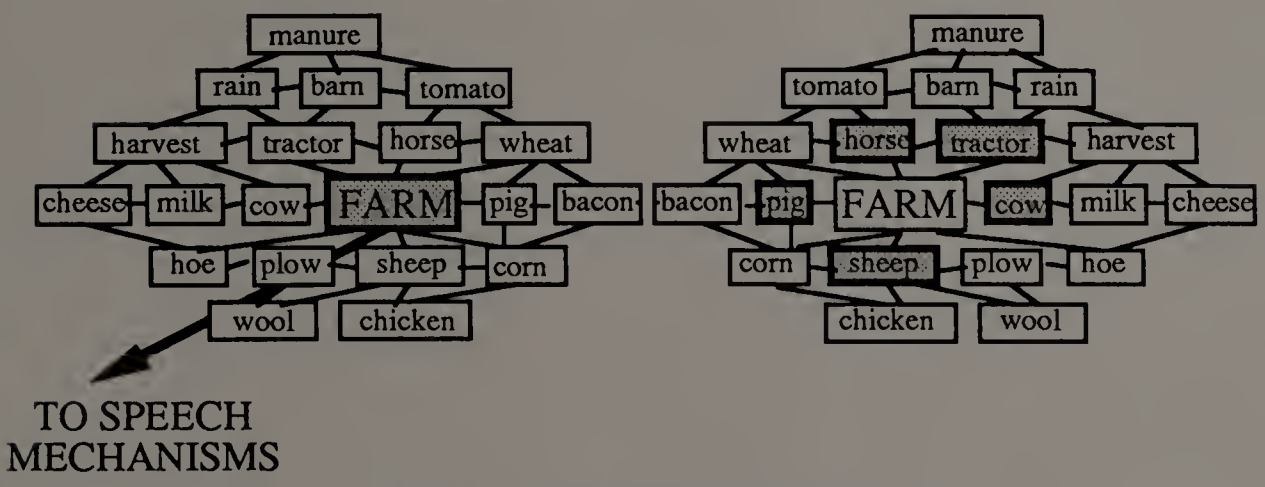
> Patients with left hemisphere damage performed quite normally with regard to metaphoric interpretation, whereas those with damage to the right hemisphere tended to chose the literal foil. In a more recent investigation Brownell et al. used word triplets derived from the set of eight adjectives (warm, cold, deep, shallow, loving, hateful, wise, and foolish) to study semantic processing. Subjects were asked to select the pair, from the triple, which were most related.
>
> The clustering solution for the RHD patients showed that as a group they focused on denotative relations.... In marked contrast the LHD patients' solution revealed a general grouping of words by shared connotation and a strong sensitivity to metaphoric equivalence beyond what could be attributed to connotative similarity alone. (Brownell, 1988, p. 27)

The inadequacy of the left hemisphere in dealing with relationships has also been noted by Norman Cook. It is often assumed that these problems are related to difficulty visualizing spatial relationships due to right hemisphere damage. Cook reports that Gianotto and colleagues, working with right-hemisphere-damaged patients, found that "...only a relatively small number of their wrong responses can be classified as purely visual.... " (Gainotti and Cicli, 1983, p .162). The variety of tasks for the right hemisphere seems to include, not only processing visual and spatial information, but finding linguistic meaning which extends beyond literal translation.

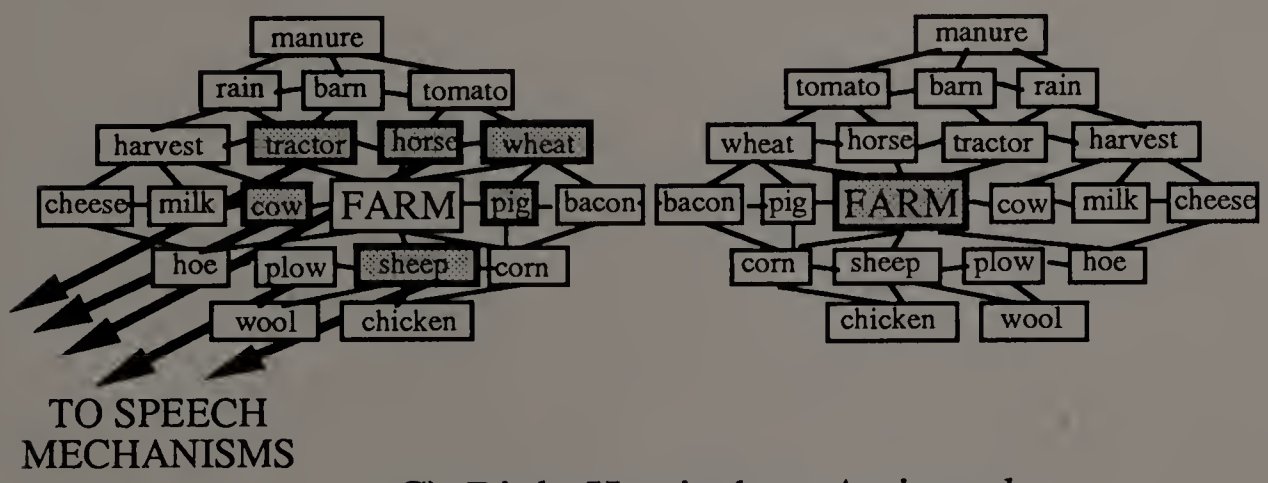
Cook suggests that knowledge is stored bilaterally in complementary mirror image neural networks. He makes a case for the inhibitory transfer of information between brain hemispheres by the corpus callosum. His model splits literal and contextual knowledge, one being provided by each hemisphere. He illustrates how bilaterally similar semantic networks might function with a possible agricultural semantic network (Cook, 1986, p. 122). Figure 2.7 is an adaptation of Cook's illustration. In this example, B demonstrates the effect when FARM is presented to the left hemisphere. The word is sent directly to speech mechanisms in the same hemisphere. FARM is suppressed in the right hemisphere and semantically related words are activated.



A) Complementary Mirror Image Neural Networks



B) Left Hemisphere Activated



C) Right Hemisphere Activated

Suppressed Farm

Figure 2.7

When FARM is presented to the right hemisphere, an inhibitory transfer to the left hemisphere activates semantically related words and produces a verbal response in which a related word is substituted for the correct word (FARM). This phenomenon, *semantic paralexia*, has been observed by researchers in a number of different situations (Farah, 1985). Regard and Landis (1984), presenting words to left or right visual hemisphere for very brief times, found the right hemisphere showed a significantly higher tendency substitute related words. Coltheart (1983) found that deep dyslexics show a tendency to misread words by substituting words which are semantically related.

The Dual Coding model of Paivio and Cook's case for complementary networks differ in approach and detail, but share the important principle that the visual and verbal are not isolated. Minsky, who views the mind as modular, nonetheless sees the left-right dichotomy as "half-brained".

> Our culture soon became entranced by this revival of an old idea in modern guise: that our minds are meeting grounds for pairs of antiprinciples. One one side stands the Logical, across from Analogical. The left-side brain is Rational; the right side is Emotional. No wonder so many seized upon this pseudoscientific scheme: it gave new life to nearly every dead idea of how to cleave the mental world into two halves as nicely as a peach. (Minsky, 1985, p. 116)

Perhaps more attention should be paid to connections and cooperation. The evolution of the "collos-bulbar ratio" in animal brains provides compelling physiological evidence of the importance of cerebral cooperation (Cook, 1986, p. 8). This ratio is the ratio of the cross sectional area of the corpus collosum, which connects the cerebral hemispheres, to the total cross sectional area of nerve fibers ascending and descending the brainstem. This ratio might be taken as in indication of relative intelligence; man having an index of 3.12, the chimpanzee 1.79, and the dolphin an index of 0.93. The visual-verbal dichotomy is not a simple left-right hemisphere split. It does not suggest a polarization of the mind, but must be understood in terms of mental integration.

CHAPTER 3
RELATED RESEARCH AND DEVELOPMENT

3.1. Introduction

Computers are being used many different ways in the study of mind. Much of this research can be categorized as either work on artificial intelligence or the study of natural intelligence. The two differ greatly in both approach and notoriety. Artificial intelligence is a very large and active field of research which has led to schemes for simulating a number of mental processes; information retrieval in expert systems, learning in neural net models, pattern recognition in machine vision, and even natural language translation and the generation of poetry. These are interesting but outside the scope of this investigation.

Educators are drawn, not so much to artificial intelligence and the modeling of human attributes with robots, but to natural intelligence and the building of worlds in which other minds can create and grow. In his book *Mindstorms* Seymour Papert introduced the concept of computer microworld. He uses "microworld" to refer to self-contained worlds each with its own limited set of assumptions and constraints. He contends that such worlds are helpful for learning because they are environments in which exploration can take place without the distraction of extraneous questions. In making a case for the power of a computer microworld which has come to be called "Turtle Graphics", he invokes the name of Isaac Newton.

> Newton 'understood' the universe by reducing the whole planets to points that move according to a fixed set of laws of motion. Is this grasping the essence of the real world or hiding it complexities? Part of what it means to be able to think like a scientist is to have an intuitive understanding of these epistemological issues and I believe that working with Turtles can give children and opportunity to get to know them.
>
> It is in fact easy for children to understand how the Turtle defines a self-contained world in which certain questions are relevant and others are not. ... Children get to know what it is like to explore the properties of a chosen microworld undisturbed by extraneous questions. In doing so they learn to transfer habits of exploration from their personal lives to the formal domain of scientific theory construction. (Papert, 1980, p. 117)

The microworld, then, is essentially a symbol system.. A microworld should be a symbol system which meets Goodman's criteria for being notational. The properties of a notational system assure predictability, reproducibility, and support understandability. If

a system is notational, scores may be written. A scores defines a work and allows repeated true performances. Another attribute of a score is that it may be easily changed in either structure or content. This makes the score an important educational device - a framework for experimentation, record keeping, and criticism. A finished score is a product which gives closure to creation.

Ideas can sprout, grow, be pruned, and blossom in a well constructed symbol system. *A microworld is notational symbol system which has been designed as a learning environment*. Recently many learning environments have been developed which are computer driven. Two classes of computer microworlds will be considered here, discursive worlds and pictorial worlds.

3.2. Verbal Microworlds

As knowledge accumulates, it eventually reaches a size where some reduction is necessary. An unwieldy collection of information is not very useful for problem solving. One approach to the reduction of data is to split a large body of information into components and deal with each component separately. Redundant or unnecessary atoms in the symbol system may be identified and thrown out, and the set of relationships between the atoms can be simplified. Information may be collapsed by assembling parts and labeling the assemblages. This information should be retrievable by expansion of the labels. A well constructed microworld exhibits all these properties. Attention is restricted to one small area of knowledge, the symbol system is clean and sparse, and information may be buried in labels.

Herbert Crovitz (1970) explores creativity in an interesting small book, *Galton's Walk*. He discusses several environments for creative thought and problem solving, the most notable being Ogden's Basic English. Ogden invented an abbreviated form of English which has a vocabulary of 850 simple words.

> Given the problem of specifying 'cognitive moves' ... the vocabulary of Basic English forces simplicity on their statement. Given a set of 'cognitive moves', however stated at the start, a translation of them into Basic English must have the effect of making them more comparable, one with another, as they are stuffed into a smaller universe. Particular works are necessarily transformed into more generally applicable ones. For after all is said and done, Basic [English] does say everything that can be said and done. (Corvitz, 1970, p. 305)

Having simplified the lexicon (the set of atoms of the symbol system) Ogden then described a system which would impose a set of simple relationships upon these atoms.

> Let us, then, consider the forms of sentences. It is here that Ogden chose a maneuver in the style of Ramon Lull, describing the "word wheel", naming it the "panopticon" - "because all the necessary units are seen together." The word wheel in the specific simple form described by Ogden consists of seven circles of increasing diameter piled on top of each other in order of decreasing diameter. In the smallest inner top circle are the words "will", "would", "may" and "might"; in the second ring are some verbs ("put", "take", "get", "give", "keep", "let", "have", "make", "come", "go"); in the third are 12 adjectives like "simple", and "some"; in the fourth are 20 nouns, like "sand" and "thing"; in the fifth are 20 directions, like "on" and "across"; in the sixth are 21 nouns, like "farm" and "edge"; in the seventh are 10 adverbs and connectives, like "here" and "but". By agreeing to put "a" or "the" where needed and starting the sentence with the word "I", one can get may mechanically produced sentences as one turns each of the wheels independently of each of the others. The sentences are grammatical. For example "I may take some sand across the edge here" and "I might keep a simple thing across the farm, but [recycling] I would have some sand on the edge here". (Corvitz, 1970, p. 98)

Ogden's Panopticon is an early example of an environment designed as an "aid" linguistic composition. The vocabulary is there, the rules are there, and the creative operator can generate sentences that are meaningful as well as grammatical. The Panopticon foreshadows not only the microworlds of Papert, but the grammars of Chomsky as well.

The digital computer is a microworld in which people may play, think, and solve problems. The binary lexicon is simple and well defined (1 & 0) as are the relationships between these atoms (1+0=1, for example). In practice this binary microworld has been used to build worlds of great complexity. The full power of the computer provides an environment too general and unrestrictive for the kind of investigations considered here. The size and complexity of symbol systems which may be built with a computer are arbitrary, however, and small microworlds with clarity and power have been created.

Inspired by the theories of Piaget, the example of Papert, and the availability of computers, many researchers and educators have developed computer microworlds for use with students. Since these environments represent untried systems, the focus of attention has generally been on the learning strategies of children.

Robert Lawler notes that writing seems to be learned more easily in languages which use syllabaries instead of alphabets (Lawler, 1987, p. 105). He cites Cherokee and Vi as examples. It is Lawler's supposition that children might learn to read more easily if they began by learning a set of monosyllabic words for reference.

Children could work out the sounds of other words by modifying and combining these monosyllabic "anchor" words.

> If it were possible to create a more nearly complete collection of anchors for the interpretation of monosyllabic worlds, we could change significantly the process of learning to read. We could make reading much more accessible to many more people in a relatively efficient and congenial fashion. (Lawler, 1987, p. 100)

As an aid for learning to read, and as a tool for research on learning, Lawler developed a microworld called BEACHES for his young daughter. It associated typed words with objects pictured on a computer screen. The typed words were labels for objects and their attributes.

> Using arbitrary symbol strings (which may be words) as the tools of her control, a child is able to make objects appear and to manipulate them in a virtual world that can be shaped to her own purposes. Even at the age of three to three and a half years (when she first began playing with the BEACH microworld), Peggy learned with reasonable facility and permanence to recognize roughly thirty words. She recognized them by sight on the screen and in other contexts. She could recreate them from memory and did so, typing them on the computer keyboard. In this specific sense, she was the master both as reader and writer of that small vocabulary of words. (Lawler, 1987, p. 101)

In his observation of Peggy working in the BEACHES microworld, Lawler's interest was in her facility with the words which labeled the pictures, not in her appreciation of visual relationships. It is computer graphics and the visual to which we now turn.

3.3. Visual Microworlds

There have, of course, been many computer simulations, developed with learning in mind, which depend heavily on visual presentation. Three notable categories are: adventure games and their variants, simulations of physical phenomena, and programs which mimic traditional drawing and painting. These all have importance for education, but are tangential to this discussion. Here the focus is on microworlds which intentionally expose their rules and invite exploration of these rule systems.

Perhaps "Turtle Graphics", implemented in the Logo language, is the visual computer microworld most widely used in the education of young children. It is also a powerful tool for the construction of more specialized microworlds. Seymour Papert, who has done much to popularize Logo and the concept of microworld, points out two levels at which microworlds can be created. They may be constructed by teachers as

specialized learning environments, or created by children for their own purposes. Papert suggests, for example, that Newton's laws of motion could be made accessible to children by creating a suitable microworld.

> We [may] recast the laws by which Turtles work in a form that parallels the Newtonian laws. This give us the following 'Turtle laws of motion'. Of course, in a world with only one Turtle, the third law, which deals with the interaction among particles, will not have an analog.
>
> 1. Every Turtle remains in its state of rest until compelled by a TURTLE COMMAND to change that state.
> 2. a. The input to the command FORWARD is equal to the Turtle's change in the POSITION part of its state.
>
> b. The input to the command RIGHT TURN is equal to the Turtle's change of the HEADING part of its state.
>
> What have we gained in our understanding of Newtonian physics by the exercise? How can students who know Turtle geometry (and thus can recognize its restatement in Turtle laws of motion) now look at Newton's laws? They are in a position to formulate in a qualitative and intuitive form the substance of Newton's first two laws by comparing them with something they already know. They know about states and state-change operators. In the Turtle world, there is a state-change operator for each of the two components of the state. The operator FORWARD changes the position. The operator TURN changes the heading, In physics, there is only one state-change operator, called force. (Papert, 1980, p. 118)

Papert goes on to suggest the construction of a sequence of microworlds culminating in microworlds of "dynaturtles" which simulate Newtonian mechanics or Einstein's special relativity. One of the strengths of Logo is that it is both an accessible learning environment for children and a powerful development tool for educators. Microworlds may be created by children who have been given Turtle graphics tools to "play" with.

> Deborah, a sixth grader who had problems with school learning, was introduced to the world of screen Turtles by being shown how the could obey the commands FORWARD, LEFT, and RIGHT. Many children find the fact that these commands can be assigned any number an exhilarating source of power and an exciting area of exploration. Deborah found it frightening, the reaction she had to most of what she did at school. In her first few hours of Turtle work she developed a disturbing degree of dependency on the instructor, constantly asking for reassurance before taking the smallest exploratory step. A turning point came when Deborah decided to restrict her Turtle commands, creating a microworld with the microworld of Turtle commands. She allowed herself only one turning command: RIGHT 30. To turn the Turtle through 90 degrees, she would repeat RIGHT 30 three times and would obtain the effect of LEFT 30 by repeating it eleven times. To an onlooker it might seem tedious to obtain simple effects in such complicated ways. But for Deborah it was exciting to be able to construct her own microworld and to discover how much she could do with its rigid constraints. She no longer asked permission to explore. And, one day, when the teacher offered to show her a "simpler way" to achieve an effect, she listened patiently and said, 'I don't think I'll do it that way.'

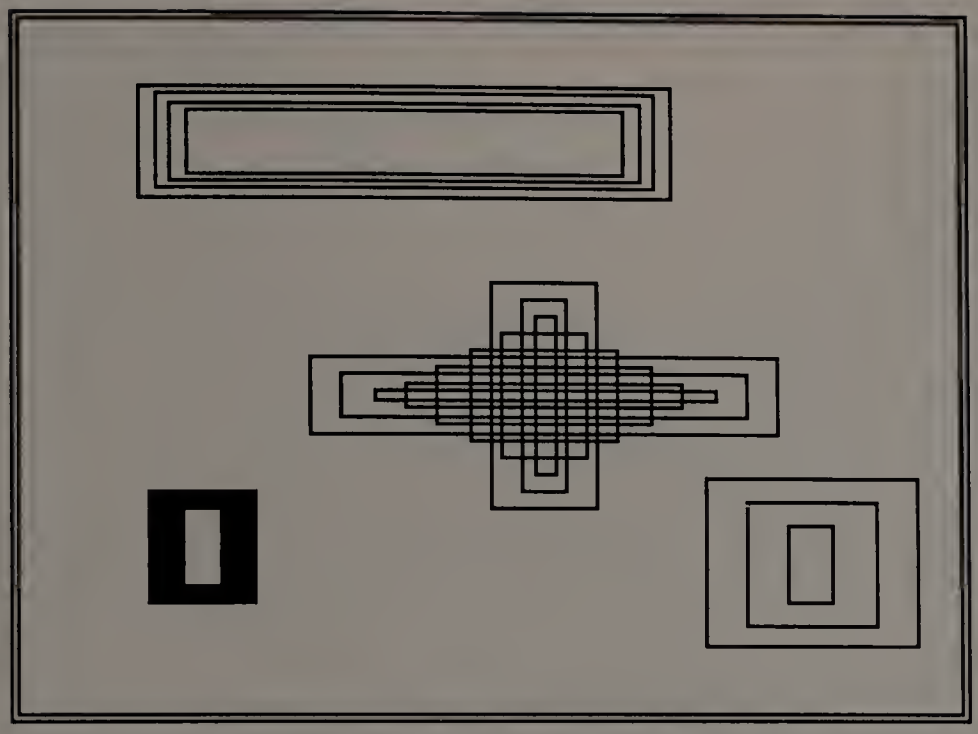
> She emerged when she was ready, several weeks later, with a new sense of confidence that showed itself not only in the more ambitious Turtle projects but in her relationship to everything else she did in school". (Papert, 1980, p. 118)

Papert's commentary gives us hope that the reassurance given in a restricted world can give may help children gain confidence that regularity may also be found in larger worlds. Teachers can use Logo to develop workspaces containing sets of special purpose procedures. A music teacher might write a set of Logo procedures which would allow children to compose songs by naming notes. Two such Logo workspaces have been created by the researcher as media for visual and verbal composition.

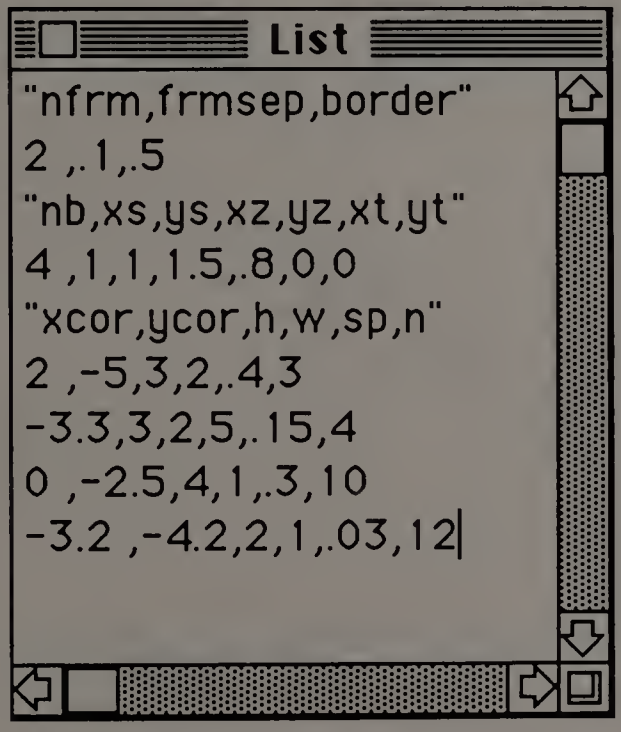
The usefulness of visual computer microworlds for teaching does not end with Logo and children. A set of microworlds called the *Artfile* (Mallary, 1986) is a notable contribution to art education at the university level. The Artfile is a collection of programs written by Robert Mallary for his Computer Graphics Workshop at the University of Massachusetts. The six basic programs of the Artfile represent an important pioneering effort and remain unique in that they emphasize aesthetic issues of composition. BOXES is the most elementary program in the series. It allows only the drawing of rectangles. The placement of the rectangles within the picture must be specified, as must their size and color. A drawn frame and an empty border must also be specified. Line thickness may be varied since each rectangle is actually a set of nested rectangles. BOXES is a microworld in which design issues such as balance, focus, and continuity may be explored. Other Artfile programs address the issues of 3-D space, line shape, point of view, use of repetition, and transformation. Mallary's Artfile programs comprise a set of statements about visual aesthetics. The microworlds he created are subsequently used for the creation of art by others.

3.4. Computer Microworlds and Scores

A work is produced with an Artfile program by creating a text file which becomes the picture specification. The Artfile program reads parameters from this file and generates a drawing of the specified picture. This text file is a score, in Goodman's sense, and from it a true performance of the work can always be produced. The expression of visual art as a score is quite revolutionary and seems to have gone unnoticed. It brings notation to visual art. Visual notation makes visual aesthetics more open to analysis and is a link with language.



Drawing



Score

Boxes
Figure 3.1

The restricted visual microworlds of the Artfile let students explore and teachers critique in the context of shared worlds which are uncluttered and rational. Visual and verbal computer microworlds are places in which to play, to experiment, and to grow. Both are symbol systems with vocabularies and rules of grammar. They are notational, so compositions created within them can be expressed as scores. The scores, in the case of computer microworlds, are programs or files which specify the work. A work created within the BOXES microworld is shown in figure 3.1 along with its score. Completed scores assure repeatable true performances of created works. Scores facilitate construction, rearrangement, and criticism. Scores which represent pictorial works demonstrate a rationality in drawing which has been generally unappreciated.

3.5. Aesthetic Merit

3.5.1. Symptoms of the Aesthetic

Nelson Goodman proposed "symptoms of the aesthetic" which may be used to separate the aesthetic from the nonaesthetic. They identify the brush stroke and the graph with the aesthetic and nonaesthetic respectively. Howard Gardner summarizes symptoms of the aesthetic suggested by Goodman.

> *Syntactic density,* where the finest differences may constitute a difference between symbols. An example would be a drawing in which the finest, most subtle differences between two lines may convey important distinctions.
>
> *Semantic density*, where the referents of symbols are distinguished by fine differences in certain respects [of meaning]. For example in ordinary English the meanings of words overlap one another in many subtle ways: it is impossible to say where "intentionally" or "deliberately" ends and "on purpose" begins.
>
> *Relative repleteness*, where comparatively many aspects of a symbol are significant. Here the difference between the stock-market graph and the Hokusai drawing becomes germane. If the symbol functions repletely, one needs to attend to an indefinitely large number of aspects. If it is functioning in a non-replete manner, only the numerical values count.
>
> *Exemplification*, where a symbol, whether or not it denotes, symbolizes by serving as a sample of properties that it literally possesses. In the musical example mentioned earlier, the tune literally exemplifies speed and metaphorically exemplifies gracefulness.

> *Multiple and complex reference*: Here the symbol performs several integrated and interacting referential functions, some direct and some mediated through other symbols. Rather than having a single unambiguous meaning which is readily accessible and which lends itself to paraphrase or translation, the symbol carries a penumbra of overlapping and difficult-to-separate meanings, each of which contributes to the work's effects". (Gardner, 1982, p. 59)

Goodman himself, in a quick stroke, points up the polarity. "Density, repleteness, and exemplificationality, then, are earmarks of the aesthetic; articulateness, attenuation, and denotationality, earmarks of the nonaesthetic". (Goodman, 1976, p. 254) These symptoms of the aesthetic do not relate to aesthetic value, they say nothing about excellence.

> The distinction here drawn between the aesthetic and the nonaesthetic is independent of all considerations of aesthetic value.... The symptoms of the aesthetic are not marks of merit; and a characterization of the aesthetic neither requires nor provides a definition of aesthetic excellence. (Goodman, 1976, p. 155)

3.5.2. Robot Aesthetics

Robot art is a small consideration here, but it has bearing on the categorization of works as aesthetic or nonaesthetic and the question of quality. Robot art is related to work produced by humans creating in computer microworlds. This is partly because both ultimately expressed by machine. Does robot art have aesthetic value? The work of robots (computers) is most often identified with the nonaesthetic symptoms of articulateness, attenuation, and denotationality. The output of computers may, nonetheless display aesthetic symptoms as well. Syntactic density is may be approached, although it is necessarily limited by finite resolution and memory. Semantic density, relating to the referents of the symbols, is supplied by human interpretation of the symbols not by the robot. Exemplification and multiple reference, while limited by resolution and memory, may be within of the robot's capability. Assuming a capability to produce aesthetic works, how is the quality of a robots output evaluated? A robot "artist" will contain some built in criteria for aesthetic quality, and the works of the robot are likely to be further judged by a human critic. The aesthetic capacity of the robot must derive from from the sensibilities its human creator. The evaluation of its output must also fall to human preference.

3.5.3. Human Learning and Aesthetic Value

Human artists are subject to many of the same restrictions as robot artists. They too are bound by their own human hardware, their personal history, and the preferences of their critics. These similarities make the study of robot art interesting to students of human learning, particularly learning in the context of computer microworlds. Microworlds may be thought of as media of expression. The works produced will be subject to evaluation by teacher or critic,and by the artist herself. The aesthetic quality of works produced cannot be legitimately ignored. Whatever the medium, and whatever the skill level of the creator, aesthetic quality is a fundamental issue for education. And what about standards? That "beauty is in the eye of the beholder" is not enough. (The eye of the beholder must have it own history and life of meaning, and a work must have links to the beholder's sensibilities.)

Educators hold considerable responsibility for the development of creators. Not only must they demonstrate the potential of media and teach technique, teachers should foster appreciation for aesthetics, and must ultimately stand in judgment of the works of their students. Accessing 'correctness' and judging merits of the nonaesthetic, like denotationality and articulateness, are generally accepted practices in education.

Aesthetic *value* is also cognitive in its character, and its assessment, though difficult, should not be neglected. The cognitive character of aesthetic value applies quite generally to human endeavor. It applies to art, music, and dance for example, as well as to language. Symbol systems, visual and verbal, serve cognitive purposes. They have importance for developing minds at many levels, from grasping syntax to creating work with aesthetic merit.

> Symbolization, then is to be judged fundamentally by how well it serves the cognitive purpose: by the delicacy of its discriminations and the aptness of its allusions; by the way it works in grasping, exploring, and informing the world; by how it analyses, sorts, orders, and organizes; by how it participates in the making, manipulation, retention, and transformation of knowledge. Considerations of simplicity and subtlety, power and precision, scope and selectivity, familiarity and freshness, are all relevant and often contend with one another; their weighting is relative to our interests, our information and our inquiry. (Gardner, 1982, p. 258)

If symbolization is to be judged, it is perhaps in order to present examples of the symbolizing of a mature artist. In that interest, a painting and a poem of Kandinsky are reproduced here.

3.5.4. The Art of Wassily Kandinsky

Kandinsky's mature art is crisp and rational. Figure 3.2 is a reproduction of a painting from 1923. His abstract paintings give the impression of symbol systems waiting to be decoded. Recurring objects may be seen in his work of a given period. These objects may be seen as symbols which held particular meaning for Kandinsky and can bear different meaning for each viewer. The clear organization of these primary symbols in his pictures suggests an underlying visual syntax. This impression of rational syntactical structure invites construction of a generating grammar for the production of synthetic Kandinsky drawings. One such generating grammar was devised by Ray Lauzzana and Lynn Pocock-Williams (1988). They developed a formal rule system describing a shape grammar. The components of such a grammar include terminal objects which will appear as graphic primitives in final drawings, non-terminals which provide a "deep structure" and order the terminals, and a rule system which provides for combining and transforming the nonterminals and terminal objects. A set of terminal objects was assembled by identifying atomic symbols from Kandinsky's Bauhaus paintings. A syntax was created as a rule system which derived from both Kandinsky's writings and his paintings. This rule system was implemented in LISP and generated drawing reminiscent of Kandisky's style. Such attempts to model visual creativity point to a potential rationality in art which is often ignored or discounted. The visual creativity of Kandinsky was not isolated. He wrote, not only concerning his ideas about art, but poetry as well. His poem *WATER*, printed in figure 3.3, shows the transfer of schema from the visual to the verbal realm.

Growth
Figure 3.2

In the yellow sand walked a little thin red man. He was always slipping.
It looked as if he walked upon an ice sheet. It was, however, yellow sand of the boundless plain.
From time to time he said: "Water... Blue water." And didn't understand himself why he said it.
A rider dressed in a green pleated coat rushed by on a yellow horse.

The green rider drew his big white bow, turned around in his saddle and shot the arrow
at the red man. The arrow whistled like a cry and wanted to force itself into the heart of the red man.
At the last moment, the red man grasped it with his hand and threw it to one side.
The green rider smiled, bent over the neck of the yellow horse and disappeared into the distance.
The red man grew larger and his step became surer. "Blue water," he said.

He walked on and the sand formed dunes and hard hills which were gray.
The farther he walked, the harder, grayer, higher the hills, until finally cliffs began.
And he had to force himself in between the cliffs until he could neither stand still nor go back.
You can't go back.

As he went by a very steep, pointed cliff, he noticed that the white man who was squatting up above
wants to drop a big gray block on him.
You couldn't go back. He had to go into the narrow passageway.
And he went.
Just as he got under the cliff, the man up above, with a gasping effort, gave the last shove.

And the block fell on the red man. He caught it on his left shoulder and tossed it behind him.
- The white man up above smiled and nodded to him in a friendly fashion. -
The red man grew even larger, i.e. taller. -- "Water, water," he said. --
The passageway between the cliffs grew wider and wider, until finally
the flatter dunes came again and they became flatter and flatter, until they weren't there at all.
- instead, nothing but a plain again.

Water
Figure 3.3

3.5.5. Conclusion

The presumed polarity of the aesthetic and the rational is an unfortunate fiction. Extremes of Empiricism and Rationalism must give way to a philosophy that can encompass both. Structuralism has provided a framework at the next higher level. Piaget's work suggests that knowledge is constructed and that each new level of understanding depends on schema already assimilated. Compositions are created within symbol systems which contain vocabularies related by syntactic rules. Description follows a pattern of elements related in a structure, whether visual figure and field, or verbal content and form. The process by which a description is constructed in a symbol system is quite important to the study of knowledge and learning. The human mind appears to have an innate ability to construct verbal sentences and visual picture. Noam Chomsky's proposal that a generating grammar might model the human capacity for language, spurred research in, not only linguistic grammars, but visual grammars as well. The applicability of generative grammar to many fields of inquiry supports the concept of general basis for human creativity. The source of creativity, long sought after, was apparently cornered in somewhere in the right hemisphere of the brain during the past decade. This focus was soon destroyed as the importance of hemispheric cooperation became evident. The brain hemispheres, though asymmetrical, are massively connected, and both are required for rational and metaphorical thought. Art does not reside on the Right unnoticed by language on the Left. Creativity is a fundamental human inclination. Whether a work is composed within a verbal or visual symbol system, it springs from the same source. Computer microworlds can provide focused environments in which the mind can practice the art of creativity. A well designed computer microworld is a notational symbol system in which scores can be written. Scores provide for multiple true performances of a work. More important here, is the fact that scores are vehicles for construction, revision, and criticism. The evaluation of aesthetic merit should not be overlooked in the education of a creator.

3.6. Relating the Visual and the Verbal

Text and picture have each been used to communicate, not only physical description, but abstract qualities like moral character as well. An article by Schwartz and Miller, which discusses pictorial vs. written representations of George Washington, points out that debate about the relative significance of description and depiction has deep roots.

> Most instructive for our purposes, however, is the great controversy in the early Church as to whether icons deserve a place alongside the scriptures as vehicles of God's Word. ...when St. John of Damascus declared, "As we listen with our bodily ears to physical words and understand spiritual things, so through corporeal vision we become spiritual", he meant that icon and scripture are two different ways of knowing one and the same truth. (Schwartz & Miller, 1986 p. 98)

The separate and complementary powers of text and picture are quite generally appreciated. Richard Jung paraphrases Kant (as applied to vision): "Visual input without abstractive labeling is blind and formal abstraction without visual images is empty" (Jung, 1973). Debate circulates about that which they hold in common. What holds meaning? Does it rest in form or in content? To study the role of semantics in learning, Moeser and Bregman (1972) devised simple grammars which generate "sentences" from nonsense syllables. The nonsense syllables are grouped into classes. For example, the class A words were GAV, DEP, FET, and KUS. The grammars are sets of replacement rules. Rules for the construction of sentences in the least complex language are shown below:

```
 S  -> AP + BP + (CP);
AP -> A + (D);
BP -> B+(CP);
CP -> C
```

In this grammar, S is a sentence and AP is a phrase containing a word from class A with an optional word from class D. BP is a phrase containing a word from class B with an optional phrase (CP) which contains only a word from class C.

Participants in the study found that identifying grammatical structure, populated with nonsense, is a difficult task. Although participants found learning pure syntax to be nearly impossible, they were able to find structure when the nonsense syllables were imbued with meaning.

> ...evidence indicates that when semantic referents are present in an artificial language a different learning strategy is employed from that used when semantic referents are not present. In the semantically empty condition, words are mapped

> directly onto sentence positions (position learning strategy); under the semantic reference condition, words are associated to relevant aspects of the reference field and the field is structured into a meaningful organization, and then this semantic information is used in the [word] mapping process.... The evidence also indicates that it is only when the elements in the [visual] reference field mirror the syntactic constraints of the language that complex grammatical relations are easily acquired. (Moeser and Bregman, 1972, p. 769)

Semantic reference was made by associating the syllables with a visual vocabularies of shapes, attributes, and spatial relationships. The study suggests that the use of spatial referents to give meaning to linguistic names makes the learning of structure possible. Moeser & Bregman's systems, in which each sentence of nonsense syllables is isomorphic with a visual composition, proved most "learnable." This work supports my contention that, in the linguistic cascade of nested meaning, our words ultimately refer to images.

Concerned that many students have difficulty with writing, Sheridan asks the question: "Can drawing be used be used to connect these students to writing as thinking?" Her Drawing/Writing curriculum integrates drawing and writing as descriptive tools.

> Drawing/Writing is a drawing process combined with a writing process. A set of drawing instructions move the student into an increasingly complete understanding of an object, and then allow the student to move away from that object in a variety of ways, using recombinant strategies and systems of comparison. Each drawing step is followed by writing. The writing reflects on the accuracy of the information expressed in the drawing. Using this integrative process, the student becomes competent as a realist, and as an abstractionist in connection with drawing. In connection with writing, the student becomes more descriptive and more reflective in connection with writing, increasingly comfortable with analytical and with inferential strategies of thought". (Sheridan, 1989, p. 92)

A study which uses this curriculum as "treatment" suggests that it is a powerful combination. "Young writers became both more fluent and more comprehensive in their observations and reflections when training in drawing [was] combined with analytical and reflective writing" (Sheridan, 1989, p. 172).

Whereas pencil drawing has been a favored mode of expression for children for generations, we are witnessing our first generation of children who make computer drawings. Teachers, seeing the enthusiasm children bring to computer programming, suspect that progressing skill in programming brings with it an increasing ability to create order in other systems as well. This might imply improved writing skills. Computer programs which generate drawings are of particular interest here.

A study by Kline indicates that writing and debugging Logo (Turtle Graphics) procedures improves students' ability to revise descriptive text. She found, in Logo, a medium linking drawing and writing.

> The LOGO program is based on a constructivist view, where knowledge is constructed by the child, and revision is an integral part of that construction. Text and graphics are interwoven in developing a desired intention. The intention is global and visualized in a gestalt. Perhaps revision practices in this model might sponsor revision practices in paper and pencil composing.... The underlying hypotheses [of this study] is that the revision strategies in LOGO, both engendered and supported by the building of graphic models, might be a stepping stone between highly contextual revision (drawing) and the more abstract revision required in writing words alone. (Kline, 1983, p. 9)

Students given experience in Logo showed significant increases in the percentage of text revision behaviors compared to the control group. In this work may be seen the germ of an idea that a computer drawing is, through its defining program (score), a language-like system.

The computer culture provides tools which can be used, not only to increase productivity, but also to study how we produce. Two essential products of the human mind throughout history have been pictures and text. Now the computer, because it puts them on common ground, puts us in a position to study the construction of pictures and paragraphs as similar mental activities. One of the frustrations of early users of personal computers was the inability to incorporate text and graphics in their documents. When that limitation was finally overcome, an enterprise quickly blossomed which came to be called "desk top publishing" (DTP). For teachers this has been a significant empowerment. Not only does it speed the preparation of teaching materials and improve their quality, DTP is itself a new classroom tool. Many of the mechanical problems of publishing recede when confronted with good tools. Desk top publishing software is such a tool, and it makes everybody an editor. Decisions about content and structure are, of course, more difficult problems. But confrontations of this nature represent the essence of education and are most appropriate for the classroom. Expressive documents which integrate pictures and text can provide information about how individuals deal with parallel aspects of the two media.

Common turf, at a more fundamental level, may be established in Logo. Logo is a computer language which was developed at MIT in the 70's under the guidance of Seymour Papert. It is a dialect of LISP designed with children in mind.

> Logo is a language for learning. That sentence, one of the slogans of the Logo movement, contains a subtle pun. The obvious meaning is that Logo is a language

> for learning programming; it is designed to make computer programming as easy as possible to understand. But Logo is also a language for learning in general. To put it somewhat grandly, Logo is a language for learning how to think. Its history is rooted strongly in computer-science research, especially in artificial intelligence. But it is also rooted in Jean Piaget's research into how children develop thinking skills. (Harvey, 1982, p. 163)

Logo has been used mainly in elementary schools where Turtle Graphics has been emphasized. Two limitations of the bare language emerged. Logo, a language of visual action, did not have a built-in visual vocabulary, nor did it provide for easy combination of pictures and text. LogoWriter (Logo Computer Systems Inc., 1988), an embellishment of Logo, provides both a vocabulary of shapes and a DTP style interface which does allow for the easy combination of text and graphics.

Although this language has gained a reputation as a tool for teaching children, Logo's basic list processing character inherited from LISP makes it particularly suited for linguistic study and Turtle Graphics gives it visual power far past kindergarten. Logo is a compelling tool which has attracted the attention of people other than the teachers of young children. Two books deserve mention. Logo is applied to linguistic structure in one and visual structure in the other. In the introduction to their book *Exploring Language with Logo* , Goldenberg and Furzeig invite the reader to:

> ...participate actively in the play and work of the linguist, exploring the structure, function, and history of language through projects, experiments, and examples of language in use. Some of the projects and experiments involve teaching a computer to produce language - words, phrases, sentences, and larger compositions. By modeling language in this way, you can try out and revise your own theories as you develop them, gaining insight into both the elegance and complexity of language. (Goldenberg & Feurzeig, 1987)

Clayson(1988), in his book *Visual Modeling with Logo*, quotes Einstein: "The physical entities which seem to serve as elements in thought are certain signs and more or less clear images which can be 'voluntarily' reproduced and combined ... this combinatory play seems to be the essential feature of productive thought. The above elements are, in my case, of the visual and some of the muscular type." Clayson's book sets forth several grammars for visual composition. Both books are written for adult readers and invite play with structure.

Computer languages like Logo may be seen as media which invite both visual and verbal composition. Composition and the relation between pictures and writing is a topic of interest to a wide audience. The connection is explored and exploited by philosophers, artists, psychologists, and teachers. Interested in finding meaningful roles for computers

in education, I became fascinated with the graphic designs which could be generated with Logo's Turtle Graphics. Finding that children under the age seven generally had difficulty using Turtle Graphics, I began creating workspaces to empower children by making Turtle Graphics more accessible. Primary, in the several problems young children face using plain Turtle Graphics, is the fact that it has no vocabulary of shapes with which to compose. Everything must be constructed. I found that, with the addition of a set of basic shapes to Turtle Graphics, children as young as four were able to compose pictures. Procedures which defined shapes, attributes, and actions were all named with single letters, so children could express their compositions as simple strings of letters. There it was; a one-to-one correspondence between writing and drawing, a score. In subsequent years I used similar techniques with adult learners. Pursuing an impression that compositional skill, whether descriptive or depictive, is likely to be based on common mental processes, I designed assignments for my students which would produce drawing/writing pairs. I have collected a body of student work which is the subject of the study described in chapter four.

CHAPTER 4
THE STUDY

4.1. Introduction

This study of compositional skill uses student work from an introductory computer course for Liberal Arts college students. This course has been used by the researcher, for several years, as a laboratory for exploring the connection between verbal and visual learning. The computer is a medium which can be used for both linguistic and graphic expression. Furthermore, the quantitative quality inherent in this medium lends itself to analysis. Course assignments, ostensibly to support learning about desktop publishing and computer programming, were developed to generate the compositions which constitute the basic data for the study. As part of their course work, students constructed both verbal and visual compositions. The minimalist nature of these student compositions makes them reasonable candidates for study. The study has two parts. One is an analysis of linked letter-text pairs in picture books created by students using standard microcomputer application software. The other is a case study of paragraphs, constructed within the constraints of a linguistic microworld, compared with pictures constructed in a visual microworld

4.2. Hypotheses

In the analysis of drawing and writing in alphabet books, four variable pairs have been recorded and analyzed for correlation. These variables are the measured use of structure, embellishment, abstraction level, and aesthetic quality in each drawn letter and its accompanying sentence. It is the conceptual hypothesis of this study that visual and linguistic compositional skill have a common mental basis. The specific hypotheses are of this study are:

a) that individuals' use of structure in visual composition has a positive correlation with their use of structure in verbal composition.

b) that individuals' use of embellishment in visual composition has a positive correlation with their use of embellishment in verbal composition.

c) that the level of individuals' use of abstraction in visual composition has a positive correlation with their use of abstraction in verbal composition.

d) that the aesthetic quality of individuals' visual compositions has a positive correlation with the aesthetic quality of their verbal compositions.

In the analysis of microworld compositions, students' use of resources for drawing has been compared with students' use of resources for constructing sentences. The composition pairs of individuals tend to show consistent levels of sophistication when compared to all the compositions in the study. Some participants show relatively little sophistication in either type of composition, while others show relatively much sophistication in both media. A pattern of relative sophistication across media suggests that compositional ability is a general mental attribute.

4.3. Methodology

This study has two components. In one component, picture books made by students are evaluated. Because desk-top-publishing involves text and graphics, it is a world in which an individual's skill with sentences and pictures may be studied. Each page of an alphabet book contains a drawn letter and a sentence, thus every book contains twenty-six drawing-text pairs. Thirty books were collected, forming a substantial base of information. Each letter and sentence was analyzed in terms of its structure, embellishment, level of abstraction, and general aesthetic quality. The correlation between features of drawing-text pairs has been measured for individual books and for the set of books. Positive correlations show that the level of compositional skill may be uniform, for an individual, over a diversity of media. The evaluation proceeded in the following way:

a) Student books were be collected

b) On each page of every book, the features of the drawn letter and the parallel features of its associated text were quantified.

c) The data for each book was reduced to provide numerical values for ten variables, five visual and five verbal. The ten variables are *Structure*, *Embellishment*, *Abstraction*, and *Gestalt*, in the visual media, along with corresponding variables in the verbal media.

d) Another pair of variables, *Total Drawing Merit* and *Total Text Merit* were formed by summing *Structure* and *Embellishment*.

e) A correlation analysis was done on five variable pairs.
f) To validate the quantitative variable of *Total Merit* it was correlated with the judgemental variable *Gestalt.*

The second part of the study examines student compositions which were constructed as written *scores*. These scores are expressed as computer programs. Computer programming may, at first glance, may seem unrelated to visual or verbal composition. The connection is, however, rather close and in this study computer programs and compositions are isomorphic. Each composition is embodied in a score which is a set of nested data structures. Languages such as APL, LISP, Forth, and Logo use nested definitions in a way which supports the idea of composition directly; complex objects are defined as assemblies of simpler objects.

Two Logo workspaces designed by the researcher are used as media for composition. The visual workspace, based on (Logo)Turtle Graphics, provides a visual vocabulary of shapes and attributes. The linguistic workspace, based on (Logo) list processing, provides a limited vocabulary of words and a simple grammar. A set of sentences is offered as stimulus for visual composition and a set of pictures offered as stimulus for the construction of paragraphs. Individuals create one composition in each medium, a drawing and a paragraph. Six of these composition pairs have been collected for this study. Relationships between these pairs are be discussed on a case study basis. The compositions have been evaluated by examining the quantity of resources used at each of five levels of sophistication. The evaluation of computer-compositions proceeded as follows:

a) Compositions were collected, one pair from each student.
b) The quantity and type of resources used in the construction of the score of each composition were measured at each of three levels.
c) Data describing each pair of scores are presented in graphical form.
d) Results are discussed individually and collectively.

4.4. Population Profile

Student work from the researcher's *Computers & Society* class at Springfield Technical Community College is the basis of this study. Participating students were adults who had completed at least English Composition I. This population was very diverse. Ages ranged from eighteen to fifty, and there was broad cultural diversity. Females outnumbered males by a slight margin. While individual

attributes such as SAT scores could have been collected for this study, no attempt was made to relate information external to the field data of the study. (The data consists of completed alphabet books and picture/paragraph pairs.)

4.5. Quantifying Alphabet Books Features

Alphabet Book Page Q
Figure 4.1

A set of thirty alphabet books made by students serve as the data for this study. Each page contains a drawn letter and a written sentence which is related to it. Figure 4.1 shows a typical page which consists of a drawn Q and text related to this letter. This sample page, including the awkward sentence, is presented as it was completed by the student. Measurable features; structure, embellishment, abstraction, and gestalt have been identified in both the drawing and the text. Drawn letters may be modified by adding "unnecessary" graphic features and the meaning of the structural nouns and verbs of the associated text may be enhanced with supportive language. The level of abstraction in the letter-keyword pairs is an attribute which may be judged, as is a general aesthetic gestalt. Features of each

graphical letter and the parallel features of its corresponding text are have been measured. Figure 4.2 shows how numbers have been assigned to reflect quality of work.

Because this quantification (of alphabet book features) generates a large amount of data, special data base software has been developed to ease collection and analysis. The data base contains ten colums of measurements, five for drawings and five for text. Two columns (D & T) are used to store the calculated variables.

The data names are listed below in figure 4.2. A data collection page for one book is shown in figure 4.3. Meaurements of drawn letter features are represented on the left and text features on the right. The variables to be studied have been gotten by a compression of this data. Four variable pairs have been defined, each with it unique summation scheme.

Each line constains measurements which are combined to form the variables which are analysed. Four variable pairs have been defined; Structure, Embellishment, Abstraction, and Gestalt.

The variables are defined in terms of the measurements as follows:

Drawing Structure = sl+fo+3d	Text Structure = vb+mt+ry
Drawing Embellishment = sd+ed+ln	Text Embellishment = pt+wm+pm
Drawing Abstraction = dab;	Text Abstraction =tab
Drawing Gestalt = dgt	Text Gestalt = tgt

Total Merit variables have been formed by summing Structure and Embellishment.

Total Drawing Merit = sl+fo+3d+sd+ed+ln

Text Merit = vb+mt+ry+pt+wm+pm.

Drawing Data

Parts (pt); the number of distinct pieces of the drawn letter.
Vertices (vr); the number of vertices of the largest piece of the drawn letter.

Shades (sd); the number of pattern shadings used in the drawn letter.
Slants (sl); the number of slanted elements in the drawn letter.

Focus (fo); if the drawn letter has a back-bone or base, assign 2
Three Dimensional (3d); if the letter is rendered in three dimensions, assign 2; if it has been given a shadow, assign 1; if both, assign 3.

Ends (ed); if the lines of the drawn letters end with an angular cap, assign 1; if they end in a curve, assign 2; if they have and "honest" serif, assign 3.
Lines (ln); if the lines are of differing thicknesses, assign 1; if individual lines have varying thickness, assign 2.

Abstraction (ab); if the letter is drawn in traditional form, assign 1; if it is distorted, assign 2; if it is stylized, assign 3; if it is abstract, assign 4.
Gestalt (gt); if the letter is weakly drawn, assign 1; if is carefully drawn, assign 2; if it is well designed, assign 3; if it is outstanding, assign 4.

Text Data

Words (wd); the number of words in the longest sentence.
Letters (lt); the number of letters in the longest word.

Punctuation (pt); the sum of the number of commas, quotes, and font changes.
Verbs (vb); the number of verbs in the longest sentence.

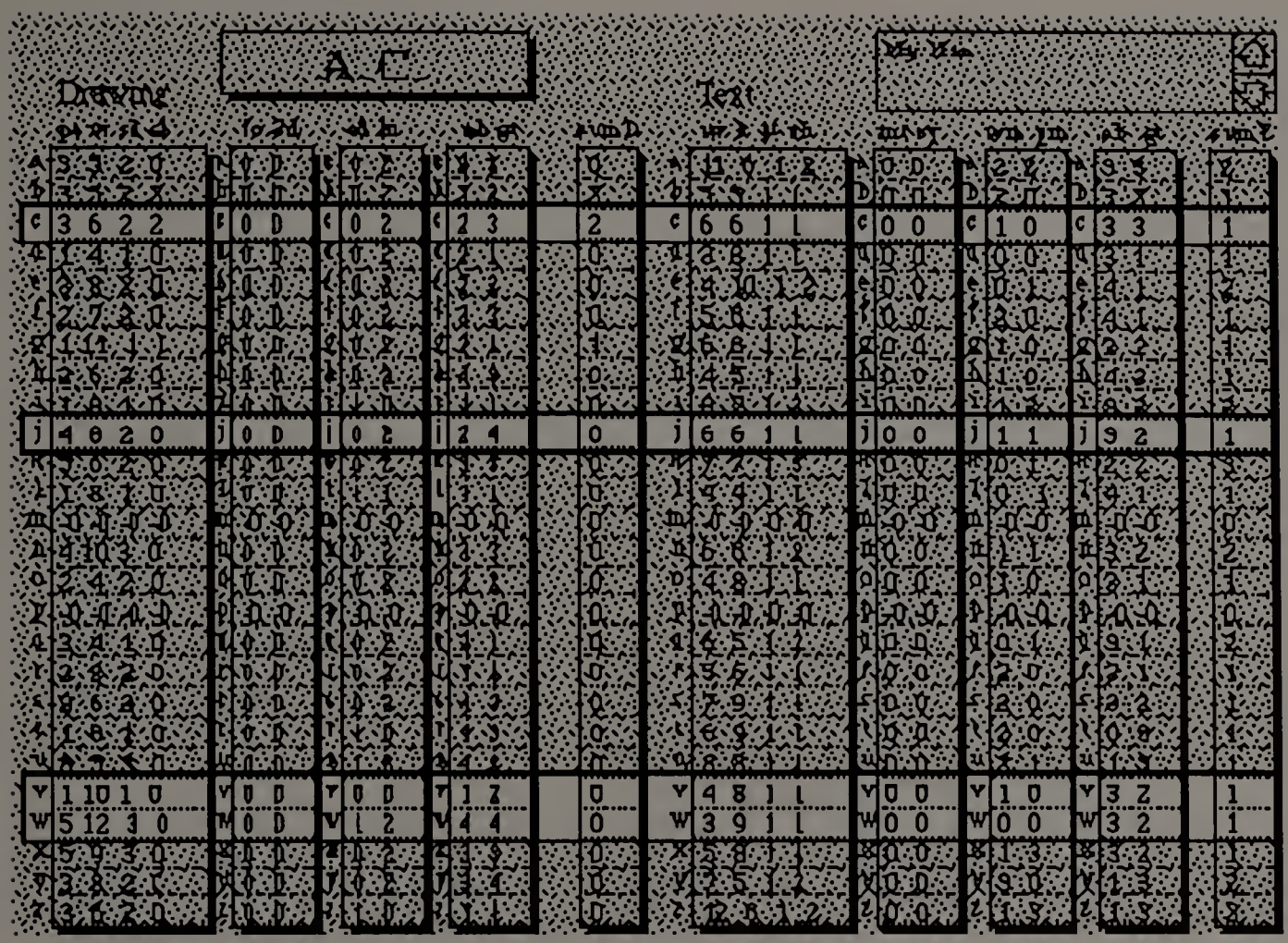
Meter (mt); if the text has a rythm, assign 2.
Rhyme (ry); if the text uses illiteration, assign 1; if rhyme is used, assign 2; if both, assign 3.

Word Modifiers (wm); the number of adverbs and adjectives.
Phrase Modifiers (pm); the number of phrases used as modifiers.

Abstraction (ab); if the keyword is a concrete noun, assign 1; if it is an adjective or adverb, assign 2; if it is a verb; assign 3; if it is an abstract noun, assign 4.

Gestalt (gt); if the text is undistinguished, assign 1; if it is interesting, assign 2; if it is good, assign 3; if it is poetic assign 4.

Data Definitions
Figure 4.2



Alphabet Book Data

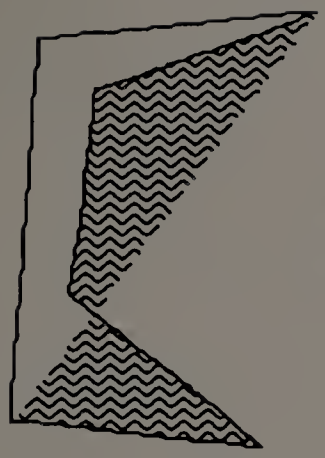
Figure 4.3

Data for A.C.'s letters; C, J, V, and W, as it is stored in the data base, are highlighted in figure 4.3. The four letter-text pairs from the alphabet book made by A.C. are pictured in figure 4.4. The measurement process particular to each letter-text pair is described below.

The drawn letter C has three elements, the most complex of these is unshaded top of the letter which has six vertices, (pt=3, vr=60). Two shades have been used but it has no slanted elements, (sd=2, sl=0). This drawing has a variety of line thicknesses and the lines of the letter end in points (ln=2, ed=1). The text ("Chris is very cute and cuddly") has a total of six words, the longest of which has six letters, (w =6, lt=6). It has a font change, uses one verb, and uses alliteration with the repeated "c" (pt=1, vb=1, ry=1). This sentence is embellished with one adverb (very), and two adjectives (cute, cuddly), but no prepositional phrases (wm=3, pm=0).

The Drawing Embellishment variable (sd+ed+ln) has a value of 2+1+2, whereas the Text Embellishment (pt+wm+pm) has a value of 2+3+0. The drawn letter C is classified as stylistic and the keywords (cute, cuddly) as adjectives (dgt=2, tgt=2). The abstraction measurements are 2 for the letter and 2 for the keyword. The drawn letter and the text have each been given an aesthetic rating of 3. The aesthetic gestalt of the drawn C was judged better than that of the drawn V. The V has a Drawing Merit of 12, less than that of C which is 15, which in this case match the judged quality. The drawn W gets high marks (Merit =23) due to its complexity and general aesthetic appeal whereas the text is quite uninteresting and its measured quality is low.

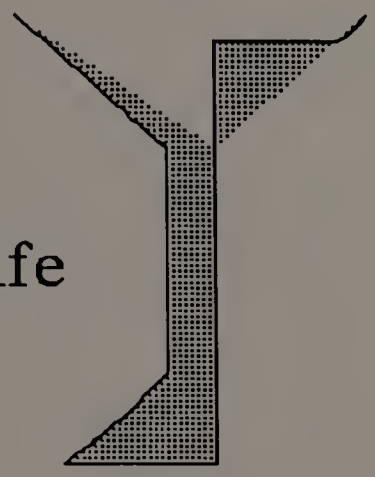
The analysis of alphabet book data is a statistical study of the correlation between the letter-text variable pairs which have been calculated for thirty individuals. The variables representing features of the drawn letters of all books in the study are compared with the corresponding variables representing text features of all books.



(a)

Chris is very cute and cuddly

Chris brings joy into my life

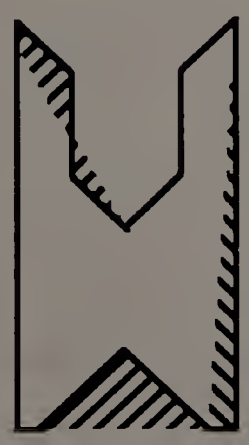


(b)

(c)

He is very handsome

He is wonderful



(d)

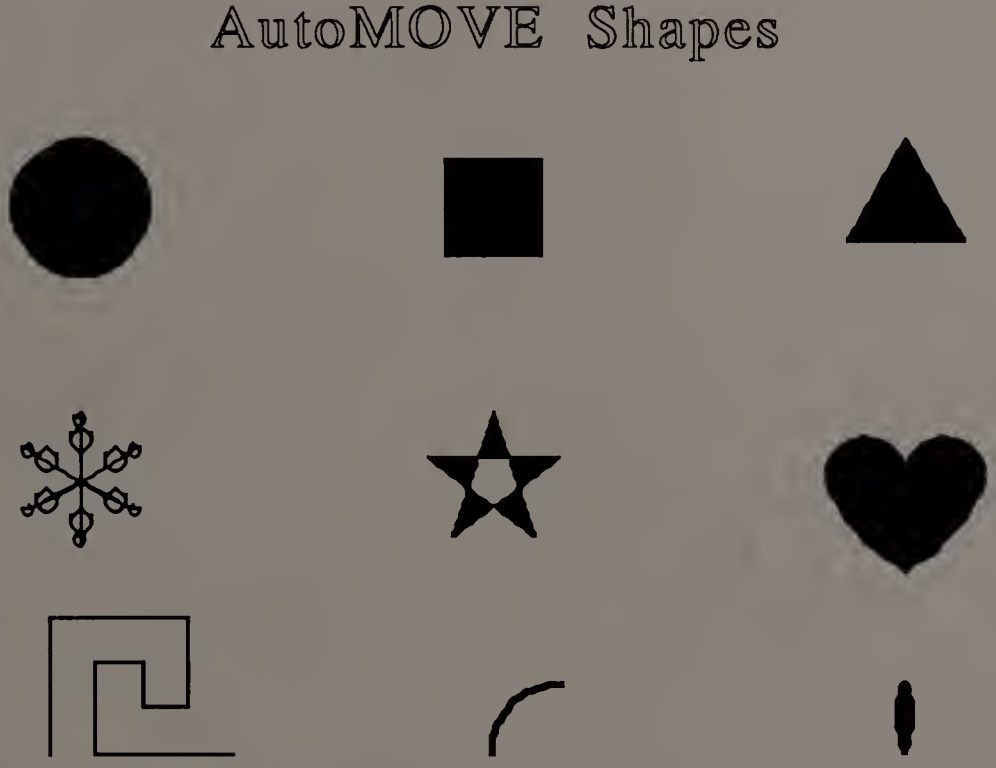
Letter - Text Pairs

Figure 4.4

4.6. Computer Tools for Composition

4.6.1. AutoMOVE, a Visual Workspace

AutoMOVE is the computer software, developed by the researcher, which in large part inspired the use of scores for the analysis of visual composition. *ComPOSER* is computer software developed especially for this study, which is used to construct scores which generate paragraphs. Both are written in the Logo language (see Appendix C). AutoMOVE is a Logo workspace which contains a set of procedures (programs) which define a vocabulary of shapes as well as a procedure which provides access to these shapes with single-key-stroke commands. This workspace is microworld with its own restricted shape vocabulary and set of commands for transforming and combining these basic shapes. AutoMOVE's basic shapes are show in figure 4.5. The command "T" draws a triangle, the command "V" draws a heart (Valentine). All the AutoMOVE commands for manipulating the basic shapes are listed in figure 4.6



AutoMOVE Shapes

Figure 4.5

AutoMOVE Commands

A .....AutoMOVE on/off
B.....Black / white
C.....Circle
D.....Draw on/off
E.....Erase
F.....Fractal
G.....Grey
H.....Home
I .....Invisible / visible
J.....Jump
K.....Key
L.....Leap
M.....Magnify
N.....Negate
O.....Ornate
P.....Petal
Q.....Quarter circle
R.....staR
S.....Square
T.....Triangle
U.....Undo
V.....Valentine
W.....Wide
X.....X position
Y.....Y position
Z..... reset (to Zerc
. ..... turn right
, ...turn left

Numbers from 0 to 9 change the scale of the action.

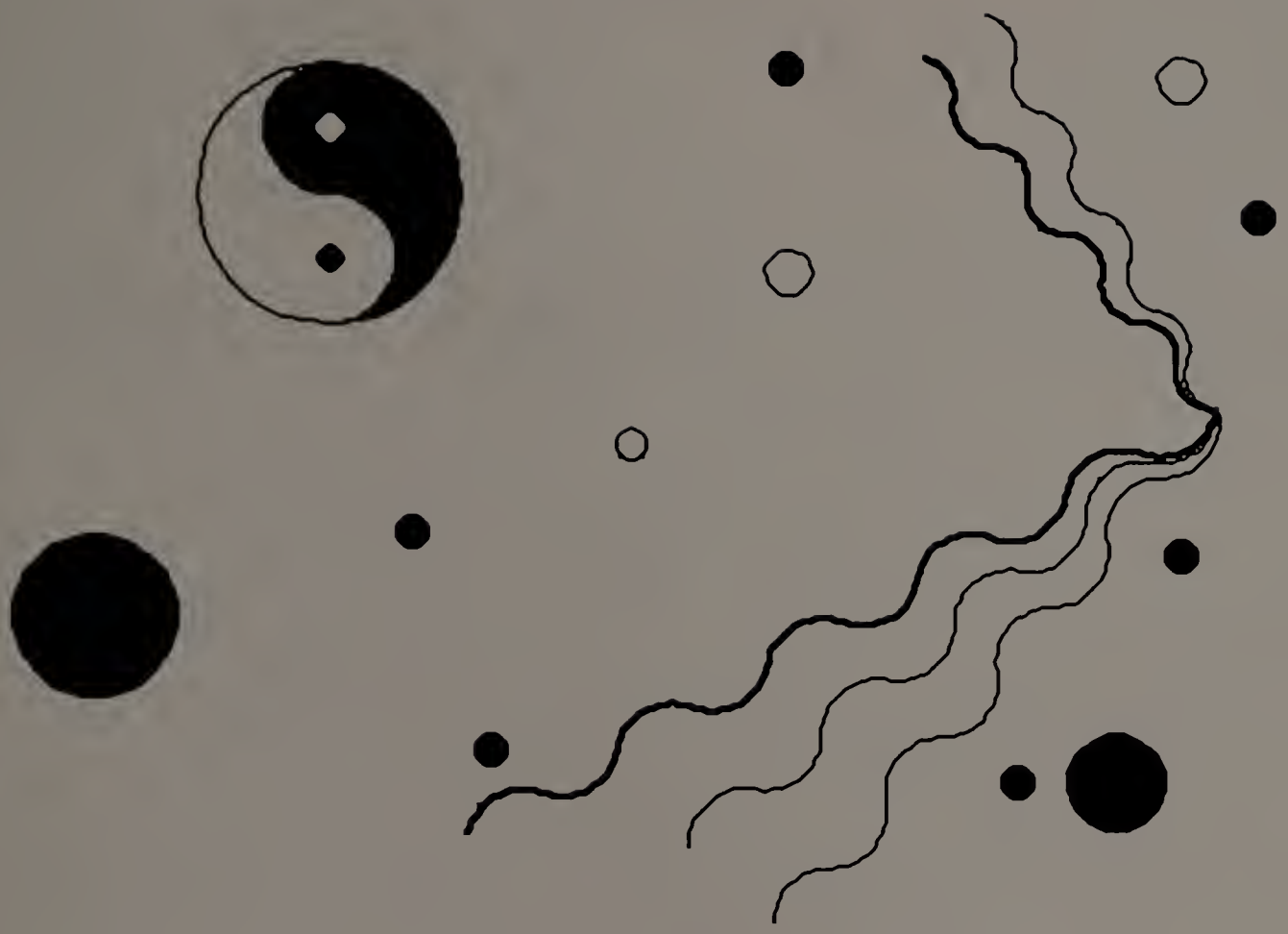
When not in automatic mode, the command SIZE must be used to change

AutoMOVE Commands

Figure 4.6

4.7. Scores and Composition Features

An example of a picture composed in the visual microworld (AutoMOVE) is shown in figure 4.7a. True copies of this picture may be generated any time by a set of computer programs (Logo procedures) which comprise its score. Paragraph scores may be written in an analogous way. The score for a paragraph consists of a set of particular rules which generates the paragraph. The paragraph example in figure 4.7b was constructed within the linguistic microworld (ComPOSER). It consists of five sentences which are constructed from phrases which are, in turn, assembled from a base vocabulary. This paragraph and its components consist of words from the lexicon which are structured according to a set of fixed rules. This paragraph may be regenerated any time by applying the author's particular set of rules, for replacement and transformation, to the base vocabulary. Note that, in figure 4.7b, **goe** and **verifie** are transformed from the singular by the "drop s " rule, and that **truely** is transformed from the adjective **true** by the "add **ly**" rule. Symbols for sentences are replaced by symbols for phrases. Then phrase symbols are replaced by word symbols which are in turn replaced by words from the lexicon.



A) K.G.'s Picture

The roads which some human creatures move on quickly are dangerous to the journey which builds knowledge. The human creature which walks truely on the roads building real knowledge feels it is a journey through fire. Good institutions which build knowledge connect leaders which love all knowledge with human creatures with questions. Human creatures which really think goe on to verifie knowledge in the institutions on earth and possess money and knowledge.

B) K.G.'s Paragraph

K.G.'s Compositions

Figure 4.7

4.7.1. Composition in the Visual Microworld

The vocabulary of the visual microworld (AutoMOVE) contains shapes, actions, and attributes. These can be combined at several levels. Three levels of sophistication have been identified. Compositional mastery level is measured in terms of quantity and diversity of resources used at each level.

1) Assemblies containing only base vocabulary
2) Assemblies containing numerical operators
3) Assemblies containing assemblies

An example of a visual composition is shown in figure 4.8. The score for this composition is a system of nested Logo procedures. The workspace containing these Logo procedures is also shown in figure 4.8. The score of this composition has been used as the basis for evaluation of the composition itself.

A) Visual Composition

```
TO WHOLE.THING
 WALT  ADD
END

TO WALT
 VALENTINE
 D SETX 200  N SETY -60 N D  SQUARE
 D SETX -200  SETY -60 D CIRC
 D  SETX -120 , , N  L L L L L L N D  TRI
 D  SETX 120  . . . . N  L L L L L L D N TRI
END

TO ADD
 D L L L  , , , , , D  TRI
 D . . . SETX -120  . .
 N L L L L L , D N TRI
END
```

```
TO SQUARE
 D M M S
 L L N M M S
 N L L N M M S  Z
END

TO VALENTINE
 D M M V L L
 N M M V
 N L L N M M V  Z
END

TO CIRC
 D M M C L L
 N M M C
 N L L N M M C  Z
END

TO TRI
 D M M T
 L L N M M T
 N L L N M M T  Z
END
```

B) Score

Visual Composition by D.P.

Figure 4.8

4.7.2. ComPOSER a Verbal Workspace

ComPOSER is a Logo workspace which contains a set of definitions (Logo names) which define a vocabulary of words, as well as procedures which define permitted transformations and combinations of these words within this microworld.

This workspace has its own restricted vocabulary and limited set of rules for transforming and combining the words in its lexicon. All the nouns in the lexicon are shown in figure 4.9. All the replacement rules and an example, using the rule for creating a sentence (SN) from a noun phrase and a verb phrase, are shown in figure 4.10. Details of the ComPOSER workspace are presented in Appendix C.

Nouns

A	Air	J	Journey	S	Song
B	Box	K	Knowledge	T	Tool
C	Creature	L	Leader	U	Umbra
D	Day	M	Money	V	Vehicle
E	Earth	N	Nothing	W	Water
F	Fire	O	Object	X	(Random)
G	Group	P	Part	Y	Yard
H	Hole	Q	Question	Z	Zealot
I	Institution	R	Road		

Nouns

Figure 4.9

Replacement Rules

```
SN <- NP  VP
PP <- PR  NP
NP <- AR (A) (A)  N  (PP)
NP <- NP CJ NP
VP <- V  (AV) (PP)
VP <- VP  CJ  VP
```

<- means "may be replaced by"

( ) means "optional"

SN = sentence
NP = noun phrase
VP = verb phrase
PP = prepositional phrase
N = noun
V = verb
A = adjective
AR = article
CJ = conjunction
PR = prepositon
AV = adverb

Rule: SN <- NP VP

```
Logo:   MAKE "SN1 [ NP1   VP1 ]
        MAKE "NP1 [ AR.A  N.R ]
        MAKE "NP2 [ AR.T  A.G  N.S ]
        MAKE "VP1 [ V.M PR.B  NP2 ]
```

The following lexical entries are used:

AR.A	is 'a'	N.R	is 'road'	V.M	is 'moves'
AR.T	is 'the'	N.S	is 'song'	A.G	is 'good'
PR.B	is 'beside'				

a road moves beside the good song

ComPOSER Rules

Figure 4.10

4.7.2.1. Composition in the Verbal Microworld

The vocabulary of the verbal microworld (ComPOSER) contains nouns, verbs, and adjectives. These can be transformed and combined at several levels. Nouns can be made plural, adjectives may be transformed to adverbs, and verbs can be made into adjectives. New nouns may be constructed as named sub-assemblies. Compositional mastery level is determined from quantity and diversity of resources used at each level. Three levels of sophistication have been identified.

1) Phrases containing only base vocabulary
2) Phrases containing transformed words
3) Phrases containing phrases or new nouns

An example of a linguistic composition is shown in Figure 4.11. This paragraph was built by student D.P. who also composed the picture illustrated in figure 4.8. The score for this composition is a system of nested replacement rules which are implemented as Logo namings. The workspace containing these Logo names is listed in Figure 4.9.

```
EXPAND [SN1 SN2 SN3]

Level 1 :
  SN1 SN2 SN3
Level 2 :
  NP4 VP4    NP4 VP8    NP6 VP9
Level 3 :
     AR.T A.T A.D N.C     V.P NP5 AR.T
 A.T A.D N.C     VP6 CJ.A VP7
  N.F CJ.A AR.T N.I          V.I NP7
Level 4 :
     the true dangerous creature possesses A.A N.K
     the true dangerous creature V.S AR.T N.G and V.H A.A
     fire and the institution is A.S AR.T N.L
Level 5 :
     the true dangerous creature possesses all knowledge
     the true dangerous creature sees the group and hears all
     fire and the institution is successor to the leader
```

```
MAKE "SN1 [NP4 VP4]
MAKE "VP9 [V.I NP7]
MAKE "VP8 [VP6 CJ.A VP7]
MAKE "SN3 [NP6 VP9]
MAKE "SN2 [NP4 VP8]
MAKE "NP [A.S AR.T N.L]
MAKE "NP5 [A.A N.K]
MAKE "VP4 [V.P NP5]

MAKE "NP7 [A.S AR.T N.L]
MAKE "VP7 [V.H A.A]

MAKE "VP6 [V.S AR.T N.G]
```

Verbal Composition by D.P.

Figure 4.11

4.8. Parallels in Visual and Verbal Composition

Each microworld contains its own vocabulary and its own grammar. Three vocabulary parallels have been identified for this study. Nouns and shapes have been associated, adjectives and attributes are considered analogous, and verbs and actions are taken as the builders of structure.

Vocabulary (linguistic)		**Vocabulary (visual)**
Nouns (N.A through N.Z)	⟷	Shapes Circle,Square,Triangle, Fractal,staR,Valentine Key,Petal,Quartercircle
Adjectives (A.A through A.Z)	⟷	Attributes Black,Grey,Ornate Magnify,Widen,SCALE_,SIZE_ Negate
Verbs (V.A through V.Z)	⟷	Actions Leap,Jump > (turn right), < (turn left) (go)Home SETX_,SETY_,SETH_

When considering grammar, layers of nested visual assemblies roughly parallel levels of verbal replacement rules.

Levels of Replacement Rules	**Layers of Nested Assemblies**
1) Phrases containing only base vocabulary	1) Assemblies containing only basewords
2) Phrases containing transformed words	2) Assemblies with numerical operators
3) Phrases containing phrases and new nouns	3) Assemblies containing assemblies

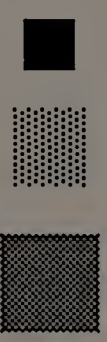
Examples of rule use in the verbal microworld and of procedure definition in the visual microworld are shown below in figure 4.12.

Visual

1) Assembly Containing Only Basic Shapes

```
TO REL.SQ
  D G S
  L L G M S
  L L B M S Z
END
```

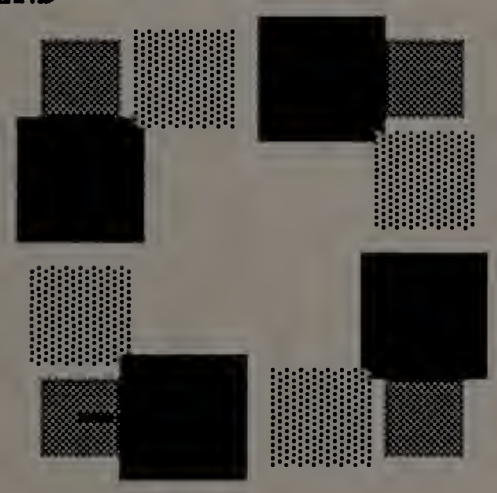
2) Assembly with Numerical Operators



```
TO ABS.SQ
  D SIZE 4 G S
   L L SIZE 3 G M S
   L L SIZE 2 B M Z
END
```

3) Assembly Containing an Assembly

```
TO MORE.SQ
  REPEAT 4[REL.SQ L L RT 90]
END
```



Linguistic

1) Phrase Containing Only Base Vocabulary

```
MAKE "NP1  [A.H N.C]
(make nounphrase one 'human creature')
```

human creature

2) Phrase Containing Transformed Words

```
MK.PN  [N.C]      creates PN.C
(make a plural noun from 'creature')
MAKE "NP2 [A.J  A.H  PN.C
(make noun phrase two 'joyous human PN.C')
```

joyous human creatures

3) Phrase Containing a Phrase

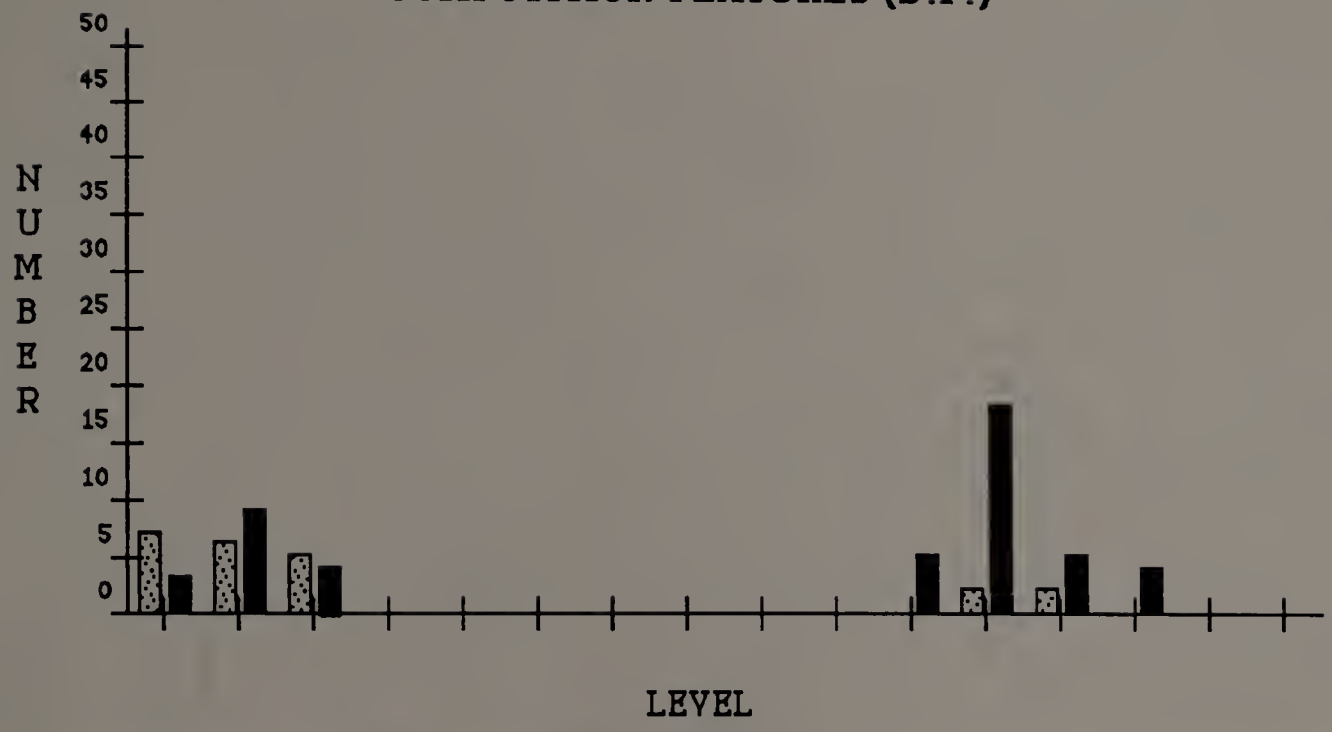
```
MAKE "PP1 [P.W  NP2]
(make preposition phrase one 'with  NP2')
MAKE "NP3  [ AR.A  N.G PP1]
(make noun phrase three 'a group PP1')
```

a group with joyous human creatures

Figure 4.12
Examples of Assemblies and Phrases

This component of the study, which investigates compositions realized as computer scores, is a much smaller data set than the thirty alphabet books. Parallels have been drawn between visual and verbal vocabulary types. Shapes are analogous to nouns, attributes to adjective, and actions are taken to be analogous to verbs. The use of vocabulary by type and the level of construction in both visual and linguistic compositions is measured. Too small for statistical analysis, these data sets are discussed as case studies. For all six composition pairs, a count of the three categories of assemblies and phrases has been recorded in spreadsheets. D.P.'s composition pair serves as an sample. The assembly count from her picture and the phrase count from her paragraph are compared in figure 4.13.

The evaluation procedures outlined in this chapter have been applied to the collection of thirty alphabet books and the set of six computer-composition pairs. More information about instructions to students and the tools created for this study may be found in the Appendix. The results of this evaluation are the subject of the following chapter.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
3					D.P. Composition Pair Data														
4																			
5		vocabulary				transformed					phrases								
6	**Paragraph**	Level One->				Level Two ---->					Level Three -------->								
7	(total)	N	A	V		N	A	V	TW		N	A	V	TW	NN	Ph			
8	**Paragraph**	7	6	5		0	0	0	0		0	0	2	2	0	0			
9																			
10		vocabulary				numerical ops.					assemblies								
11	**Picture**	Level One->				Level Two ---->					Level Three-------->								
12	(largest)	S	T	A		S	T	A	Op		S	T	A	Obj	Scl	Pos			
13	**Picture**	3	9	4		0	0	0	0		0	5	18	5	4	0			
14																			
15		KEY:			N=noun A=adj V=verb						S=shape T=attribute A=action								
16					TW=transformed words						Op=operators								
17					NN= new nouns						Ob=objects								
18					Ph= phrase w. phrase						Sc=scalers								
19											Po= positioners								

Figure 4.13

Comparision of D.P.'s Assemblies and Paragraphs

CHAPTER 5
RESULTS AND DISCUSSION

5.1. Composition in the Information Age

Increasing accessibility of information is placing new demands and new opportunities before educators. A category of activity which rises to great importance in our information rich environment is that of composition. Composition is the construction of wholes from parts. Competent composition requires the ability to choose, relate, and assemble. Think of any subject from anthropology to digital circuit design, from linguistics to plumbing. Objectifying information, identifying relationships, and discovering or creating structure are common to much of our mental activity. Not only has the information age brought new demands, it has brought new tools. There is some irony in the fact that while science, engineering, and business have been using them for decades, thinkers and scholars in the humanities have had little inclination to explore the potential of these new tools. When the word processor brought computers into the world of the writer, the situation began to change rapidly. That change accelerated as computer graphics became commonplace. Once it was understood that computers could be used to manipulate symbols other than numbers, humanists began to notice them. The implications for educators are enormous.

This study uses computer environments for an exploration of students' general compositional ability. What began with the collection of student alphabet books, continued with an informal analysis of these books, identification of quantifiable features in both the text of these books and their drawn letters, and a correlation study to validate initial impressions. As the collection of student picture books grew, a second opportunity to study general composition arose. Recognition of the difficulty quantifying compositional quality, coupled with experience using "scores" in the form of computer programs for visual composition, led rather naturally to the creation of computer software with which paragraphs could be composed as scores. With this addition, students were able to produce paragraphs, as well as pictures, within a common context of computer scores. Now comparisons could be made between scores which produced pictures and scores which produced paragraphs. A comparison of pictures and paragraphs, which have been written as scores, completes this study.

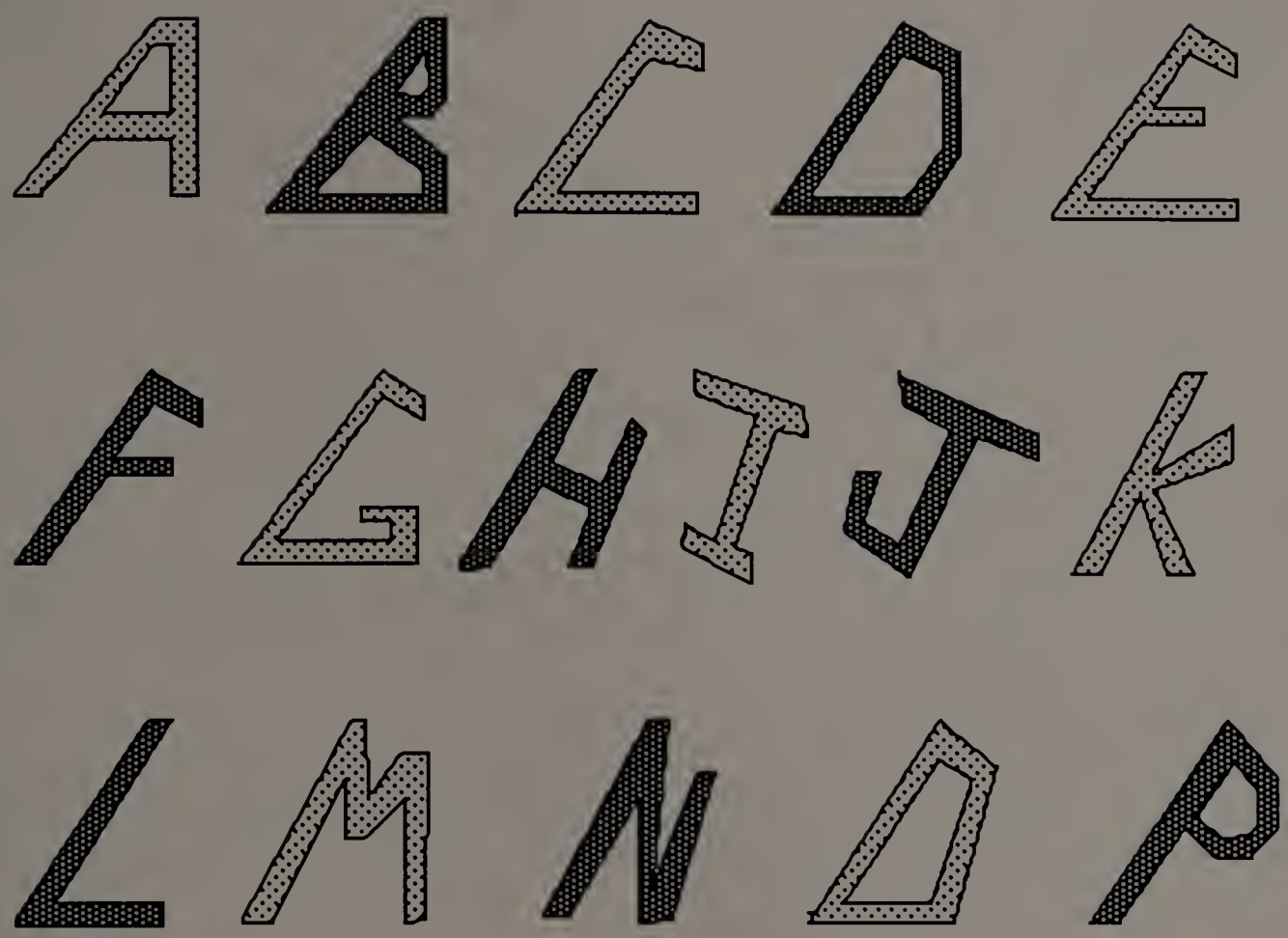
This chapter reviews examples from the alphabet book collection which indicate tendencies and then presents data from a study of the correlation between the drawings and text of this collection. After an presentation and analysis of student compositions created with AutoMOVE and ComPOSER, this chapter concludes with suggestions for continuing investigation of links between compositional proficiency in visual and verbal modes of expression.

5.2. Alphabet Books; Tendencies in the Collection

Samples from the alphabet book collection are shown on the following pages. Two complete sets of drawn letters show typical consistency within individual books, and a series of V's shows the variety across the collection. Several "G" pages are shown to demonstrate the range of quality of composition.

5.2.1. Consistency

Two complete alphabets of drawn letters are shown as examples of consistency within individual works. C.T.'s alphabet, figure 5.1, is drawn with care and the letters have clear consistency. In contrast, Figure 5.2 shows one of the most sophisticated and complex in the collection. Even though each letter in this set has its own strong personality, a clear continuity of style persists throughout all twenty-six letters.



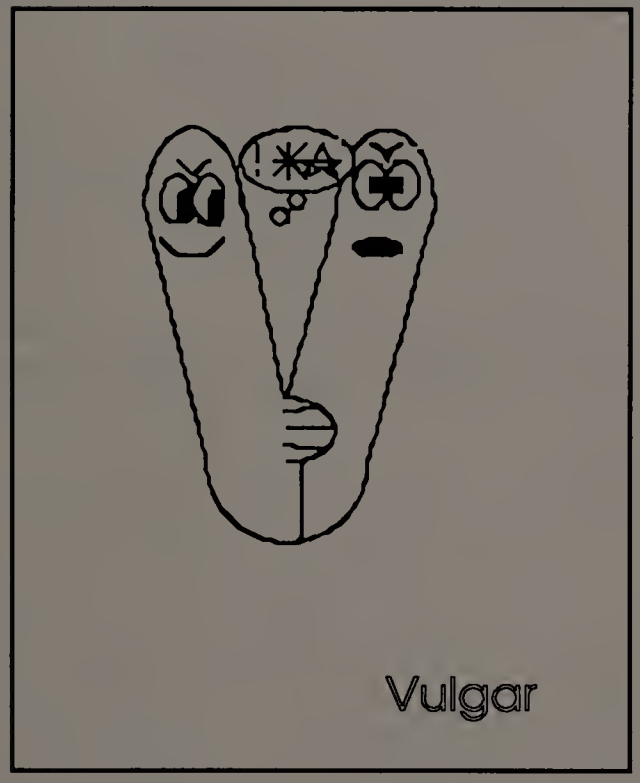
C.T.'s Alphabet
Figure 5.1

L.E.'s Alphabet

Figure 5.2

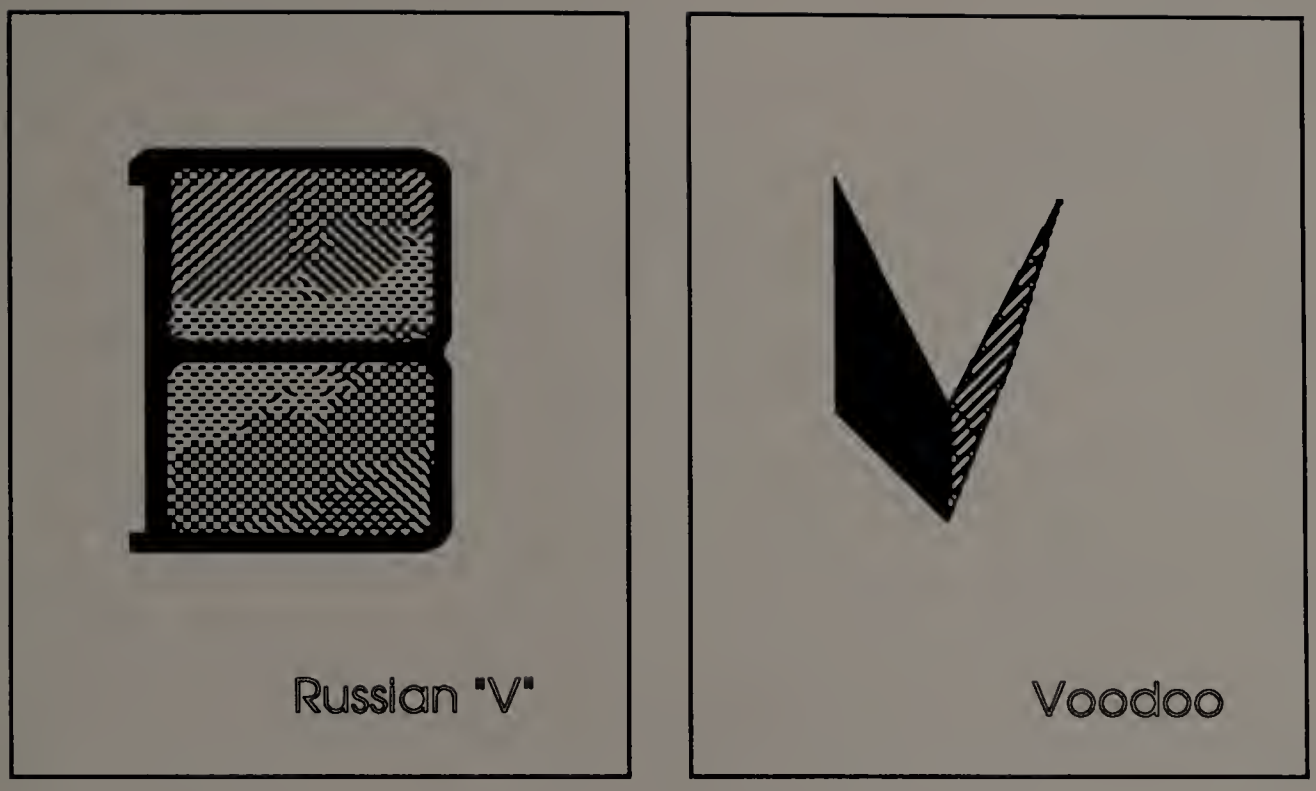
5.2.2. Diversity

The diversity of styles across the complete set of thirty books is striking. The graphically simple letter "V" seems particularly inspirational, perhaps because many interesting words, from VORTREFLICHKIET to VULGAR start with the letter V. A representative sample of V's is shown in figures 5.3 to 5.5



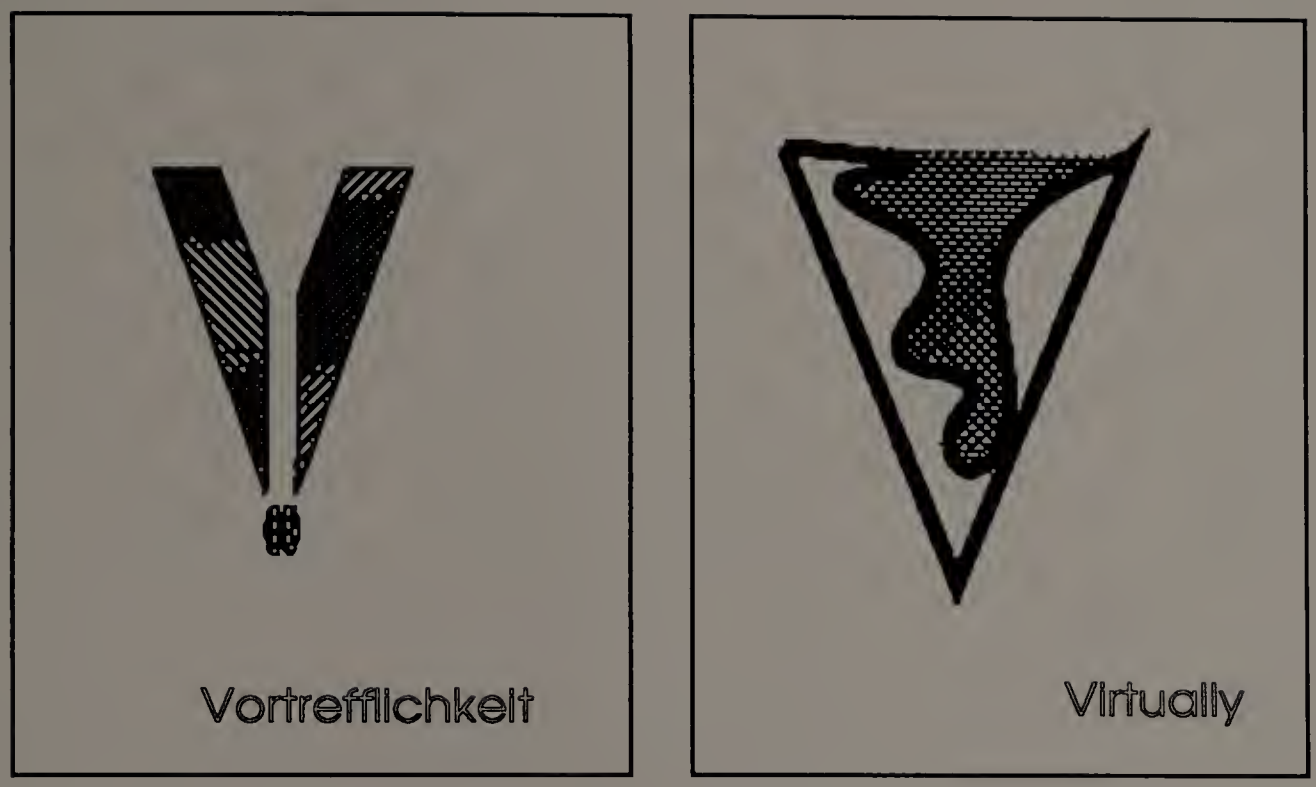
A Variety of V's

Figure 5.3



Various of V's

Figure 5.4



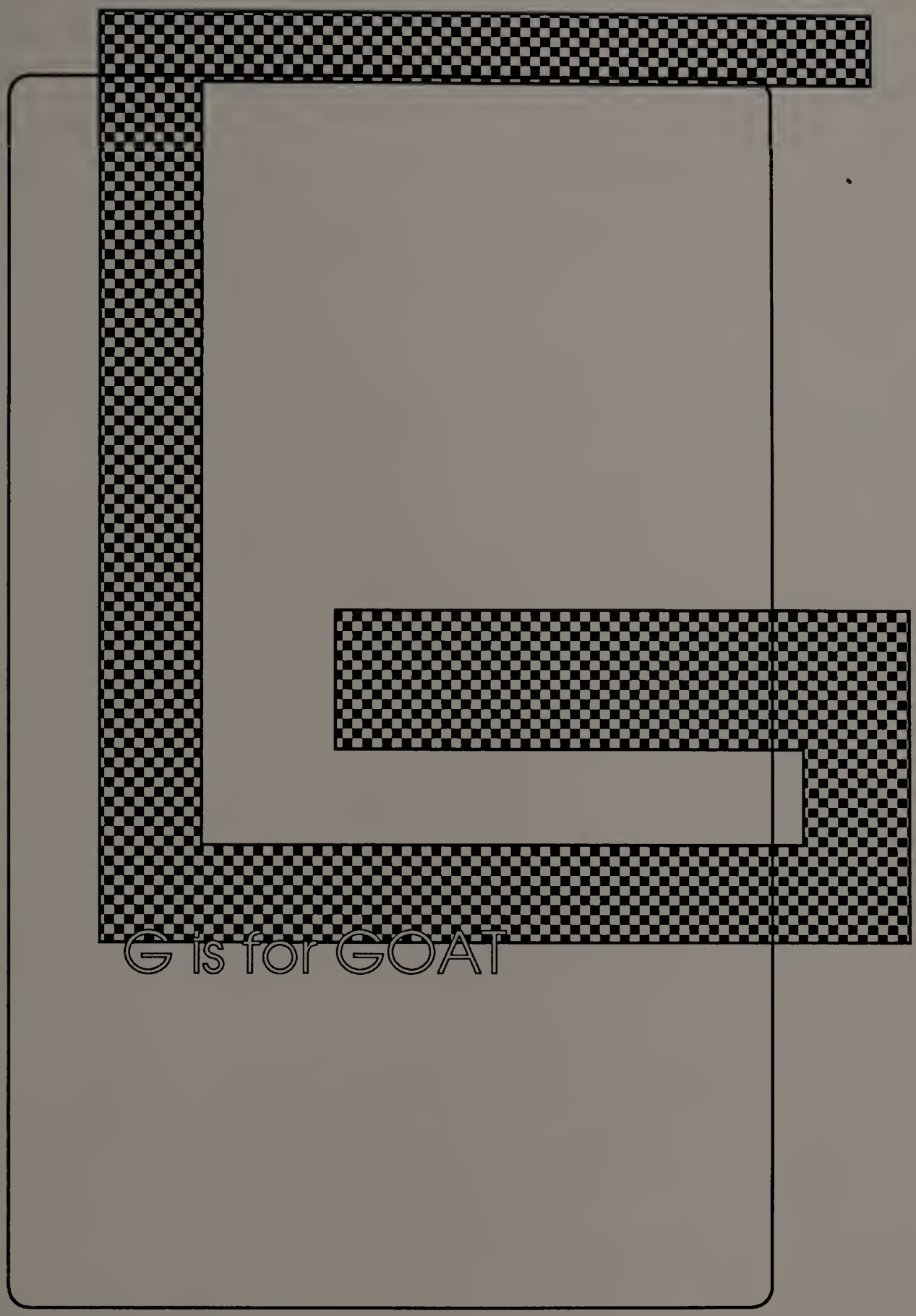
$\overline{\text{IV}}$ V's

Figure 5.5

5.2.3. Range of Quality

A set of G's is shown below to demonstrate both a general increase in quality with quantity as well as a link between text quality and drawing quality. The members of this set were chosen to emphasize an impression gotten from surveying all thirty books.

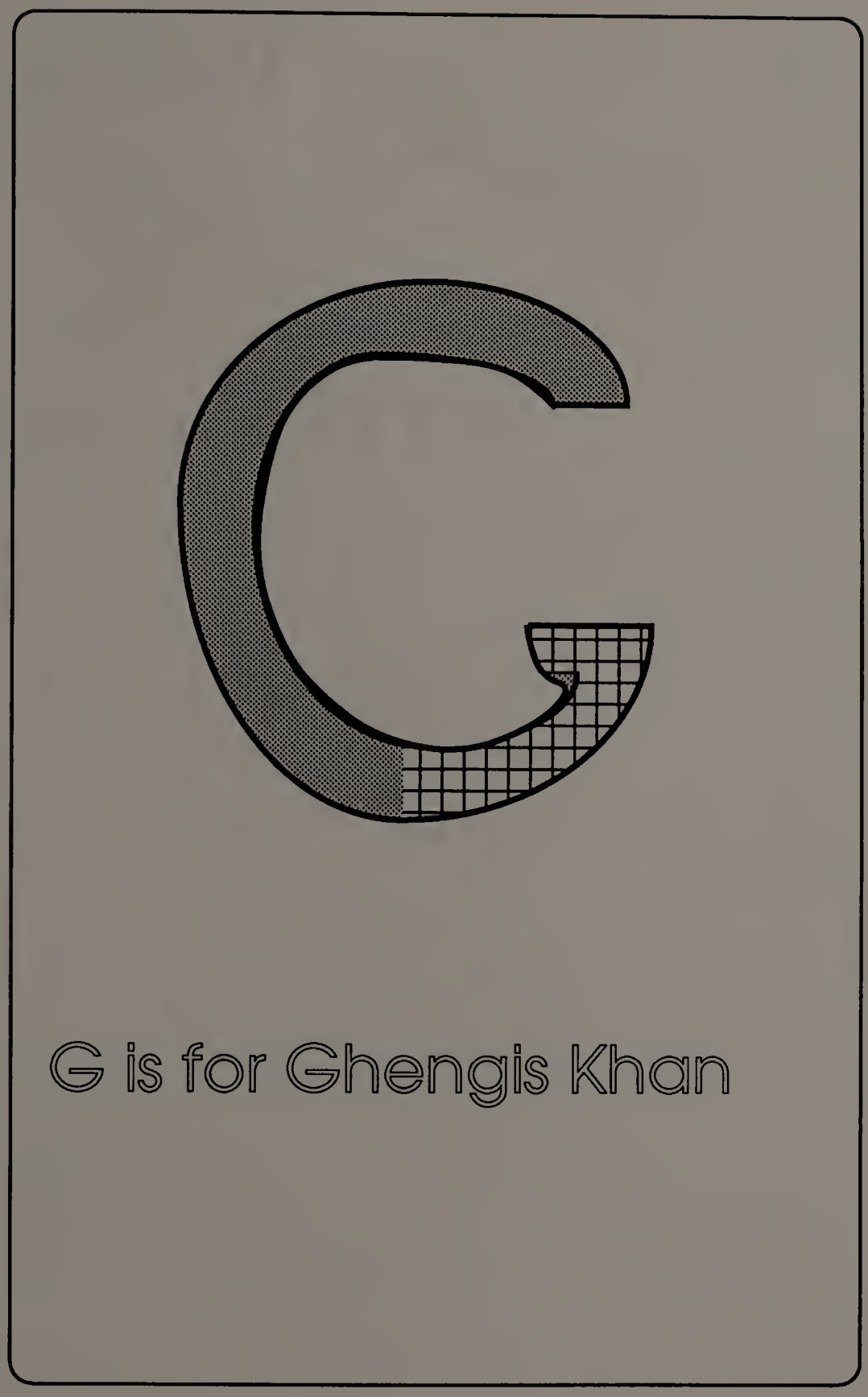
These examples are shown sequentially, in order of the number of words in their text. Figure 5.6, the first in the series, has a word count of 4 , whereas figure 5.14, the last in the series, has a word count of 25. It may be seen that, as the word number increases, the information value and interest inherent in the text increases. In these examples the information value and the aesthetic appeal of the drawn letters also generally increases as the quantity of the text increases.



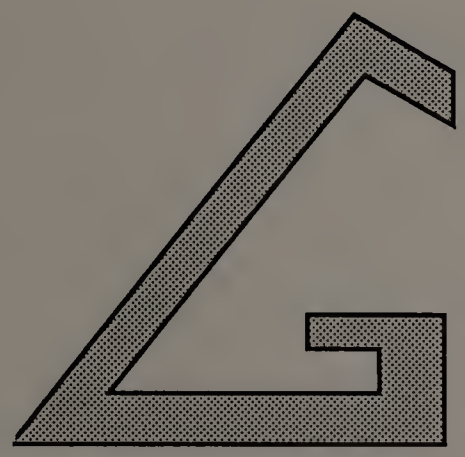
G - Goat

Figure 5.6

G-GMC
Figure 5.7



G- Gehengis Khan
Figure 5.8



G-Gray-- the color your hair becomes when your children reach their teens.

G- Grey
Figure 5.9

Chris is always fun and goofy

G- Goofy

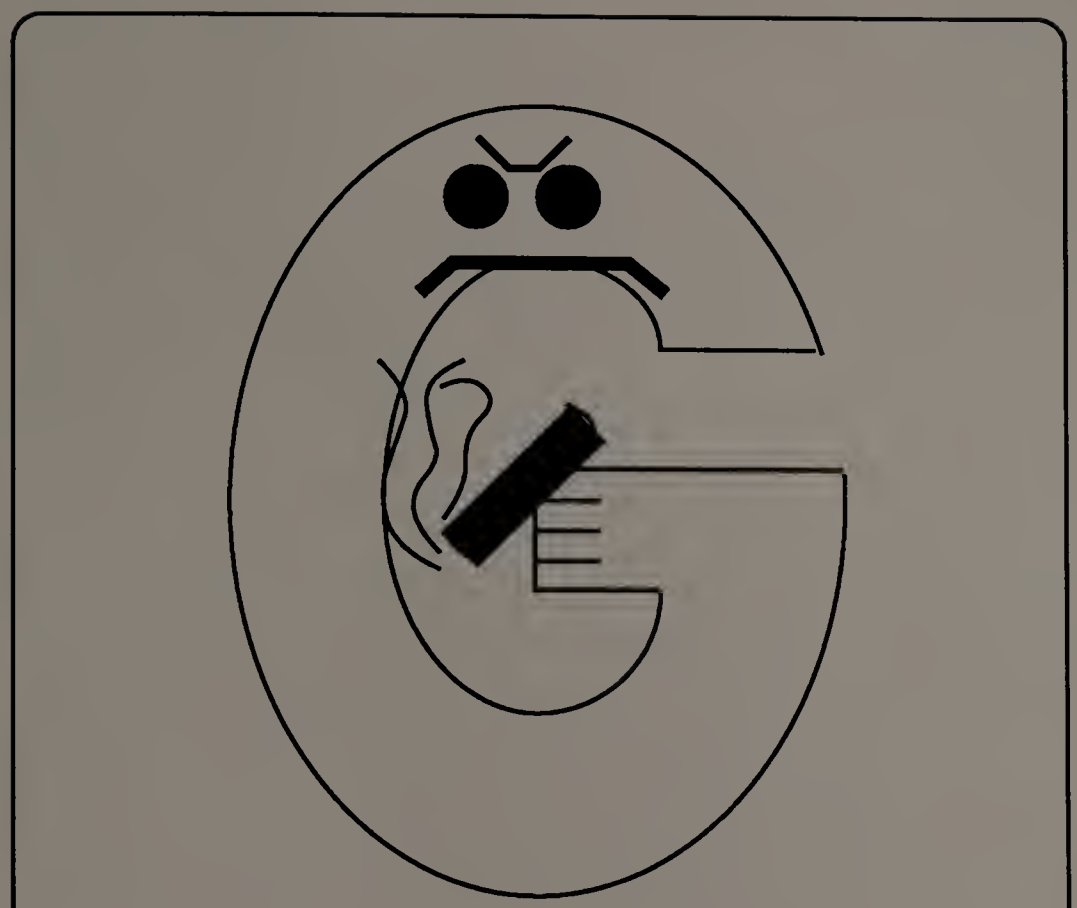
Figure 5.10

G- Gary

Figure 5.11

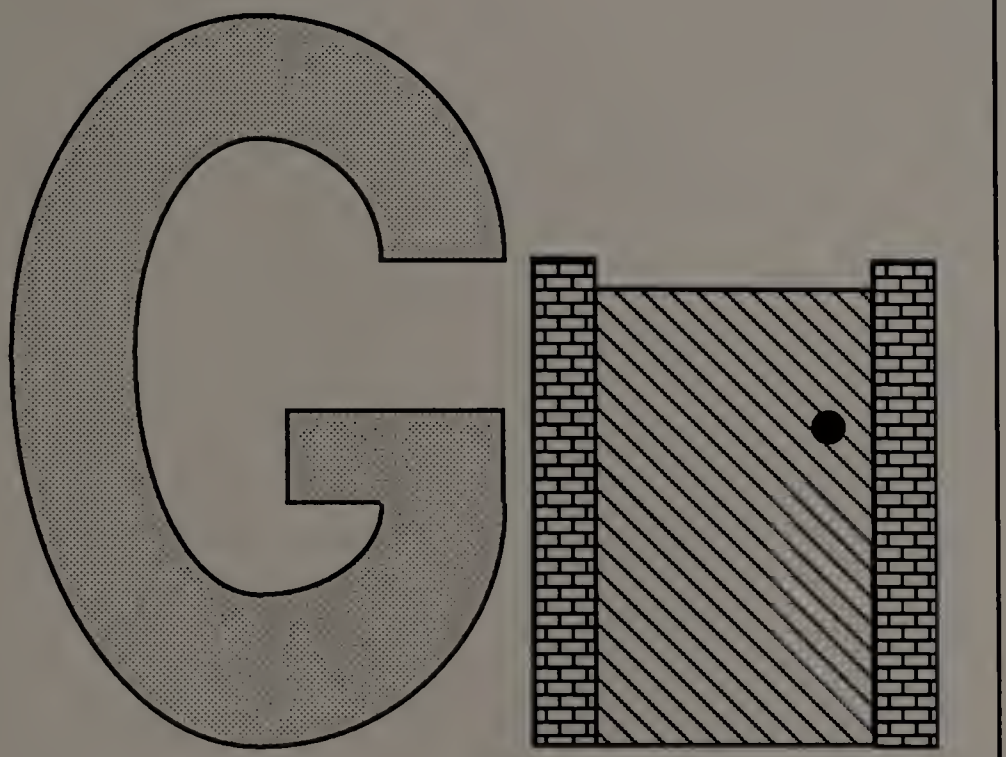
G is for Garbage,
that fills the land.

G- Garbage
Figure 5.12



G- Grouchy

Figure 5.13



G is for gate that gets you in and out of the yard. People often forget to close the gate and the dog gets out.

G- Gate
Figure 5.14

5.2.4. Correlation Study

To support the hypothesis of links between picture production and text production, correlation between the two has been investigated by comparing features of individual student's visual compositions with similar features of that student's written compositions. Picture books, created by students, have been formally evaluated in terms of features of their drawn letters and the text which accompanies them. The frequency and complexity of word (or shape) usage are used as simple measures of aesthetic merit. A positive correlation between parallel aspects of visual and linguistic expression in the alphabet books has been demonstrated. Comparisons of the text-picture features of structure, embellishment, abstraction, and gestalt show small positive correlations. *Structure* is a measure of the contribution to large scale enhancements of the standard letter shape or sentence structure, whereas *Embellishment* is a measure of the enrichment of the drawing or text by small scale details. *Abstraction* is a judgement of deviation from the "concrete", and *Gestalt* is a judgment of general aesthetic merit. Measures of quantity have been combined with measures of structure and embellishment to create a variable called *Total Merit* . The statistics relating *Total Drawing Merit* and *Total Text Merit* are shown in figure 5.15. Although the twenty-six of drawing-text pairs in individual books generally show no significant correlation, when the *Total Merit* sums from individual books are compared, a correlation coefficient of 0.5 is obtained, indicating a correlation above the 0.01 level of significance.[1]

Do these measures of merit have any validity? Quantity and quality are often thought of as being unique, nearly antithetical attributes. It is an assumption of this study that quality is in part measurable in terms of quantity. Are the measures of Merit (quantities) related to judgments of quality? As a partial answer to this question, the correlation between Total Merit and Gestalt has been calculated. Correlation coefficients for the drawings and texts are 0.55 and 0.79 respectively, showing significance above the 0.01 level between these variable pairs. These statistics are shown in figures 5.16 and 5.17.

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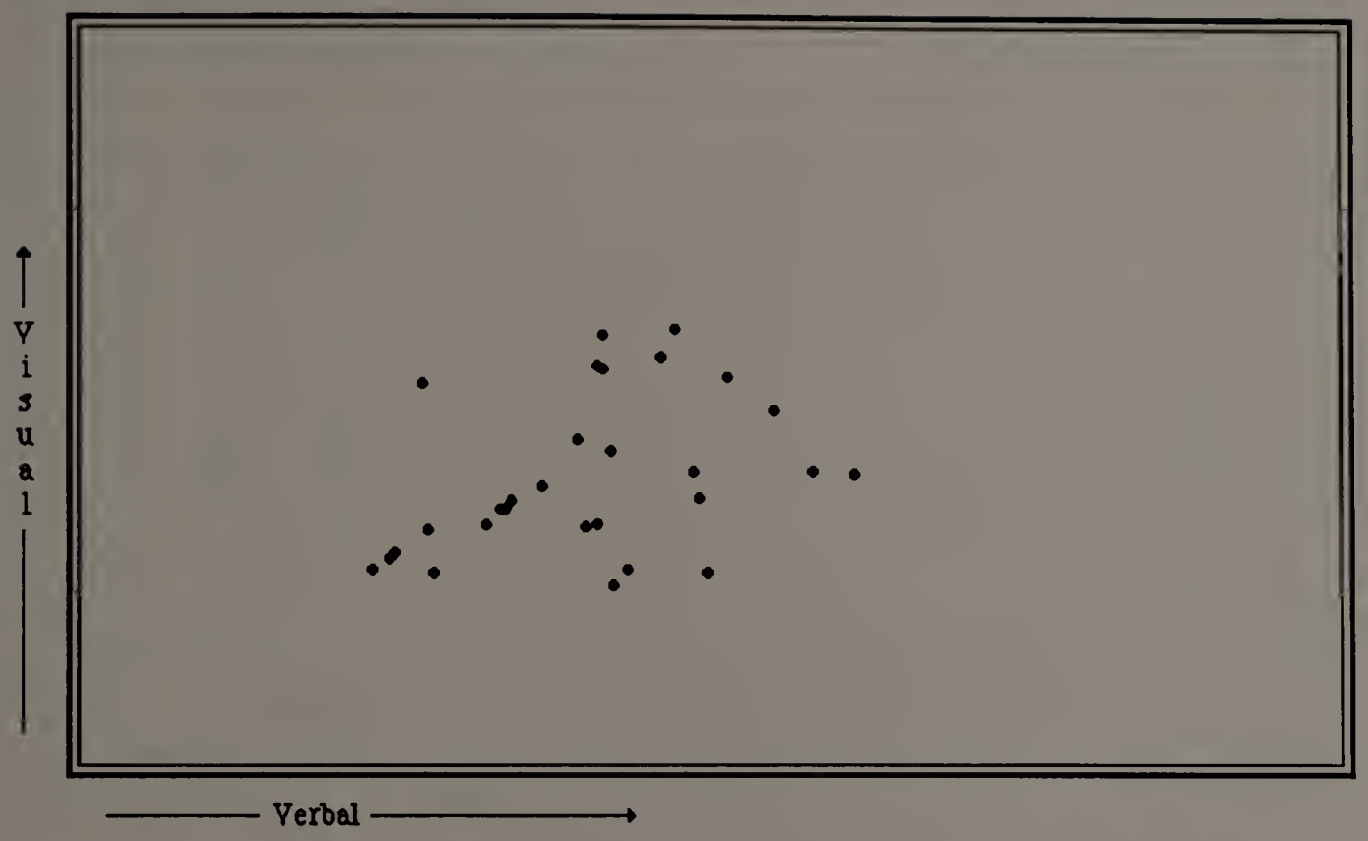
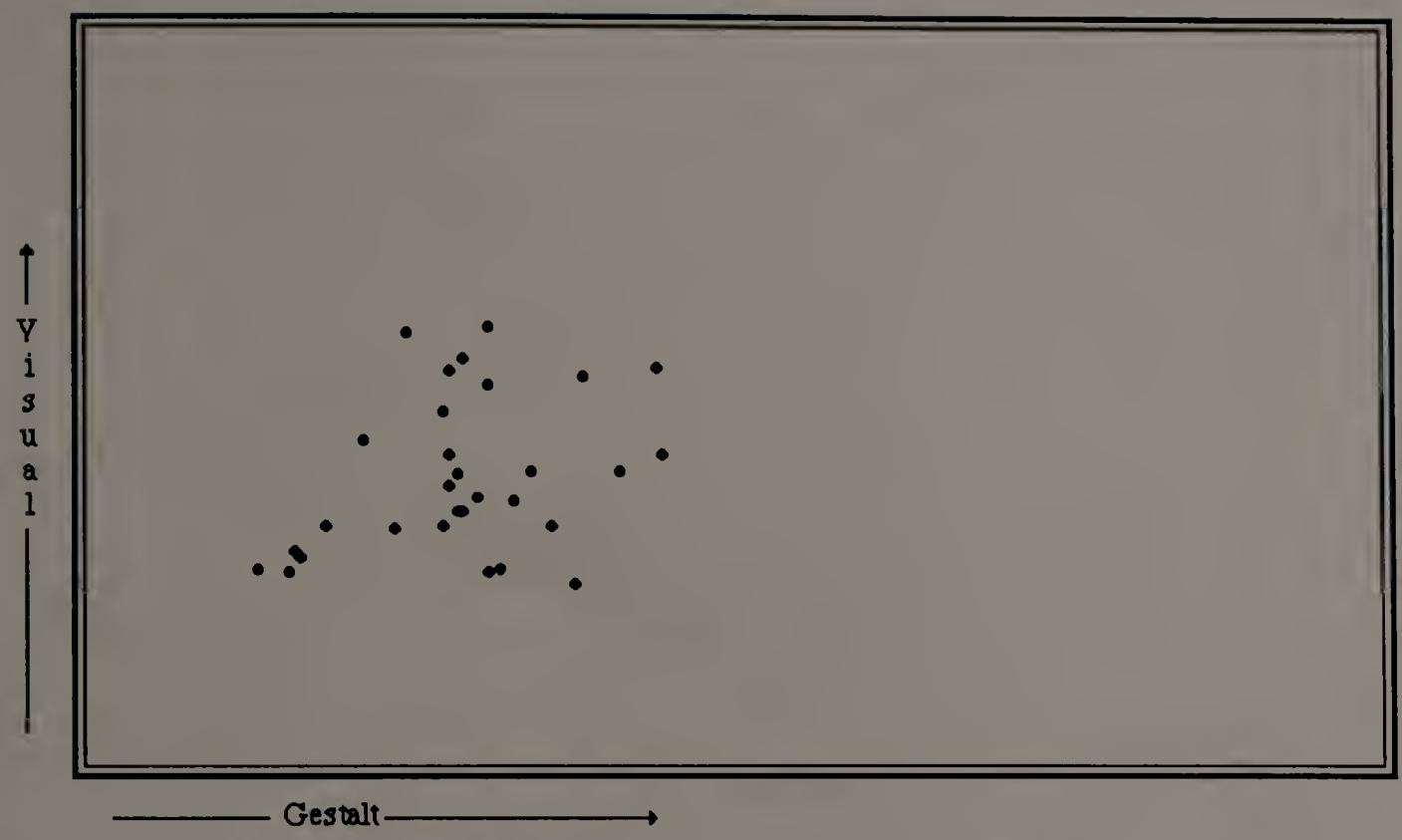
1. See for example, Lacy , O.L. *Statistical Methods in Experimentation.* (1953) New York: MacMillan Co.



	Artist	$\bar{D}$	sd.D	$\bar{T}$	sd.T	Cor
1	J.H.	14.50	4.02	9.08	1.64	0.45
2	P.T.	20.05	2.78	10.31	2.55	0.34
3	A.C.	12.70	4.81	7.97	3.10	0.67
4	G.G.	12.71	3.24	10.20	2.10	0.31
5	M.H.	15.20	2.56	12.16	3.89	-.22
6	C.T.	15.19	2.67	14.58	3.76	-.09
7	Z.G.	15.08	3.15	15.38	2.57	-.58
8	F.G.	11.16	4.36	6.05	2.14	-.12
9	L.E.	22.00	6.06	11.77	1.86	0.23
10	C.C	13.39	2.31	8.28	2.62	0.04
11	T.B.	10.51	2.30	12.43	3.49	-.27
12	D.K	10.60	2.88	5.71	2.10	0.05
13	K.R.	18.09	2.71	13.80	2.54	-.12
14	M.A.	20.59	4.26	11.47	2.26	0.24
15	R.R.	10.55	1.94	10.82	1.94	-.07
16	E.D	11.39	3.08	6.13	2.26	0.06
17	M.N.	13.89	2.85	8.47	2.31	-.09
18	A.W.	16.08	2.22	10.51	2.21	0.18
19	M.L.	9.87	2.22	10.55	2.55	-.06
20	C.C.	20.18	3.66	10.22	1.06	-.04

	Artist	$\bar{D}$	sd.D	$\bar{T}$	sd.T	Cor
21	J.C.	10.43	1.65	6.90	1.74	-.15
22	A.L.	12.47	2.75	6.82	2.05	-.11
23	E.O.	16.08	6.81	10.50	1.61	-.16
24	P.P.	12.63	1.73	10.01	0.04	0.09
25	G.F.	16.68	2.52	9.85	2.03	-.01
26	B.D.	14.01	2.72	12.28	2.15	-.02
27	A.L.	13.39	3.25	8.36	2.25	-.12
28	M.L.	19.67	5.04	12.85	1.73	0.04
29	J.L.	21.69	4.48	10.30	1.63	-.25
30	J.K.	19.40	6.74	6.67	2.79	0.47
☞	Totals	15.01	3.39	10.01	2.23	
☞	Correlation	0.59				

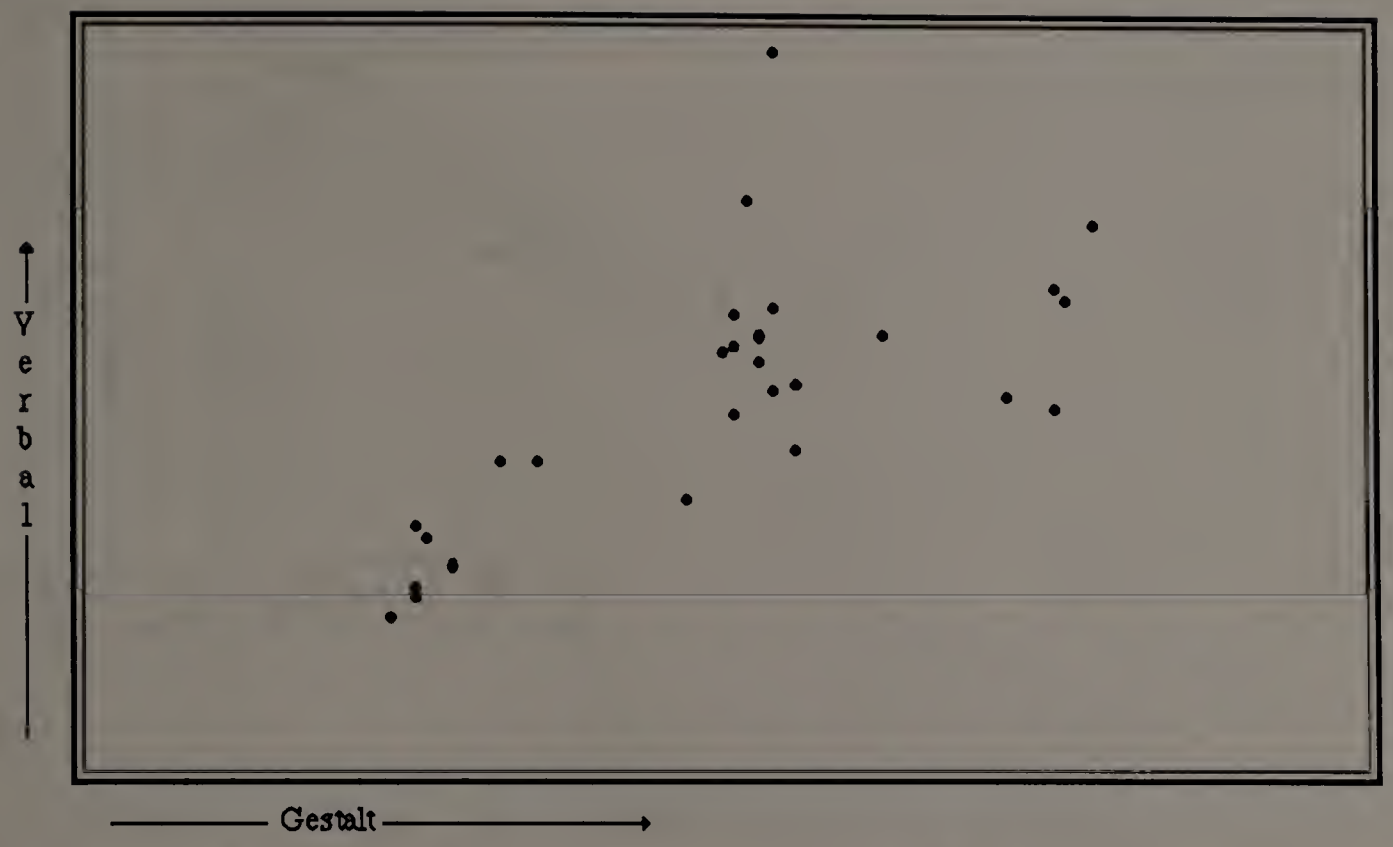
Total Drawing Merit vs. Total Text Merit
Figure 5.15



	Artist	D̄	sd.D	Ḡ	sd.G	Cor
1	J.H.	14.50	4.02	2.19	0.68	0.13
2	P.T.	20.05	2.78	2.19	0.68	-.04
3	A.C.	12.70	4.81	2.15	1.17	0.70
4	G.G.	12.71	3.24	1.42	0.88	-.03
5	M.H.	15.20	2.56	3.23	0.93	0.42
6	C.T.	15.19	2.67	2.69	0.54	0.28
7	Z.G.	15.08	3.15	2.23	0.75	0.35
8	F.G.	11.16	4.36	1.27	0.59	-.18
9	L.E.	22.00	6.06	2.42	0.93	0.47
10	C.C.	13.39	2.31	2.23	0.93	0.15
11	T.B.	10.51	2.30	1.19	0.39	0.03
12	D.K	10.60	2.88	1.00	0.02	0.01
13	K.R.	18.09	2.71	2.15	0.53	0.31
14	M.A.	20.59	4.26	2.27	0.52	0.48
15	R.R.	10.55	1.94	2.50	0.75	-.21
16	E.D	11.39	3.08	1.23	0.58	0.34
17	M.N.	13.89	2.85	2.58	0.74	0.07
18	A.W.	16.08	2.22	3.50	0.64	0.11
19	M.L.	9.87	2.22	2.96	0.71	-.03
20	C.C.	20.18	3.66	3.46	0.63	-.44

	Artist	D̄	sd.D	Ḡ	sd.G	Cor
21	J.C.	10.43	1.65	2.42	1.01	0.18
22	A.L.	12.47	2.75	1.85	0.82	-.09
23	E.O.	16.08	6.81	2.19	0.83	-.02
24	P.P.	12.63	1.73	2.81	0.79	0.23
25	G.F.	16.68	2.52	1.65	0.78	0.30
26	B.D.	14.01	2.72	2.35	0.73	0.27
27	A.L.	13.39	3.25	2.27	0.44	0.01
28	M.L.	19.67	5.04	3.00	0.02	0.05
29	J.L.	21.69	4.48	1.92	1.17	0.13
30	J.K.	19.32	6.95	2.42	0.93	0.79
☞	Average	15.00	3.40	2.26	0.70	
☞	Correlation	0.55				

Total Drawing Merit vs. Gestalt
Figure 5.16



	Artist	$\bar{T}$	sd.T	$\bar{G}$	sd.G	Cor		Artist	$\bar{T}$	sd.T	$\bar{G}$	sd.G	Cor
1	J.H.	21.31	2.33	2.12	0.85	-.04	21	J.C.	12.25	1.78	1.12	0.42	0.00
2	P.T.	24.12	5.91	2.08	0.83	0.33	22	A.L.	12.12	2.16	1.12	0.32	-.02
3	A.C.	15.66	5.59	1.85	0.91	0.70	23	E.O.	22.74	3.74	2.08	0.47	0.57
4	G.G.	17.70	4.04	1.27	0.52	0.61	24	P.P.	20.02	0.08	2.00	0.02	0.69
5	M.H.	17.59	3.94	1.38	0.56	0.53	25	G.F.	21.58	3.73	2.19	0.39	0.29
6	C.T.	31.20	11.52	2.04	0.44	0.20	26	B.D.	25.16	4.79	2.00	0.02	-.17
7	Z.G.	39.07	2.83	2.12	0.58	0.09	27	A.L.	14.36	2.24	1.00	0.02	-.25
8	F.G.	11.06	2.13	1.00	0.02	0.24	28	M.L.	26.58	2.42	3.00	0.02	-.30
9	L.E.	24.23	3.40	2.46	0.57	0.54	29	J.L.	20.42	1.36	3.00	0.02	0.23
10	C.C.	13.74	5.56	1.04	1.06	0.61	30	J.K.	9.63	3.48	0.92	0.27	0.79
11	T.B.	25.51	8.47	2.12	0.32	-.14							
12	D.K	10.67	2.05	1.00	0.02	0.03							
13	K.R.	25.92	3.86	3.04	0.19	0.26							
14	M.A.	29.93	5.20	3.12	0.32	0.31	☞	Average	20.46	3.80	1.90	0.35	
15	R.R.	24.05	4.37	2.08	0.27	-.07	☞	Correlation	0.79				
16	E.D	11.13	2.27	1.00	0.02	-.30							
17	M.N.	18.27	3.30	2.19	0.39	-.01							
18	A.W.	23.62	3.02	2.00	0.02	0.16							
19	M.L.	23.23	6.90	1.96	0.34	0.33							
20	C.C.	21.00	1.52	2.85	0.36	0.49							

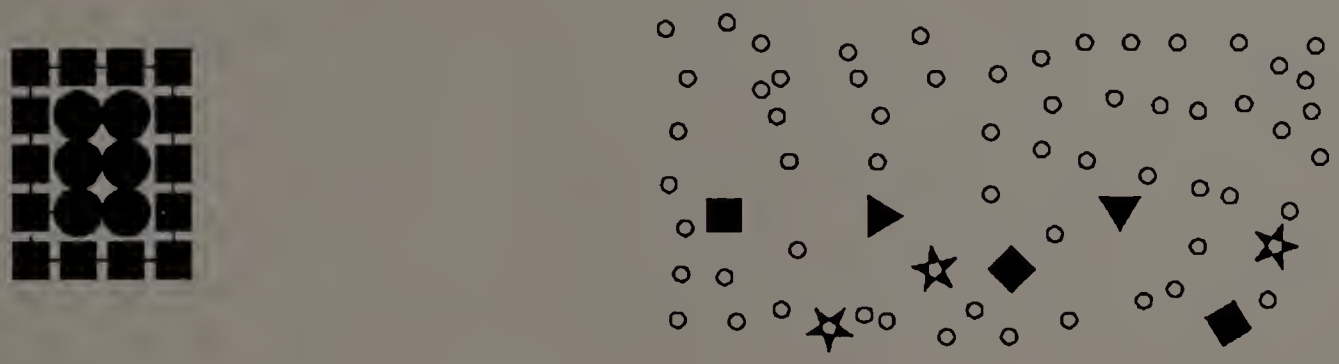
Total Text Merit vs. Gestalt
Figure 5.17

In this set of thirty pairs of variable averages, all the measured variables have been shown to be positively correlated. Measures of *Structure, Embellishment, Abstraction,* and *Gestalt*, for the drawn letters and their associated texts show small positive correlations. A total of *Structure* and *Embellishment*, combined to form *Total Merit,* yields a larger positive correlation. This correlation (R=.59) is significant, supporting the hypotheses of the study. Positive correlations between quantitative measures of Merit and judgments of Gestalt help validate the contention that aesthetic quality may evaluated quantitatively.

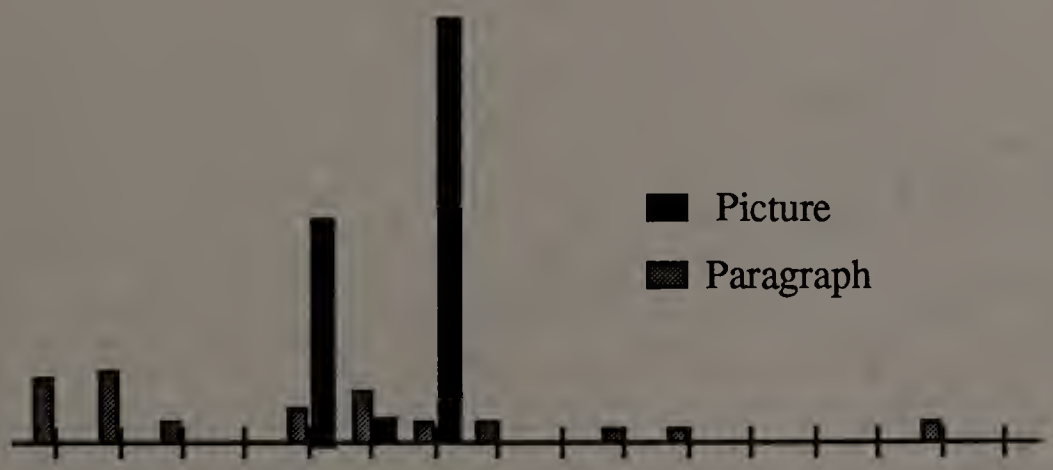
5.3. Computer -composition Pairs

The Computer Compositions have been treated as case studies. Evaluation of these works uses measures of compositional competence in each of the two media investigated. Because these compositions are formulated as scores they may be analyzed in a quantitative manner. The work has been evaluated in terms of sophistication. Three levels of sophistication have been identified. Compositional mastery levels have been measured in terms of quantity and diversity of the resources used at each level. Each of the six composition pairs is discussed below. A short description of the student's work is followed by a graphical comparison of performance levels in drawing composition and paragraph composition. All six composition pairs and the scores which generate them are shown in the appendix.

Two of M.I.'s drawings are shown below. An early drawing, entitled "JAIL", is locked in symmetry. It typifies composition at a low level. The second drawing, used for the comparison with the paragraph, shows growth in technique and interest. Because no high level naming was used, all the information for this drawing was pressed into one Logo procedure. The data for this drawing was scaled by a third to control the artificially large number of commands in this single procedure. Competent use of resources at only one level yielded a successful composition which seems free of the mechanical constraints of the computer. Although this drawing was expressed using only the central level, the paragraph was composed over a broad range of levels and a case could be made for balance in M.I.'s compositions.



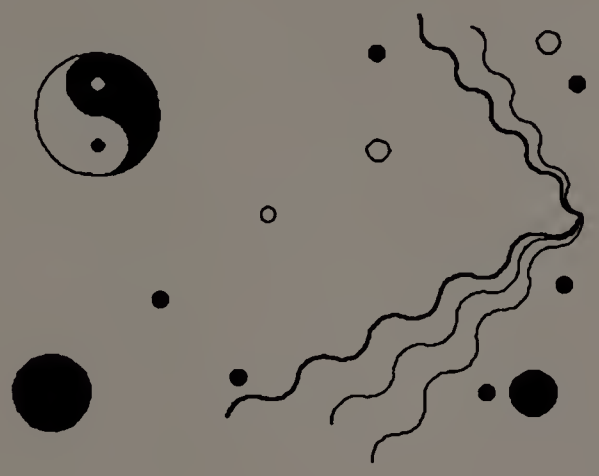
The warm female human object moves the good institution with a pretty song. Earth connects roads equivalent joyous love inside a violent fire. The leader neglects the true question and walks around the young creatures yard. The journey knows nothing and feels through money.



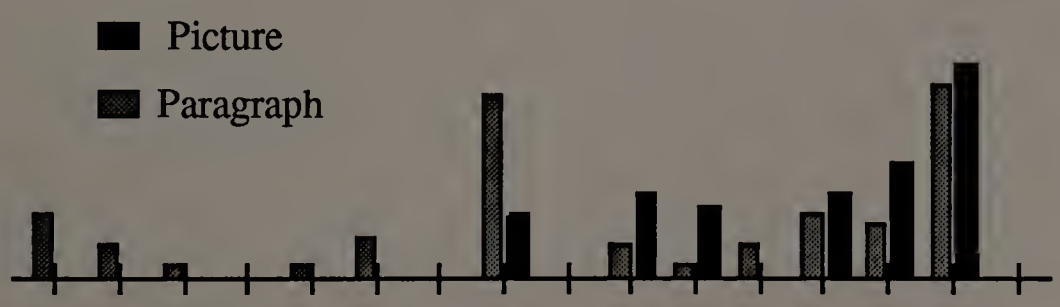
M.I.'s Compositions

Figure 5.18

Sustained effort and aesthetic sensitivity are evident in both compositions of this pair. The level at which the works were composed is very high. Both the drawing and the paragraph show substantial sophistication. K.G. chose not to follow any guide so the motivation for subject matter is not known. A balance of compositional skill is evident.



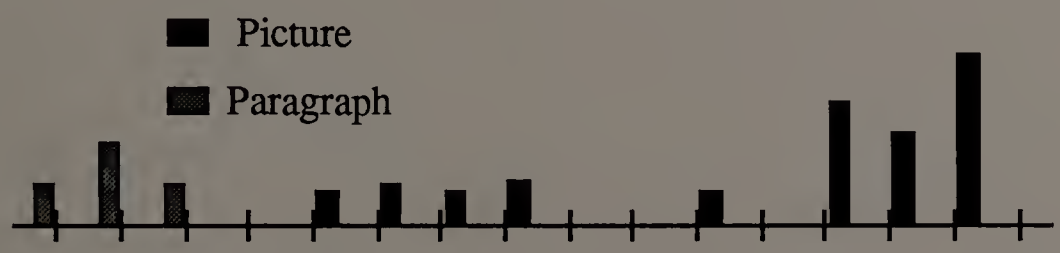
The roads which some human creatures move on quickly are dangerous to the journey which builds knowledge. The human creature which walks truely on the roads building real knowledge feels it is a journey to fire. Good institutions which build knowledge connect leaders which love all knowledge with human creatures with questions. Human creatures which really think goe on to verifie knowledge in the institutions on earth and possess money and knowledge.



K.G.'s Compositions
Figure 5.19

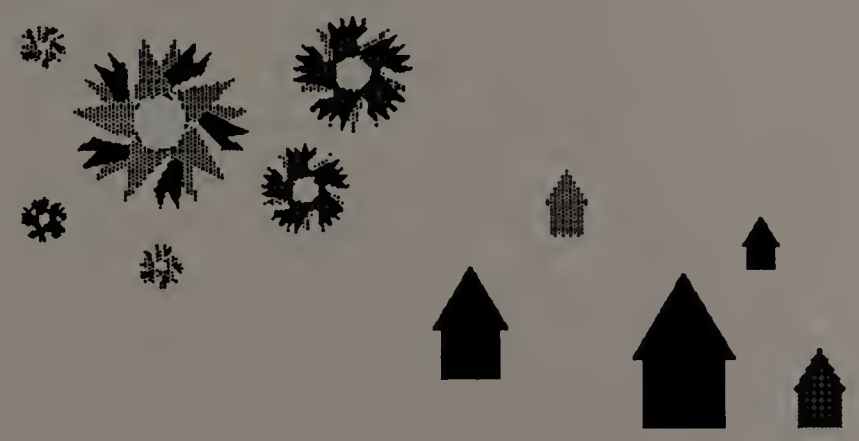
Based on the guide sentence "The big ones eat the little ones, the little ones eat the tiney ones, the tiney ones flee", this drawing shows a high level of sophistication in the use of resources and considerable aesthetic control. The paragraph is composed in the simplest possible manner, defining only noun phrases and verb phrases. These compositions are not balanced, so D.K.'s work does not support the hypothesis of balanced compositional skill. From classroom observation it is known that weakness in the paragraph is in part due to a lack of time to work on it. The drawing was made first and interest in it pushed the paragraph too close to a deadline.

Inside the hole the young female moves through the liquid. The warm water feels good on a human. The pretty female hears and sees the vehicle on the road.

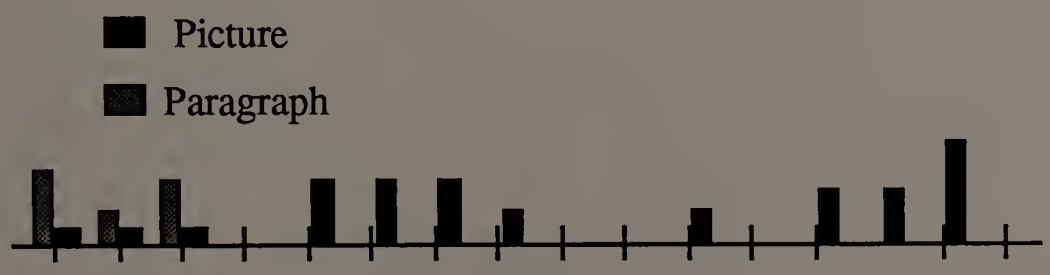


D.K.'s Compositions
Figure 5.20

The similarity of the graph of A.P.'s composition features with D.K.'s graph indicates the same strengths and weaknesses. Students were encouraged to help each other, and these students did. It was a healthy cooperation and the compositions are appropriately individualistic. A.P. followed the guide sentence "Stars watch a village nestled in the valley". None-the-less, the level and pace at which the two students worked was closely synchronized. The inspiration for the paragraph remains as obscure as the paragraph itself.



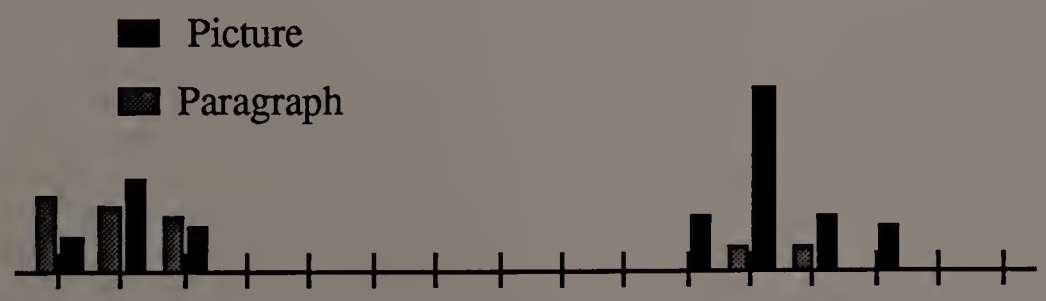
The young zealot acts on knowledge and loves. Knowledge sees all around the earth. Loves builds dangerous institution. All creature knows loves journey.



A.P.'s Compositions
Figure 5.21

D.P's drawing is clearly stronger than her paragraph. In the classroom she expressed concern about her ability with the linguistic composition, and postponed it as long as possible. In spite of the relatively less effort spent on the paragraph, the compositions show balance.

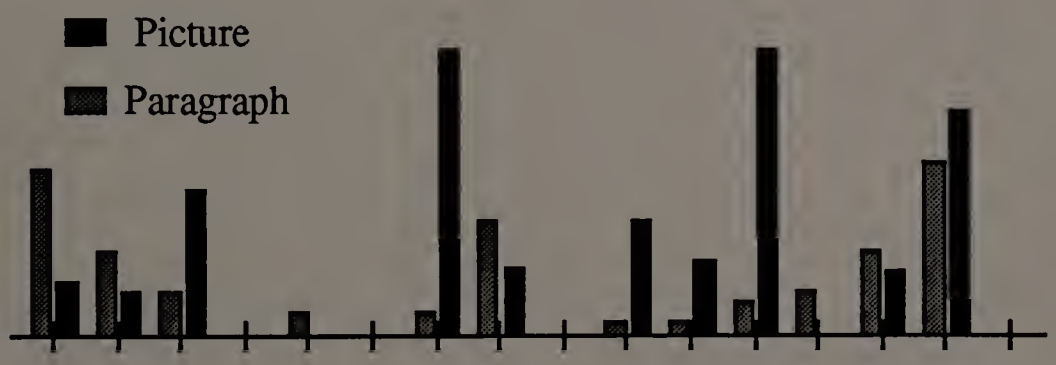
The true dangerous creature possesses all knowledge. The true dangerous creature sees the group and hears all. Fire and the institution is successor to the leader.



D.P.'s Compositions
Figure 5.22

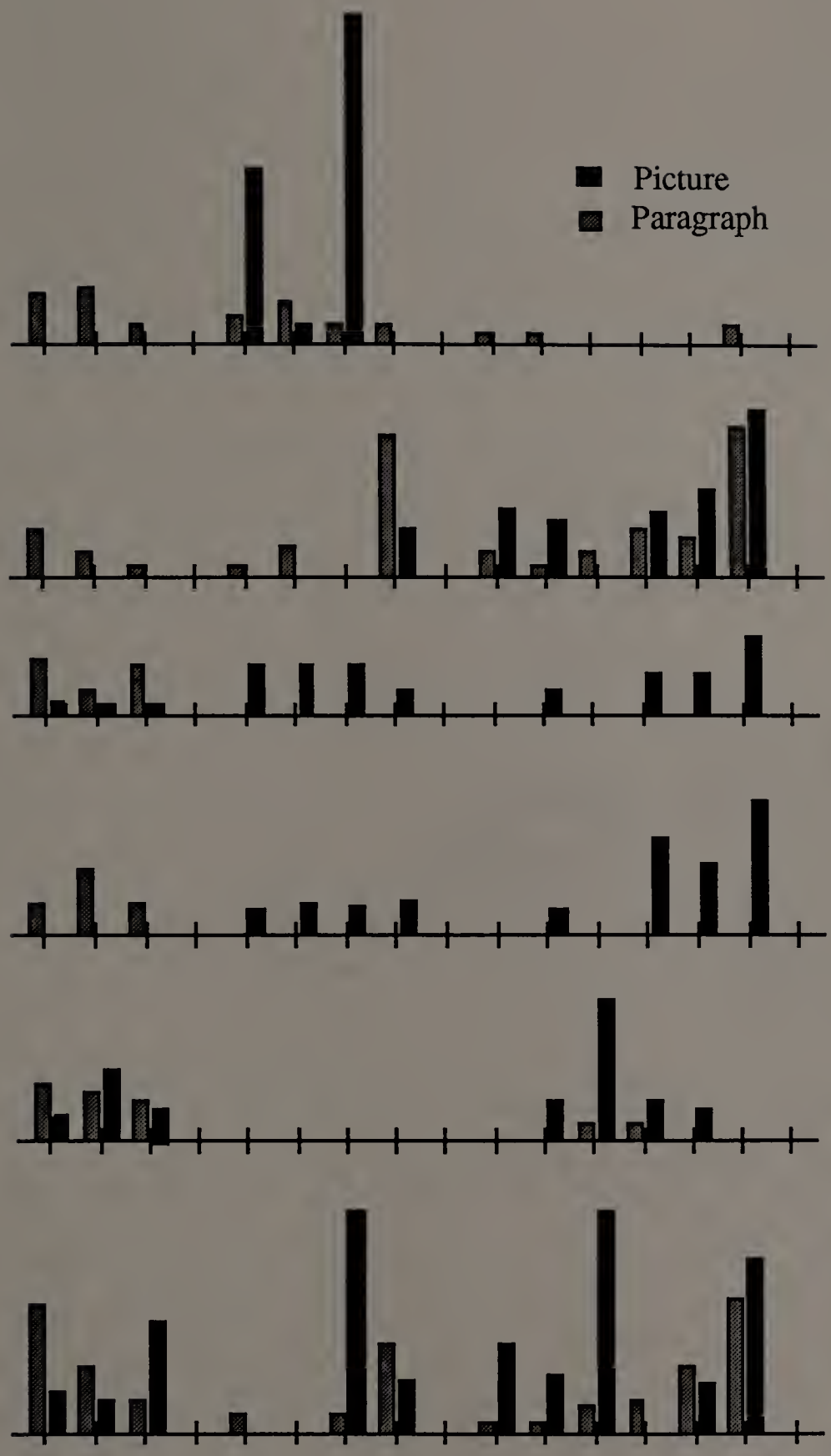
These compositions show competent use of resources and are quite balanced. While both compositions demonstrate a substantial quantity of effort, the paragraph is perhaps most successful aesthically. F.F. chose a guide picture "Haulin' Fish" for this paragraph but followed her own inspiration for her "Winter Scene". "Haulin' Fish", shown in figure 5.15 , demonstrates motivation for choice of subject matter. This composition pair supports the hypothesis that visual and verbal compositional skill is generally balanced in an individual artist.

The big vehicle moves uniformly on a warm metal road. The creature which is on the inside journeys quickly through the institution which builds completely with knowledge. A group which resides dangerously under some warm water goes not through the institution which builds completely with knowledge. Some knowing nothing truely eat earth creatures which move violently around on a metal object which zaps through completely.



F.F.'s Compositions
Figure 5.23

These results are preliminary because the sample is small and strong control of the variables had not been yet been established. Because the researcher is evaluating effects of his own work, researcher bias has some effect. The composition pairs, which are the basis for this part of the study, were obtained in a class where the idea of producing drawing-paragraph pairs in this manner was first introduced. The paragraph-building was a completely new idea, thus expectations were not yet well defined. As with any attempt to study student proficiency, the quality of these compositions was sensitive to classroom management and teacher bias. An analysis of scores reveales a broad range of sophistication across the six pairs of computer compositions. Figure 5.23 is a collection of all six comparisions. When time management problems led to inordinate emphasis on drawing, the drawing ended up as the better composition. Where there was a uniformity of time commitment, each individual's pair of computer compositions tended to show consistent quality. In spite of its inherent limitations, this small sample provides tantalizing if not convincing evidence which supports the positive correlations found in the picture book component of this study. Together these results support the general hypothesis that individual students' verbal and visual compositional skills are likely to be consistent. It is of equal (or greater) importance that this study has explored a new analytical technique. The symbolization of compositions in terms of scores provides a viable basis for quantitative analysis of aesthetic merit. This study has only begun to exploit the potential of the **score** as an analytical tool.



Composition Comparisons
Figure 5.24

5.4. Summary of Results

An inspection of a collection of thirty picture books made by students gives an impression that, although there is a wide range of quality across the collection, individual books show consistent quality in both drawing and writing. To support this impression a correlation study was done on the collection of books. In this collection of thirty picture books eight measures of feature quantities and two subjective measures of quality were collected for each letter (26) of each book. All feature pairs were tested for correlation in each book. There were exceptions, but in general no significant correlation was found between measures of text quality and drawing quality in individual books. When the features were summed over all thirty books patterns began to emerge. For a sample of thirty pairs, a correlation coefficient above .47 may be taken to show a correlation significant at the 0.01 level. Though all eight measures showed positive correlations between drawing and text features, only the subjective measure (Drawing Gestalt vs. Text Gestalt; R = 0.55) showed a correlation strong enough to be considered significant. When measures of Structure and Embellishment were created by summing individual features, the correlations were somewhat higher (Drawing Structure vs. Text Structure; R = 0.22 and Drawing Embellishment vs. Text Embellishment; R = 0.24) , but still not significant. When eight measures of feature quantity are summed to form a measure of Total Merit, the correlation between Total Text Merit and Total Drawing Merit was significant (R = 0.59). To test the validity of the measure of Total Merit, its correlation with the judgmental measure of Gestalt was determined. The Total Drawing Merit vs. Drawing Gestalt showed a positive correlation of R = 0.55 whereas the Total Text Merit vs. Text Gestalt showed a positive correlation of R = 0.79; both correlations are significant above the 0.01 level.

Only six composition pairs were collected and no correlation study was done. Four of the pairs indicateshow a balance. Two show substantially more attention to drawing than writing. These are the work of students who worked together quite closely and ran out of time. With this exception, the composition pairs follow a pattern similar to the pattern seen in the alphabet book collection, a tendency for individuals to show consistent quality in their drawing and writing.

5.5. Suggestions for Future Research

Although process is hinted at in the structure of written scores, combining student interviews with analyses of scores might shed additional light on process and help validate analysis techniques. Time series experiments might be developed in which some participants first compose in a visual medium and later compose in a verbal medium; whereas other participants would work in reverse order. The resulting compositions could then be evaluated to see whether previous experience in one medium improves performance in the other.

The work of established artists could be studied. Where artists have worked in more that one medium, visual-verbal comparisons might be made. Kandinsky, for example, created a book of poems (*der Klang*) which contains wood cuts along with text. Collecting existing sets of sufficiently similar work by different artists seems unlikely. On the other hand, a careful definition of constraints on scope and direction might be used to guide artists in the creation of new works in disparate media which might then be compared. Professional artists have generally been trained preferentially in the use of one medium, and their work is likely to exhibit a sophistication difficult to evaluate. This suggests that work with naive artists could be expected to be more fruitful. Adult learners are potential participants in studies of general compositional competence. Adults bring a wealth of experience, insight, and sophistication which enhance (and confuse) learning research. Children are perhaps ideal candidates for participation in such studies. They are accessible in schools and they are in the midst of the process of learning. Can the teaching of compositional skills in visual art affect students' compositional skill with language? Proficiency in verbal composition might be associated with a presence or absence of previous experience in an art class. Similar studies in the transfer effects of music education are possible.

5.6. Conclusion

This study addresses the potential of the computer as a general tool for composition. Three distinct systems for composition have been used by students whose work this study examines. All share the distinction of being small symbol systems within which students can explore composition. (Papert has given the name *Microworld* to this kind of learning environment.)

One of these microworlds takes the Alphabet as its fundamental set of abstract symbols. The drawn letters have visual importance and each one points to an infinity of meanings. Students using this microworld produced alphabet books containing drawn letters and related text. A study of these picture-text pairs shows a positive correlation between the quality of the drawing and the quality of the writing. A computer microworld (AutoMOVE) consists of a visual vocabulary of basic shapes embedded in a subset of the computer language Logo. Compositions from this microworld are pictures constructed from a vocabulary of shapes, compositions in the traditional sense. The second computer microworld used here (ComPOSER) is a linguistic world containing a very limited vocabulary and a small set of grammatical rules. Students compose paragraphs in this microworld. Each paragraph is constructed from the inside out, beginning with "deep structure" (in the sense used by Chomsky), then building to a complete surface structure by operating on the vocabulary words with the replacement and transformational rules of the grammar. Although the number of composition pairs is small (six), a pattern of consistent quality for individual artists may be seen.

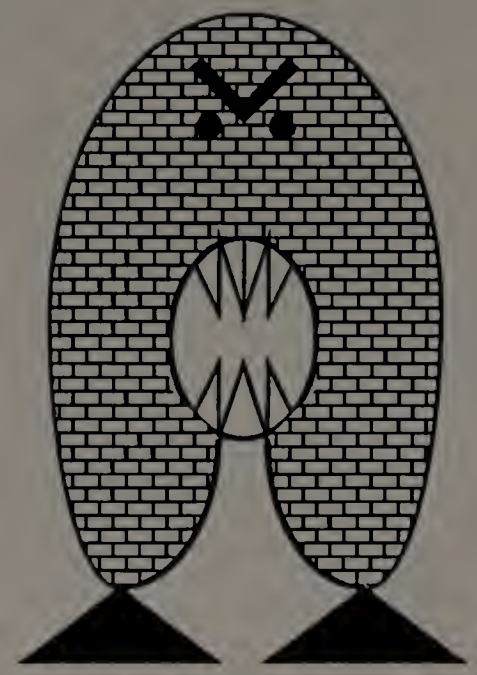
All three worlds, though technically quite different, emphasize the development of compositional skill. All use the computer as primary tool. This study has examined the work of student composers and attempted to quantify the quality of their compositions. Aesthetic merit is often assumed to be unmeasurable, yielding only to some human faculty which is essentially mysterious. Wide spread familiarity with electronic computers, memory limitations, and the limited visual resolution of video displays, has helped create new perceptions of human limitations and potentialities. For example, the direct relation between the quality (resolution) of a computer-generated image and the memory requirements inherent in its production emphasize the link between quality and quantity. A large part of the value of art is in the quantity of its information, the richness of its structure, and the density of its detailing. Valid measurement of these features of simple works of art seems within reach. This study of picture-text pairs shows a positive correlation between the quality of the drawing and the quality of the writing. A natural next step would be to search for a causal relationship between learning compositional skill in a visual medium and compositional production in a verbal medium.

APPENDICES

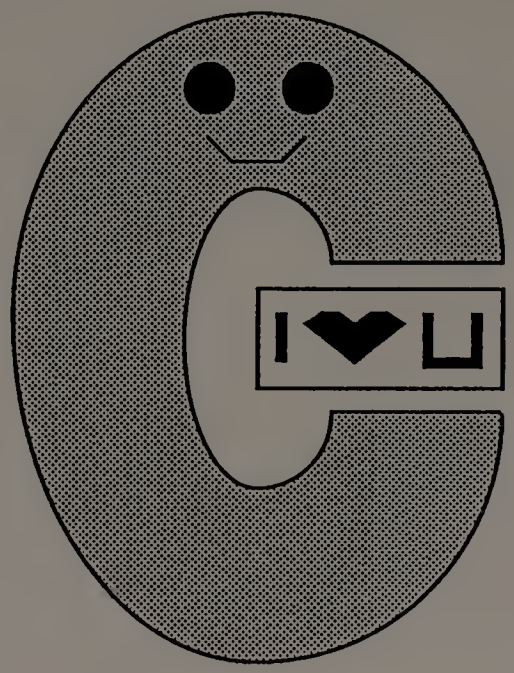
APPENDIX A
M.L.'S ALPHABET BOOK

This a complete alphabet book. When these pages are folded together they produce a half-size book with the alphabet letters in standard order.

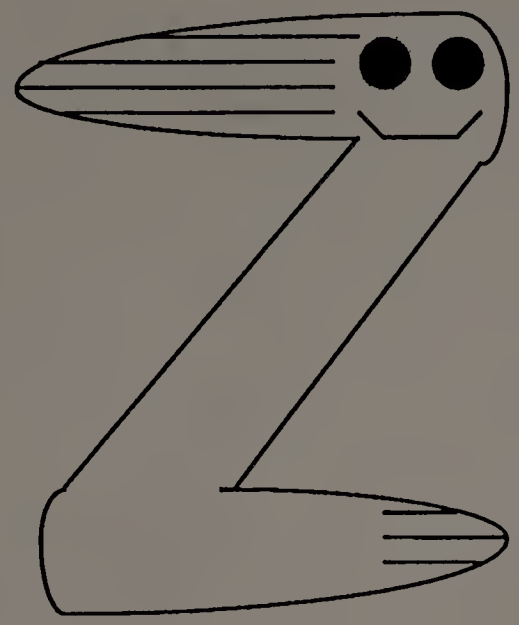
M_____'S
ALPHABET
****
*
COMPUTERS
&
SOCIETY
****
*
S.T.C.C. 1989



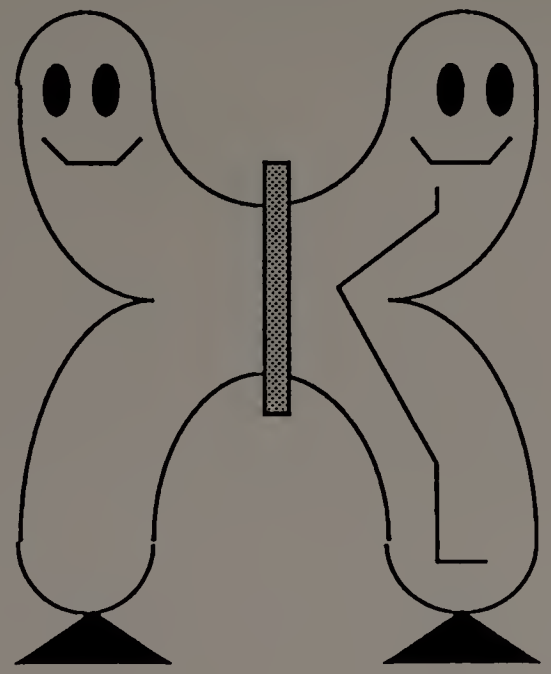
A IS FOR ANGRY.
(VERY MAD)
THE ANGRY CAB
DRIVER CURSED AT
THE TRAFFIC.



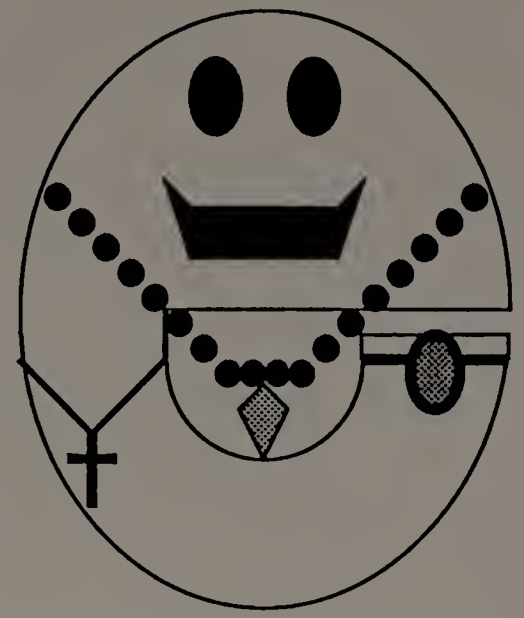
C IS FOR CARING.
(THOUGHTFUL)
MY GRANDMA IS A
VERY CARING LADY
AND I LOVE HER.



Z IS FOR ZEALOUS.
(ENERGETIC)
THE ZEALOUS CHIL-
DREN JUMPED IN THE
PILE OF LEAVES.

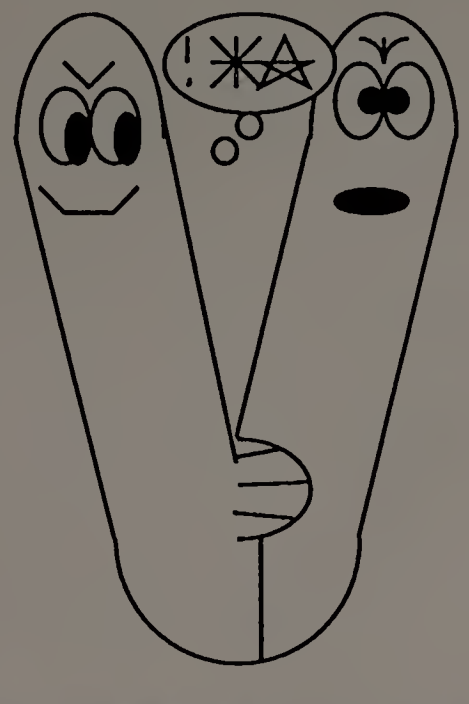


X IS FOR X-RAYED.
(VIEWED INSIDE)
THE BOY WHO WAS X-RAYED HAD A BROKEN ARM.

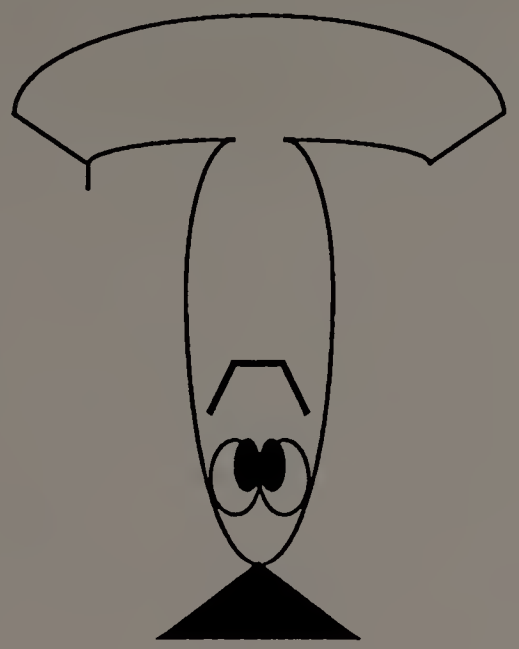


E IS FOR ELEGANT.
(SOPHISTICATED)
PRINCESS DIANA IS A VERY ELEGANT LADY.

G IS FOR GROUCHY.
(MEAN AND NASTY)
THE GROUCHY OLD
MAN YELLED AT ME.



V IS FOR VULGAR.
(OBSCENE)
THE RUDE BOY MADE A
VULGAR REMARK TO
HER.

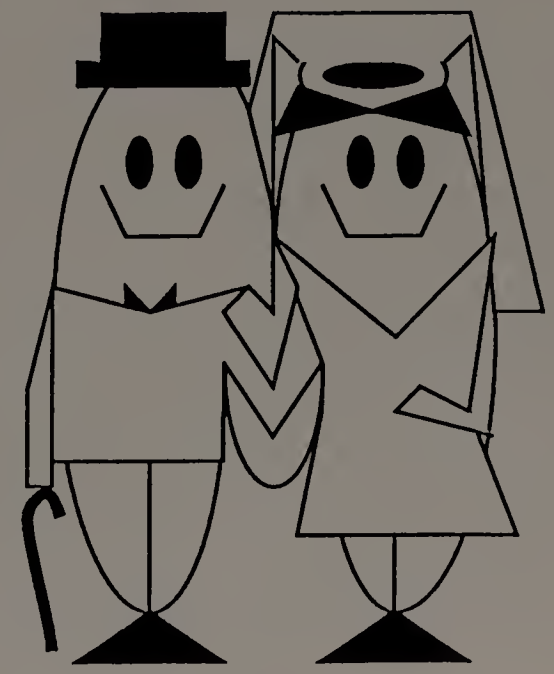


T IS FOR TERRIFIC.
(EXCELLENT)
THE GYMNAST IS TERRIFIC AT HEAD STANDS.

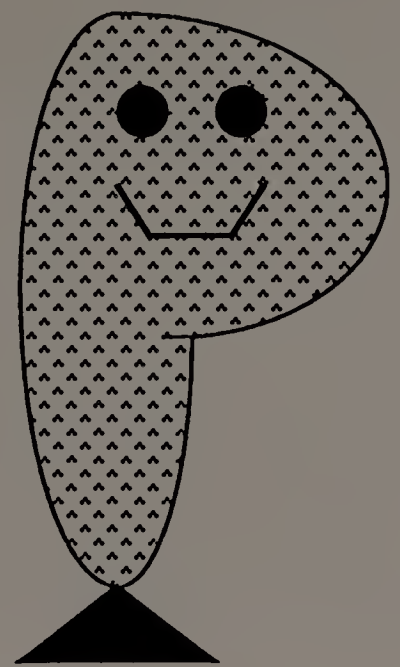
I IS FOR INDEPENDENT.
(SELF-RELIANT)
WOMEN OF THE 1980'S ARE INDEPENDENT.

K IS FOR KISSING.
(TOUCHING LIPS)
THE NEWLYWEDS
WOULD NOT STOP
KISSING.

R IS FOR ROTTEN.
(OFFENSIVE TO SMELL)
THE NEW BOY AT
SCHOOL SMELLED OF
ROTTEN EGGS.



M IS FOR MARRIED.
(JOINED AS ONE)
THE BRIDE AND
GROOM WERE MAR-
RIED ON SATURDAY.



P IS FOR PLEASANT.
(KIND AND NICE)
THE GIRL ACTED IN A
PLEASANT WAY TO THE
TEACHER.

B IS FOR BEAUTIFUL.
(GORGEOUS)
MISS AMERICA IS
VERY BEAUTIFUL.

Computers & Society

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STCC Fall 1989

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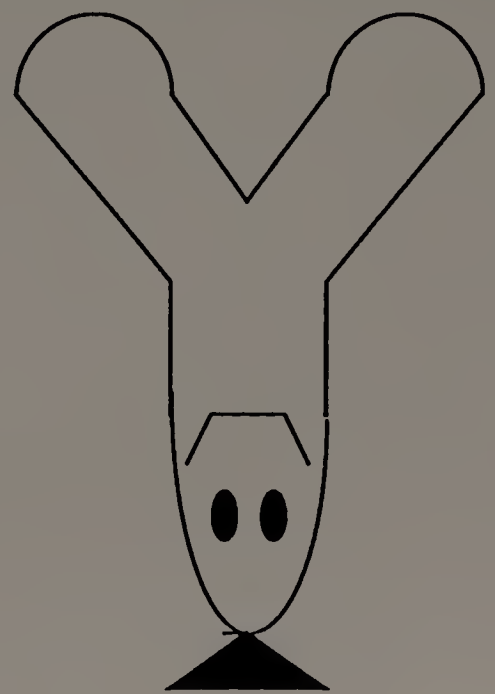
M_____

L_____'S

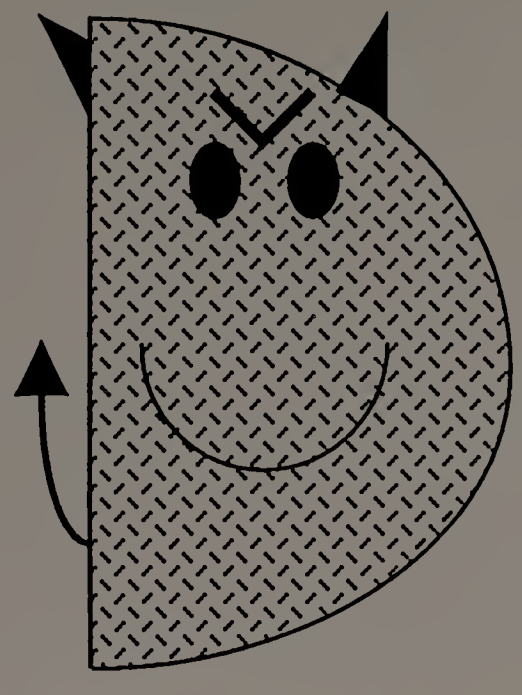
ALPHABET

^^^^^^^^^^^^^^^^^^

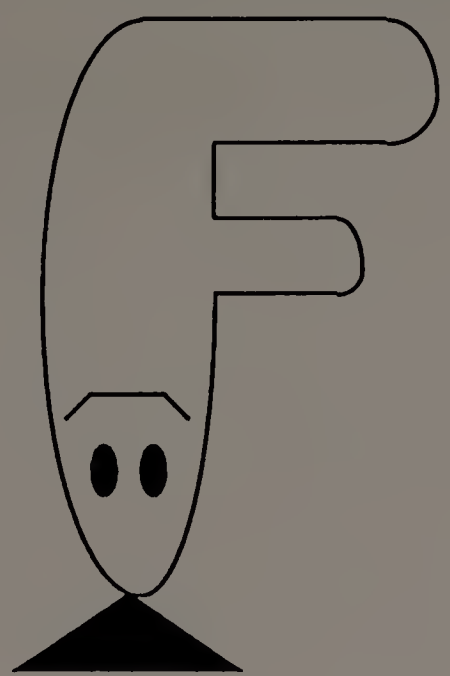
TUESDAY/THURSDAY
~~~~~~~~~~~~~~~~~~~~



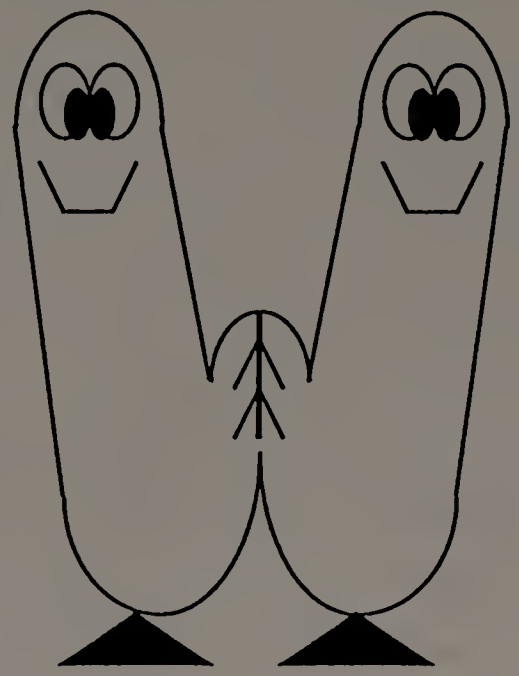
Y IS FOR YOUTHFUL.
(YOUNG, ENERGETIC)
A PERSON WHO IS
YOUTHFUL IS FULL OF
PEP.



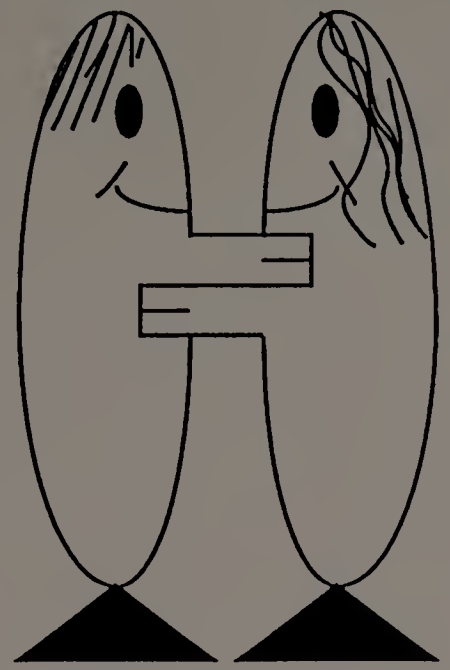
D IS FOR DEVILISH.
(SNEAKY)
A CHILD WHO CAUSES
TROUBLE IS VERY
DEVILISH.



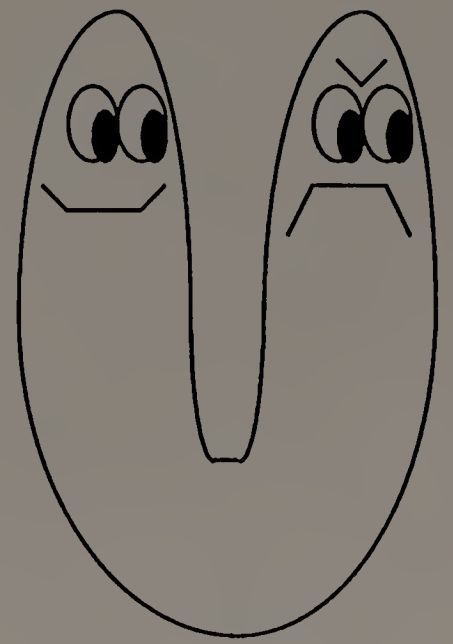
F IS FOR FUNNY.
(SILLY)
A FUNNY PERSON IS
SOMEONE WHO CAN
MAKE YOU LAUGH.



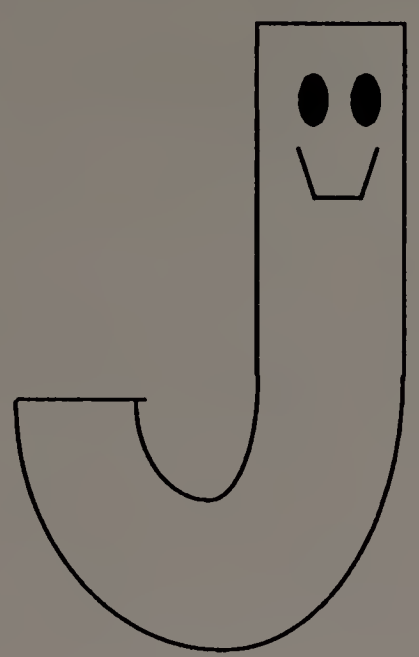
W IS FOR WINNERS.
(CHAMPIONS)
THE TEAM WHO WON
THE RACE ARE ALL
WNNERS.



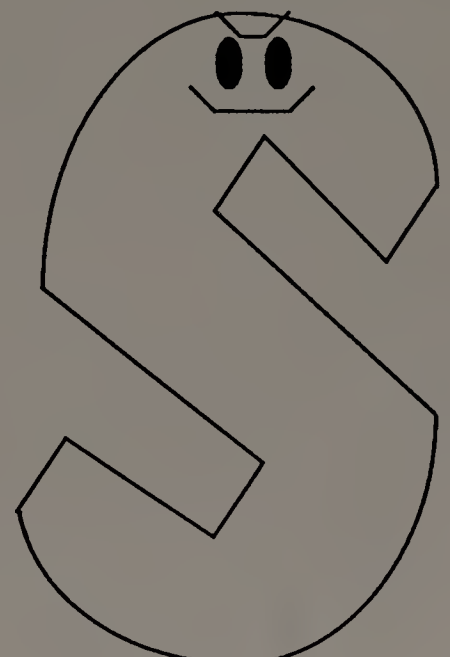
H IS FOR HUGGABLE.
(SQUEEZABLE)
A MOTHER IS A HUG-
GABLE PERSON.



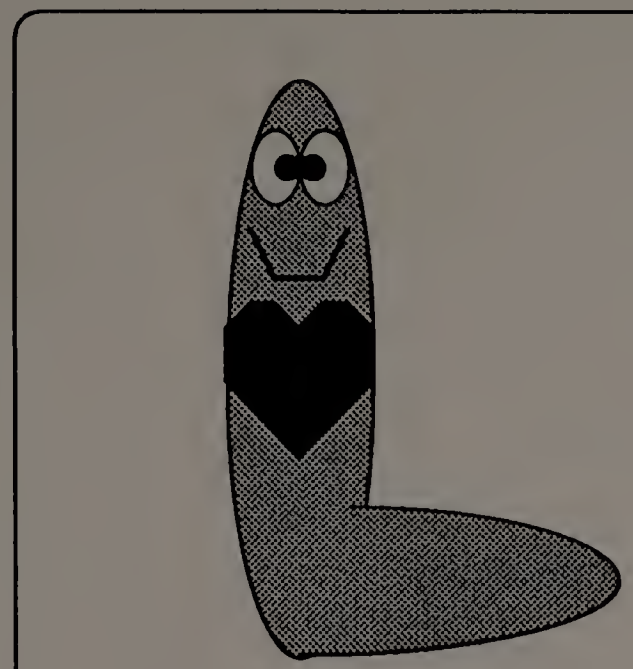
U IS FOR UNFRIENDLY.
(NOT NICE)
THE KIDS AT SCHOOL
WERE UNFRIENDLY.



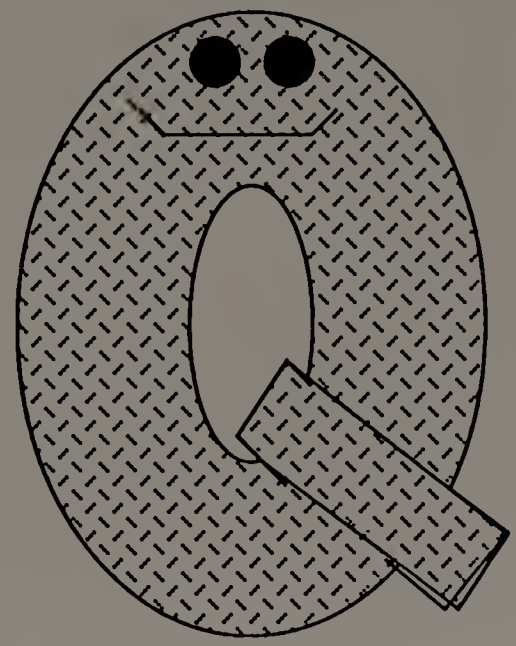
J IS FOR JOYFUL.
(HAPPY)
SANTA CLAUS IS A
VERY JOYFUL PERSON.



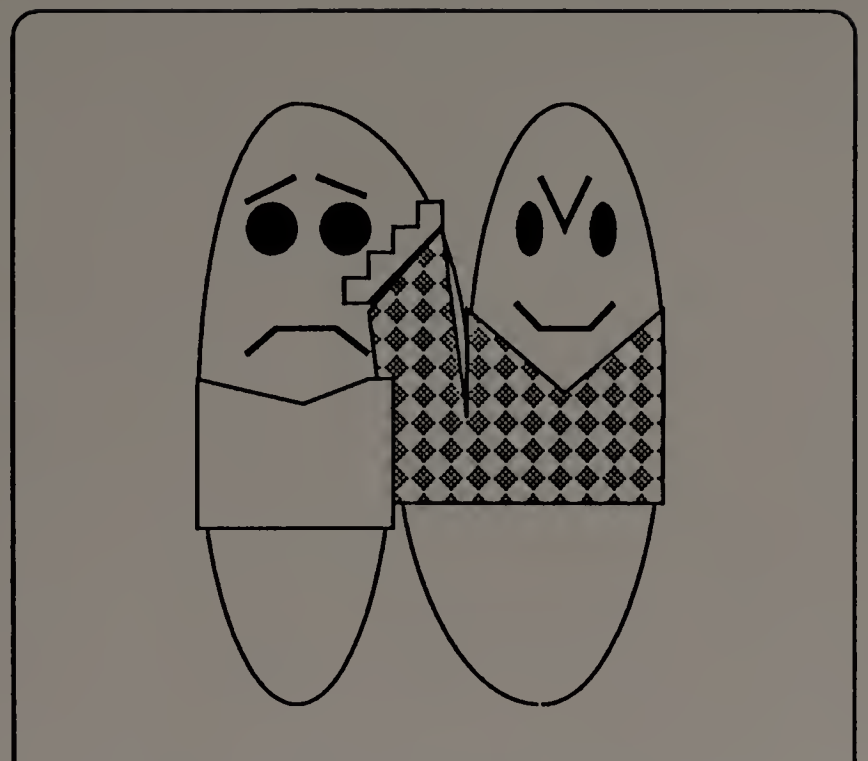
S IS FOR SLY.
(UNDERHANDED)
THE SLY POLITICIAN
DOES DISHONEST
DEEDS.



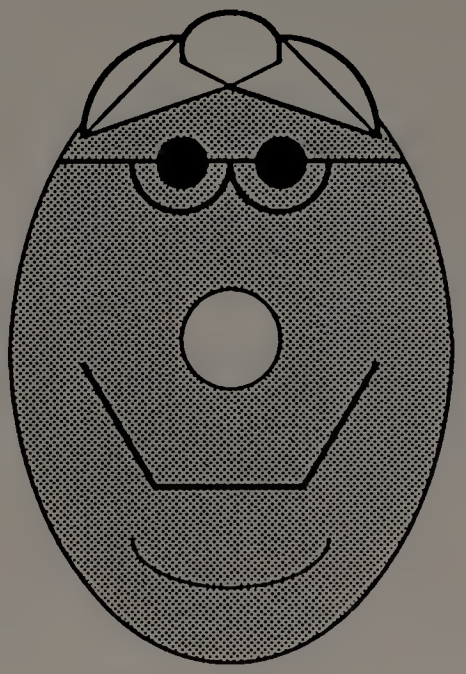
L IS FOR LOVABLE.
(CARING AND NICE)
MY TEDDY BEAR IS
VERY LOVABLE.



Q IS FOR QUIET
(NOT NOISY)
A PERSON MUST BE
VERY QUIET IN THE LI-
BRARY.



N IS FOR NAUGHTY.
(VERY BAD)
THE BOY WHO
PUNCHED ME IS
NAUGHTY.



O IS FOR OLD.
(AGED)
THE OLD WOMAN
HAD WHITE HAIR AND
BIFOCALS.

Appendix B

Alphabet Book Data

A.C.

Drawing

	pt	vr	sd	sl	fo	3d	ed	ln	ab	gt	sumD
a	3	5	2	0	0	0	0	2	2	3	12.0
b	3	5	2	2	0	0	0	2	2	2	14.0
c	3	6	2	2	0	0	0	2	2	3	15.0
d	1	4	1	0	0	0	0	2	2	1	8.0
e	3	8	2	0	0	0	0	2	2	2	15.0
f	2	7	2	0	0	0	0	2	3	3	13.0
g	1	11	1	1	0	0	0	2	2	1	16.0
h	2	6	2	0	0	0	0	2	4	3	12.0
i	1	8	1	0	0	0	1	0	1	1	11.0
j	4	8	2	0	0	0	0	2	2	4	16.0
k	5	6	2	0	0	0	0	2	3	3	15.0
l	1	8	1	0	0	0	1	1	1	1	12.0
m	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	0.0
n	4	10	3	0	0	0	0	2	3	3	19.0
o	2	4	2	0	0	0	0	2	2	2	10.0
p	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	0.0
q	3	4	1	0	0	0	0	2	2	1	10.0
r	2	8	2	0	0	0	0	2	1	1	14.0
s	2	6	2	0	0	0	0	2	4	3	12.0
t	1	8	1	0	0	0	1	0	1	3	11.0
u	3	5	3	0	0	0	1	2	4	2	14.0
v	1	10	1	0	0	0	0	0	1	2	12.0
w	5	12	3	0	0	0	1	2	4	4	23.0
x	5	9	3	0	0	0	0	2	3	3	19.0
y	3	8	2	0	0	0	0	2	3	4	15.0
z	3	6	2	0	0	0	1	0	1	1	12.0

Text

	wr	lt	pt	vb	mt	ry	wm	pm	ab	gt	sumT
a	11	6	1	2	0	0	2	2	3	3	10.0
b	5	5	1	1	0	0	2	0	3	2	7.0
c	6	6	1	1	0	0	1	0	3	3	7.0
d	3	8	1	1	0	0	0	0	3	1	8.0
e	4	10	1	2	0	0	0	1	4	1	11.0
f	5	6	1	1	0	0	2	0	4	1	8.0
g	6	6	1	1	0	0	1	0	3	2	7.0
h	4	5	1	1	0	0	1	0	4	3	6.0
i	9	7	1	2	0	0	1	2	2	2	10.0
j	6	6	1	1	0	0	1	1	3	2	8.0
k	7	7	1	3	0	0	0	1	2	2	8.0
l	4	4	1	1	0	0	0	1	4	1	5.0
m	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	0.0
n	6	6	1	2	0	0	1	1	3	2	8.0
o	4	8	1	1	0	0	1	0	3	1	9.0
p	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	0.0
q	6	5	1	2	0	0	0	1	3	1	6.0
r	5	6	1	1	0	0	2	0	3	1	8.0
s	7	9	1	1	0	0	2	0	3	2	11.0
t	6	9	1	1	0	0	2	0	0	3	11.0
u	8	8	1	1	0	0	2	1	1	3	11.0
v	4	8	1	1	0	0	1	0	3	2	9.0
w	3	9	1	1	0	0	0	0	3	2	9.0
x	5	8	1	1	0	0	1	3	3	2	15.0
y	7	5	1	2	0	0	3	0	1	3	9.0
z	12	6	1	2	0	0	1	3	1	3	6.0

G.G.

Drawing

	pt	vr	sd	sl	fo	3d	ed	ln	ab	gt	sumD
a	3	4	2	0	0	0	0	1	1	2	10.0
b	3	12	2	0	0	0	0	2	1	1	19.0
c	1	12	2	0	0	0	0	0	1	1	15.0
d	3	6	2	0	0	0	0	1	1	1	12.0
e	1	12	2	0	0	0	0	0	1	1	15.0
f	2	7	2	0	0	0	2	1	1	1	14.0
g	1	15	2	0	0	0	0	1	1	1	19.0
h	3	4	2	0	0	0	0	1	1	1	10.0
i	3	7	2	0	0	0	0	2	1	1	14.0
j	2	8	2	0	0	0	2	2	1	2	16.0
k	3	6	2	0	0	0	0	1	1	1	12.0
l	2	6	2	0	0	0	1	1	1	1	12.0
m	3	4	2	0	0	0	0	2	2	3	11.0
n	2	4	2	0	0	0	0	1	1	1	9.0
o	2	1	2	0	0	0	0	0	1	1	5.0
p	2	6	2	0	0	0	0	1	2	2	11.0
q	3	5	2	0	0	0	0	0	1	1	10.0
r	3	5	2	0	0	0	0	1	2	1	11.0
s	5	4	2	0	0	0	2	1	1	1	14.0
t	2	6	2	0	0	0	0	1	1	1	11.0
u	1	10	2	0	0	0	0	1	1	1	14.0
v	2	4	2	0	0	0	0	2	2	4	10.0
w	1	14	2	0	0	0	1	0	1	1	18.0
x	2	4	2	0	0	0	0	1	1	1	9.0
y	4	8	2	0	0	0	0	2	3	4	16.0
z	3	4	2	0	0	0	2	2	1	1	13.0

Text

	wr	lt	pt	vb	mt	ry	wm	pm	ab	gt	sumT
a	9	8	0	2	0	0	2	1	1	2	11.0
b	11	10	0	2	0	0	2	1	1	2	13.0
c	5	11	0	1	0	0	0	0	1	1	11.0
d	3	6	0	1	0	0	1	0	1	1	7.0
e	6	8	0	2	0	0	0	1	1	1	9.0
f	5	8	0	1	0	0	2	0	1	1	10.0
g	5	9	0	2	0	0	0	1	1	1	10.0
h	5	7	1	1	0	0	2	0	1	1	9.0
i	6	11	0	1	0	0	0	1	1	1	12.0
j	6	12	0	1	0	0	2	0	1	1	14.0
k	6	7	0	1	0	0	1	1	1	1	9.0
l	4	7	0	1	0	0	1	0	1	1	8.0
m	5	7	0	2	0	0	0	1	1	1	8.0
n	11	8	1	1	0	0	5	1	1	2	14.0
o	5	9	0	1	0	0	1	0	1	1	10.0
p	4	5	0	1	0	0	1	0	1	1	6.0
q	6	7	1	1	0	0	3	0	1	1	10.0
r	5	6	0	1	0	0	2	0	1	1	8.0
s	5	8	0	1	0	0	2	0	1	2	10.0
t	8	5	0	2	0	0	1	1	1	1	7.0
u	11	8	1	2	0	0	3	1	1	2	12.0
v	7	9	0	1	0	0	1	2	3	3	12.0
w	5	10	0	1	0	0	3	0	1	1	13.0
x	6	9	1	1	0	0	0	2	4	1	11.0
y	4	10	0	1	0	0	1	0	1	1	11.0
z	4	9	0	1	0	0	0	1	1	1	10.0

Drawing

	pt	vr	sd	sl	fo	3d	ed	ln	ab	gt	sumD
a	3	5	3	1	0	0	0	1	2	3	13.0
b	4	6	2	2	0	0	0	1	1	3	15.0
c	2	4	2	0	0	0	0	1	1	2	9.0
d	4	7	3	2	0	0	0	1	1	2	17.0
e	2	8	2	0	0	0	0	1	1	2	13.0
f	2	6	2	0	0	0	0	1	1	2	11.0
g	2	13	2	1	0	0	1	2	1	2	21.0
h	2	9	2	0	0	0	1	1	1	2	15.0
i	2	8	2	0	0	0	1	0	1	2	13.0
j	2	8	2	0	0	0	1	1	1	2	14.0
k	2	8	2	0	0	0	1	0	1	3	13.0
l	2	7	2	0	0	0	1	1	1	1	13.0
m	2	9	2	0	0	0	1	0	1	3	14.0
n	2	8	2	0	0	0	0	1	1	2	13.0
o	2	9	2	4	0	0	1	2	1	3	20.0
p	3	6	2	2	1	0	1	1	1	3	16.0
q	1	17	2	4	0	0	1	2	1	2	27.0
r	2	13	2	2	0	0	1	1	1	2	21.0
s	3	5	2	0	0	0	1	1	1	1	12.0
t	2	7	2	0	0	0	1	1	2	3	13.0
u	2	7	2	0	0	0	1	1	1	1	13.0
v	2	4	2	0	0	0	0	1	1	3	9.0
w	2	9	2	0	1	0	1	0	1	3	15.0
x	2	3	2	0	0	0	0	1	1	1	8.0
y	3	8	2	0	0	0	0	2	1	2	15.0
z	2	7	2	0	0	0	1	2	1	2	14.0

Text

J.H.

	wr	lt	pt	vb	mt	ry	wm	pm	ab	gt	sumT
a	9	7	2	1	0	0	0	1	1	2	8.0
b	9	8	1	1	0	0	0	1	1	2	9.0
c	11	7	0	1	0	0	1	1	1	4	9.0
d	11	5	2	2	0	1	0	2	1	1	8.0
e	9	8	1	3	1	0	0	0	3	3	9.0
f	7	7	0	2	0	1	0	0	1	2	8.0
g	8	10	1	2	0	0	0	0	1	1	10.0
h	8	5	1	2	1	1	0	1	4	1	8.0
i	10	10	1	2	0	1	0	0	2	3	11.0
j	8	9	2	2	0	0	0	1	2	3	10.0
k	11	8	0	1	0	0	2	1	1	2	11.0
l	8	7	2	2	0	0	1	1	1	3	9.0
m	11	8	1	3	0	0	0	0	4	1	8.0
n	8	6	1	2	0	0	2	1	4	1	9.0
o	7	7	2	1	1	0	1	0	4	3	9.0
p	9	11	0	2	0	0	0	1	1	3	12.0
q	10	12	2	1	0	0	1	1	4	2	14.0
r	10	7	1	3	1	0	0	1	2	2	9.0
s	9	9	2	1	0	0	1	0	4	1	10.0
t	9	7	2	2	1	0	0	0	4	3	8.0
u	9	6	3	2	0	0	0	1	4	1	7.0
v	7	6	2	2	1	1	0	0	4	2	8.0
w	11	7	2	3	0	0	0	3	4	2	10.0
x	7	7	3	2	0	0	0	2	3	2	9.0
y	9	6	1	3	0	0	0	0	1	2	6.0
z	8	5	1	1	0	0	2	0	2	3	7.0

Drawing

	pt	vr	sd	sl	fo	3d	ed	ln	ab	gt	sumD
a	5	9	3	0	1	2	0	1	1	3	21.0
b	6	6	3	0	1	2	0	1	1	3	19.0
c	4	12	3	0	1	2	0	1	1	2	23.0
d	3	6	3	0	1	2	0	1	1	2	16.0
e	4	12	2	0	0	2	0	1	1	2	21.0
f	3	10	2	0	1	2	0	1	1	2	19.0
g	5	14	3	0	1	2	0	1	1	2	26.0
h	5	12	3	0	1	2	0	1	1	2	24.0
i	5	12	2	0	1	2	0	1	1	2	23.0
j	3	10	2	0	1	2	0	1	1	2	19.0
k	6	11	3	0	0	2	0	1	1	3	23.0
l	3	6	2	0	1	2	0	1	1	1	15.0
m	3	12	2	0	1	2	0	1	1	3	21.0
n	3	10	2	0	1	2	0	1	1	2	19.0
o	3	6	3	0	0	2	0	1	1	3	15.0
p	3	10	3	0	1	2	0	1	1	3	20.0
q	6	7	3	0	1	2	0	1	1	2	20.0
r	7	6	3	0	1	2	0	1	1	2	20.0
s	4	10	2	0	1	2	0	1	1	1	20.0
t	3	10	2	0	1	2	0	1	1	3	19.0
u	3	8	3	0	1	2	0	1	1	1	18.0
v	3	7	3	0	1	2	0	1	1	3	17.0
w	3	12	3	0	0	2	0	1	1	3	21.0
x	6	12	3	0	1	2	0	1	1	1	25.0
y	3	8	3	0	0	2	0	1	1	2	17.0
z	4	10	2	0	1	2	0	1	1	2	20.0

Text

P.T.

	wr	lt	pt	vb	mt	ry	wm	pm	ab	gt	sumT
a	12	7	1	1	1	2	2	1	1	2	13.0
b	6	9	2	1	1	1	0	0	1	2	11.0
c	6	7	1	3	1	2	5	0	1	4	15.0
d	8	5	1	3	0	0	1	1	1	1	7.0
e	15	5	2	5	1	2	0	3	3	3	11.0
f	13	6	1	1	0	1	1	0	1	2	8.0
g	6	9	1	1	0	1	0	0	1	1	10.0
h	6	7	1	1	0	1	0	2	4	1	10.0
i	15	7	1	2	0	0	1	1	2	2	9.0
j	15	6	1	1	1	2	1	0	2	3	10.0
k	7	9	1	1	0	0	1	0	1	2	10.0
l	7	7	2	1	1	1	0	0	1	3	9.0
m	7	6	1	1	0	0	1	0	4	1	7.0
n	7	6	3	1	0	0	1	0	4	1	7.0
o	12	8	1	3	0	0	2	1	4	3	11.0
p	17	7	3	2	0	1	3	2	1	3	13.0
q	10	10	3	3	0	2	0	2	4	2	14.0
r	15	9	1	3	0	2	1	1	2	2	13.0
s	12	8	2	6	0	0	2	3	4	1	13.0
t	7	5	3	1	1	1	0	0	4	3	7.0
u	6	10	1	2	0	0	0	1	4	1	11.0
v	14	6	2	1	0	0	2	1	4	2	9.0
w	10	9	1	3	0	0	1	2	4	2	12.0
x	12	7	5	4	1	2	1	1	3	2	12.0
y	9	4	1	1	0	0	0	0	1	2	4.0
z	8	7	0	3	1	3	0	1	2	3	12.0

K.R.

Drawing

	pt	vr	sd	sl	fo	3d	ed	ln	ab	gt	sumD
a	5	8	2	0	1	0	0	0	2	2	16.0
b	7	9	2	0	1	0	0	0	1	2	19.0
c	5	8	2	0	1	0	0	0	1	1	16.0
d	6	6	2	0	1	0	0	0	1	2	15.0
e	5	12	2	0	1	0	0	0	1	2	20.0
f	5	10	2	0	1	0	0	0	1	2	18.0
g	1	10	2	0	1	0	0	0	1	2	14.0
h	5	12	2	0	1	0	0	0	1	2	20.0
i	5	12	2	0	1	0	0	0	1	2	20.0
j	5	8	2	0	1	0	0	0	1	2	16.0
k	5	10	2	0	1	0	0	0	1	2	18.0
l	5	6	2	0	1	0	0	0	1	2	14.0
m	5	15	2	0	1	0	0	0	1	2	23.0
n	5	10	2	1	1	0	0	0	1	3	19.0
o	6	8	2	0	1	0	0	0	1	2	17.0
p	6	8	2	0	1	0	0	0	1	2	17.0
q	6	11	2	0	1	0	0	0	1	2	20.0
r	6	11	2	0	1	0	0	0	1	2	20.0
s	5	10	2	0	1	0	0	0	1	2	18.0
t	5	8	2	0	1	0	0	0	1	2	16.0
u	5	8	2	0	1	0	0	0	1	2	16.0
v	5	7	2	0	1	0	0	0	1	3	15.0
w	5	12	2	0	1	0	0	0	1	2	20.0
x	5	18	2	0	1	0	0	0	1	3	26.0
y	5	12	2	0	1	0	0	0	1	4	20.0
z	5	9	2	0	1	0	0	0	1	2	17.0

Text

	wr	lt	pt	vb	mt	ry	wm	pm	ab	gt	sumT
a	10	9	2	4	1	3	0	2	4	4	15.0
b	10	4	0	1	1	2	0	2	3	3	9.0
c	9	13	2	1	1	2	0	2	3	3	18.0
d	8	8	1	1	1	2	2	0	3	3	13.0
e	8	8	2	1	1	2	0	1	3	3	12.0
f	10	11	1	2	1	2	0	2	3	3	16.0
g	9	6	2	1	1	2	0	2	3	3	11.0
h	8	6	1	1	1	2	2	0	3	3	11.0
i	11	12	2	1	1	2	0	2	3	3	17.0
j	10	6	0	1	1	2	2	1	3	3	12.0
k	8	6	1	1	1	2	2	0	3	3	11.0
l	8	8	1	1	1	2	2	0	3	3	13.0
m	11	8	2	3	1	2	1	2	3	3	14.0
n	11	7	1	3	1	2	1	2	3	3	13.0
o	11	10	1	2	1	2	1	2	3	3	16.0
p	9	7	1	1	1	2	2	1	3	3	13.0
q	10	11	2	2	1	2	2	1	3	3	17.0
r	8	8	1	1	1	2	1	1	3	3	13.0
s	8	9	2	2	1	2	1	1	3	3	14.0
t	10	10	1	2	1	2	1	1	3	3	15.0
u	5	7	2	1	1	2	0	1	3	3	11.0
v	10	13	1	1	1	2	2	1	3	3	19.0
w	10	5	1	2	1	2	2	1	3	3	11.0
x	9	9	0	3	1	2	0	1	3	3	13.0
y	10	8	1	1	1	2	1	2	3	3	14.0
z	10	12	1	2	1	2	2	1	3	3	18.0

M.A.

Drawing

	pt	vr	sd	sl	fo	3d	ed	ln	ab	gt	sumD
a	4	10	2	0	0	0	0	0	1	2	16.0
b	9	10	2	3	0	0	0	0	1	3	24.0
c	5	12	2	1	0	0	0	0	1	2	20.0
d	6	5	3	2	0	0	0	0	1	2	16.0
e	13	12	3	0	0	0	0	0	1	2	28.0
f	13	10	2	0	0	0	0	0	1	3	25.0
g	4	12	3	0	0	0	0	0	1	2	19.0
h	4	12	2	1	0	0	0	0	1	2	19.0
i	5	12	3	0	0	0	0	0	1	2	20.0
j	8	8	3	1	0	0	0	0	1	2	20.0
k	5	11	2	1	0	0	0	0	1	2	19.0
l	5	11	4	1	0	0	0	0	1	2	21.0
m	4	12	3	0	0	0	0	0	1	2	19.0
n	2	10	2	0	0	0	0	0	1	2	14.0
o	3	20	2	0	0	0	0	0	1	3	25.0
p	10	7	3	0	0	0	0	0	1	2	20.0
q	3	9	2	0	0	0	0	0	1	2	14.0
r	5	9	3	0	0	0	0	0	1	2	17.0
s	3	14	2	0	0	0	0	0	1	2	19.0
t	9	8	4	2	0	0	0	0	1	2	23.0
u	7	9	2	0	0	0	0	0	1	3	18.0
v	8	16	3	3	0	0	0	0	1	4	30.0
w	3	12	3	2	0	0	0	0	1	3	20.0
x	12	12	3	4	0	0	0	0	1	2	31.0
y	5	9	4	1	0	0	0	0	1	2	19.0
z	6	10	3	0	0	0	0	0	1	2	19.0

Text

	wr	lt	pt	vb	mt	ry	wm	pm	ab	gt	sumT
a	9	7	1	4	0	0	0	4	1	4	11.0
b	11	8	3	1	0	0	4	0	3	3	12.0
c	16	6	4	4	0	0	2	2	3	3	10.0
d	12	8	1	3	0	0	2	3	3	3	13.0
e	8	10	2	4	0	0	2	0	1	3	12.0
f	17	7	1	4	0	0	2	4	1	3	13.0
g	12	5	1	5	0	0	0	4	1	3	9.0
h	16	7	3	3	0	0	0	4	1	3	11.0
i	9	5	1	2	0	0	4	1	1	3	10.0
j	17	7	1	2	0	0	2	2	1	3	11.0
k	13	9	1	2	0	0	3	1	1	3	13.0
l	15	5	1	1	0	0	1	2	1	3	8.0
m	15	9	2	6	0	0	3	7	1	3	19.0
n	11	7	1	5	0	0	2	2	4	3	11.0
o	15	7	1	2	0	0	1	2	1	3	10.0
p	18	7	2	5	0	0	2	5	1	3	14.0
q	11	7	2	5	0	0	1	2	1	3	10.0
r	11	7	1	3	0	0	1	1	1	3	9.0
s	16	6	1	4	0	0	1	3	1	3	10.0
t	19	7	3	4	0	0	2	3	1	4	12.0
u	21	8	1	6	0	0	0	4	1	4	12.0
v	9	10	1	3	0	0	2	1	1	3	13.0
w	12	10	1	2	0	0	1	2	1	3	13.0
x	12	9	2	4	0	0	1	4	1	3	14.0
y	13	6	1	3	0	0	1	1	1	3	8.0
z	11	9	3	2	0	0	0	1	1	3	10.0

R.R.

	Drawing pt	vr	sd	sl	fo	3d	ed	ln	ab	gt	sumD	Text wr	lt	pt	vb	mt	ry	wm	pm	ab	gt	sumT
a	2	8	1	0	0	0	0	1	1	3	12.0	5	7	0	3	0	0	1	1	.9	2	9.0
b	4	5	1	0	0	0	0	2	2	2	12.0	7	5	0	6	0	0	3	3	1	2	11.0
c	2	4	2	0	0	0	1	2	3	3	11.0	9	6	0	4	0	0	2	2	1	2	10.0
d	3	5	3	0	1	0	0	2	3	4	14.0	12	5	0	6	0	0	1	3	1	2	9.0
e	3	6	2	0	0	0	0	1	1	2	12.0	6	9	0	4	0	0	2	1	1	2	12.0
f	3	6	2	0	0	0	0	1	1	2	12.0	16	5	0	5	0	0	2	3	1	2	10.0
g	3	4	2	0	0	0	0	1	4	2	10.0	10	6	0	5	0	0	2	2	1	2	10.0
h	3	6	2	0	0	0	0	1	2	2	12.0	5	9	0	5	0	0	1	2	1	2	12.0
i	3	6	2	0	0	0	0	1	2	2	12.0	9	7	0	4	0	0	1	1	1	3	9.0
j	3	6	2	0	0	0	0	1	2	2	12.0	12	5	0	5	0	0	3	2	1	2	10.0
k	2	7	2	0	0	0	0	1	1	2	12.0	7	8	0	2	0	0	2	1	1	2	11.0
l	2	6	2	0	0	0	0	1	2	2	11.0	7	6	0	4	0	0	3	1	1	2	10.0
m	3	4	2	0	0	0	0	1	3	2	10.0	10	7	0	5	0	0	2	3	1	2	12.0
n	3	4	2	0	0	0	0	1	3	2	10.0	9	5	0	4	0	0	2	1	1	2	8.0
o	2	6	2	0	0	0	0	2	2	2	12.0	5	12	0	3	0	0	1	1	1	2	14.0
p	2	4	2	0	0	0	0	1	3	4	9.0	12	7	0	4	0	0	2	1	1	2	10.0
q	2	4	2	0	0	0	0	0	3	3	8.0	7	7	0	3	0	0	1	2	1	2	10.0
r	3	4	2	0	0	0	0	1	3	3	10.0	7	7	0	4	0	0	2	1	1	2	10.0
s	1	9	1	0	0	0	0	0	1	1	11.0	6	6	0	5	0	0	1	3	1	2	10.0
t	2	4	2	0	0	0	0	1	1	3	9.0	21	7	0	5	0	0	2	3	1	2	12.0
u	3	6	2	0	0	0	0	2	4	3	13.0	9	7	0	3	0	0	2	1	1	2	10.0
v	2	3	2	0	0	0	0	0	4	4	7.0	12	8	0	4	0	0	2	1	1	2	11.0
w	3	4	2	0	0	0	0	2	3	3	11.0	8	8	0	5	0	0	5	3	1	2	16.0
x	2	4	2	0	0	0	0	0	1	2	8.0	9	13	0	3	0	0	2	1	1	2	16.0
y	2	4	2	0	0	0	0	0	1	2	8.0	8	6	0	6	0	0	1	3	1	3	10.0
z	1	4	1	0	0	0	0	0	3	3	6.0	6	6	0	3	0	0	2	1	1	2	9.0

E.D

	Drawing pt	vr	sd	sl	fo	3d	ed	ln	ab	gt	sumD	Text wr	lt	pt	vb	mt	ry	wm	pm	ab	gt	sumT
a	1	10	1	0	0	0	0	0	1	1	12.0	4	9	0	1	0	0	0	0	1	1	9.0
b	3	5	3	0	0	0	0	2	1	1	13.0	4	4	0	1	0	0	0	0	1	1	4.0
c	1	6	1	0	0	0	0	0	1	1	8.0	4	3	0	1	0	0	0	0	1	1	3.0
d	2	6	1	0	0	0	0	0	1	1	9.0	4	3	0	1	0	0	0	0	1	1	3.0
e	1	12	1	0	0	0	0	0	1	1	14.0	4	8	0	1	0	0	0	0	1	1	8.0
f	1	10	1	0	0	0	0	0	1	1	12.0	4	4	0	1	0	0	0	0	1	1	4.0
g	2	6	1	0	0	0	0	0	1	1	9.0	4	7	0	1	0	0	0	0	1	1	7.0
h	1	12	1	0	0	0	0	0	1	1	14.0	4	5	0	1	0	0	0	0	1	1	5.0
i	1	12	1	0	0	0	0	0	1	1	14.0	4	6	0	1	0	0	0	0	1	1	6.0
j	1	8	1	0	0	0	0	0	1	1	10.0	4	6	0	1	0	0	0	0	1	1	6.0
k	2	7	1	0	0	0	0	0	1	1	10.0	4	5	0	1	0	0	0	0	1	1	5.0
l	1	6	1	0	0	0	0	0	1	1	8.0	4	4	0	1	0	0	0	0	1	1	4.0
m	3	7	1	0	0	0	0	0	1	1	11.0	4	6	0	1	0	0	0	0	1	1	6.0
n	3	4	1	0	0	0	0	0	1	1	8.0	4	11	0	1	0	0	0	0	1	1	11.0
o	2	6	1	0	0	0	0	0	1	1	9.0	4	7	0	1	0	0	0	0	1	1	7.0
p	3	5	1	0	0	0	0	2	2	1	11.0	4	7	0	1	0	0	0	0	1	1	7.0
q	3	6	1	0	0	0	0	0	1	1	10.0	4	5	0	1	0	0	0	0	1	1	5.0
r	4	5	1	0	0	0	0	2	2	2	12.0	4	6	0	1	0	0	0	0	1	1	6.0
s	1	12	1	0	0	0	0	0	1	1	14.0	4	5	0	1	0	0	0	0	1	1	5.0
t	1	8	1	0	0	0	0	0	1	1	10.0	4	6	0	1	0	0	0	0	1	1	6.0
u	1	6	1	0	0	0	0	0	1	1	8.0	4	6	0	1	0	0	0	0	1	1	6.0
v	1	6	1	0	0	0	0	0	1	1	8.0	4	7	0	1	0	0	0	0	1	1	7.0
w	1	12	1	1	0	0	0	2	1	3	17.0	4	12	0	1	0	0	0	0	1	1	12.0
x	2	6	1	0	0	0	1	0	1	2	10.0	4	9	0	1	0	0	0	0	1	1	9.0
y	1	11	1	0	0	0	1	0	1	3	14.0	4	3	0	1	0	0	0	0	1	1	3.0
z	1	19	1	0	0	0	0	0	1	1	21.0	4	5	0	1	0	0	0	0	1	1	5.0

Drawing

	pt	vr	sd	sl	fo	3d	ed	ln	ab	gt	sumD
a	2	10	1	0	0	0	0	0	1	3	13.0
b	3	8	1	0	0	0	1	0	1	3	13.0
c	1	16	1	0	0	0	1	0	1	2	19.0
d	2	6	1	0	0	0	1	0	1	2	10.0
e	1	12	1	0	1	0	0	0	1	2	15.0
f	1	10	1	0	1	0	0	0	1	2	13.0
g	1	22	1	0	0	0	1	0	1	2	25.0
h	1	12	1	0	0	0	0	0	1	2	14.0
i	1	12	1	0	0	0	0	0	1	2	14.0
j	1	14	1	0	0	0	0	0	1	2	16.0
k	1	11	1	0	0	0	1	0	1	3	14.0
l	1	6	1	0	0	0	0	0	1	2	8.0
m	1	12	1	0	0	0	0	0	1	3	14.0
n	1	10	1	0	0	0	1	0	1	2	13.0
o	2	8	1	0	0	0	1	0	1	2	12.0
p	2	8	1	0	0	0	1	1	1	2	13.0
q	3	8	1	0	0	0	1	0	1	2	13.0
r	2	10	1	0	0	0	0	1	1	2	14.0
s	1	12	1	0	0	0	0	1	3	3	15.0
t	1	8	1	0	0	0	0	0	1	2	10.0
u	1	8	1	0	0	0	0	0	1	2	10.0
v	1	7	1	0	0	0	0	0	1	2	9.0
w	1	12	1	0	0	0	0	0	1	3	14.0
x	1	12	1	0	0	0	0	0	1	2	14.0
y	1	9	1	0	0	0	0	0	1	3	11.0
z	1	10	1	0	0	0	0	0	1	2	12.0

Text

A.L.

	wr	lt	pt	vb	mt	ry	wm	pm	ab	gt	sumT
a	4	11	1	1	0	0	0	0	4	0	11.0
b	4	7	1	1	0	0	0	0	4	1	7.0
c	4	7	1	1	0	0	0	0	4	1	7.0
d	4	11	1	1	0	0	0	0	4	1	11.0
e	4	8	1	1	0	0	0	0	4	1	8.0
f	4	9	1	1	0	0	0	0	4	1	9.0
g	4	8	1	1	0	0	0	0	4	1	8.0
h	4	9	1	1	0	0	0	0	4	1	9.0
i	4	8	1	1	0	0	0	0	4	1	8.0
j	4	9	1	1	0	0	0	0	4	1	9.0
k	4	4	1	1	0	0	0	0	4	1	4.0
l	4	6	1	1	0	0	0	0	4	1	6.0
m	4	9	1	1	0	0	0	0	4	1	9.0
n	4	5	1	1	0	0	0	0	4	1	5.0
o	4	8	1	1	0	0	0	0	4	1	8.0
p	4	6	1	1	0	0	0	0	4	1	6.0
q	4	5	1	1	0	0	0	0	4	1	5.0
r	4	10	1	1	0	0	0	0	4	1	10.0
s	4	13	1	1	0	0	0	0	4	1	13.0
t	4	11	1	1	0	0	0	0	4	1	11.0
u	4	13	1	1	0	0	0	0	4	1	13.0
v	4	9	1	1	0	0	0	0	4	1	9.0
w	4	7	1	1	0	0	0	0	4	1	7.0
x	4	9	1	1	0	0	0	0	4	1	9.0
y	4	8	1	1	0	0	0	0	4	1	8.0
z	4	7	1	1	0	0	0	0	4	1	7.0

Drawing

	pt	vr	sd	sl	fo	3d	ed	ln	ab	gt	sumD
a	6	18	3	0	0	0	0	0	3	3	27.0
b	7	11	3	0	0	0	0	0	3	3	21.0
c	3	12	3	0	0	0	0	0	3	3	18.0
d	5	14	2	0	0	0	0	0	3	3	21.0
e	5	19	4	0	0	0	0	0	3	3	28.0
f	3	12	2	0	0	0	0	0	3	3	17.0
g	3	11	2	0	0	0	0	0	3	3	16.0
h	8	9	3	0	0	0	0	0	3	3	20.0
i	5	8	2	0	0	0	0	0	3	3	15.0
j	2	8	2	0	0	0	0	0	3	3	12.0
k	11	16	5	0	0	0	0	0	3	3	32.0
l	4	12	3	0	0	0	0	0	3	3	19.0
m	12	15	2	0	0	0	0	0	3	3	29.0
n	7	8	3	0	0	0	0	0	3	3	18.0
o	4	12	3	0	0	0	0	0	3	3	19.0
p	3	8	3	0	0	0	0	0	3	3	14.0
q	4	6	2	0	0	0	0	0	3	3	12.0
r	4	12	2	0	0	0	0	0	3	3	18.0
s	2	16	2	0	0	0	0	0	3	3	20.0
t	3	13	2	0	0	0	0	0	3	3	18.0
u	3	14	1	0	0	0	0	0	3	3	18.0
v	5	16	1	0	0	0	0	0	3	3	22.0
w	6	12	2	0	0	0	0	0	3	3	20.0
x	7	16	3	0	0	0	0	0	3	3	26.0
y	3	10	2	0	0	0	0	0	3	3	15.0
z	4	10	2	0	0	0	0	0	3	3	16.0

Text

M.L.

	wr	lt	pt	vb	mt	ry	wm	pm	ab	gt	sumT
a	10	7	2	2	0	0	4	2	4	3	13.0
b	6	9	2	2	0	0	3	1	4	3	13.0
c	12	7	2	3	0	0	4	1	4	3	12.0
d	9	8	2	2	0	0	2	2	4	3	12.0
e	8	13	2	2	0	0	4	1	4	3	18.0
f	11	7	2	4	0	0	2	2	4	3	11.0
g	11	7	2	2	0	0	4	2	4	3	13.0
h	7	10	2	2	0	0	2	1	4	3	13.0
i	7	11	2	2	0	0	1	2	4	3	14.0
j	8	6	2	2	0	0	3	1	4	3	10.0
k	8	9	2	3	0	0	1	2	4	3	12.0
l	10	7	2	2	0	0	4	2	4	3	13.0
m	11	8	2	3	0	0	0	3	4	3	11.0
n	9	7	2	2	0	0	2	2	4	3	11.0
o	7	8	2	2	0	0	3	1	4	3	12.0
p	13	8	2	2	0	0	3	3	4	3	14.0
q	11	7	2	3	0	0	3	2	4	3	12.0
r	12	9	2	2	0	0	2	4	4	3	15.0
s	7	11	2	2	0	0	3	1	4	3	15.0
t	8	9	2	2	0	0	2	1	4	3	12.0
u	8	10	2	2	0	0	2	3	4	3	15.0
v	10	7	2	2	0	0	3	2	4	3	12.0
w	10	9	2	2	0	0	2	2	4	3	13.0
x	11	6	2	3	0	0	1	3	4	3	10.0
y	11	9	2	3	0	0	2	3	4	3	14.0
z	10	9	2	2	0	0	2	3	4	3	14.0

Drawing

	pt	vr	sd	sl	fo	3d	ed	ln	ab	gt	sumD
a	2	12	1	1	0	0	1	2	2	4	19.0
b	3	19	1	1	0	0	1	0	1	1	25.0
c	1	17	1	1	0	0	2	0	1	3	22.0
d	2	10	1	1	0	0	0	0	1	1	14.0
e	1	19	1	1	0	0	2	2	1	4	26.0
f	1	18	1	1	0	0	0	1	1	1	22.0
g	1	18	1	1	0	0	0	0	1	4	21.0
h	1	12	1	1	0	0	1	0	1	2	16.0
i	1	16	1	1	0	0	1	1	1	1	21.0
j	1	12	1	1	0	0	2	0	1	1	17.0
k	1	21	1	1	0	0	0	2	1	2	26.0
l	1	15	1	1	0	0	1	2	1	1	21.0
m	1	22	1	1	0	0	0	2	2	4	27.0
n	1	19	1	1	0	0	0	1	1	2	23.0
o	1	12	1	1	0	0	0	0	1	2	15.0
p	1	16	1	1	0	0	2	0	1	1	21.0
q	2	12	2	1	0	0	2	2	1	3	21.0
r	2	25	1	1	0	0	2	0	1	1	31.0
s	1	18	1	1	0	0	1	2	1	1	24.0
t	1	21	1	1	0	0	0	0	1	1	24.0
u	1	22	1	1	0	0	0	0	1	1	25.0
v	1	17	1	1	0	0	0	0	1	1	20.0
w	1	22	1	1	0	0	0	2	2	4	27.0
x	1	12	1	1	0	0	1	0	1	1	16.0
y	1	10	1	1	0	0	0	0	1	2	13.0
z	1	24	1	1	0	0	0	0	1	1	27.0

Text

J.L.

	wr	lt	pt	vb	mt	ry	wm	pm	ab	gt	sumT
a	7	6	1	1	1	2	2	1	1	3	12.0
b	6	6	2	1	1	3	2	1	1	3	13.0
c	6	6	2	1	1	2	0	1	1	3	10.0
d	6	6	3	1	1	2	1	1	1	3	11.0
e	8	4	2	2	1	2	1	0	1	3	8.0
f	8	4	2	2	1	2	0	1	1	3	8.0
g	6	7	2	1	1	2	2	0	1	3	12.0
h	5	10	2	1	1	2	1	0	1	3	14.0
i	6	6	2	1	1	2	2	0	1	3	11.0
j	8	5	1	2	1	2	1	1	1	3	10.0
k	7	4	1	2	1	2	0	1	1	3	8.0
l	8	4	2	1	1	2	1	0	1	3	8.0
m	6	6	1	2	1	2	0	0	1	3	9.0
n	7	6	2	2	1	2	2	1	1	3	12.0
o	6	6	2	1	1	2	2	0	1	3	11.0
p	8	5	1	2	1	2	0	2	1	3	10.0
q	6	5	2	1	1	2	2	0	1	3	10.0
r	8	5	1	2	1	2	0	1	1	3	9.0
s	6	6	1	2	1	2	0	0	1	3	9.0
t	8	4	2	3	1	2	1	0	1	3	8.0
u	7	7	1	2	1	2	1	1	1	3	12.0
v	8	5	1	2	1	2	0	2	1	3	10.0
w	7	6	1	1	1	2	1	1	1	3	11.0
x	8	4	1	2	1	2	1	2	1	3	10.0
y	8	4	1	1	1	2	2	1	1	3	10.0
z	7	6	2	2	1	2	2	1	1	3	12.0

Drawing

	pt	vr	sd	sl	fo	3d	ed	ln	ab	gt	sumD
a	4	13	2	0	0	2	0	1	3	3	22.0
b	5	17	2	0	0	2	0	1	1	3	27.0
c	3	8	2	0	0	2	0	0	1	2	15.0
d	3	10	2	0	0	2	0	1	1	2	18.0
e	4	12	2	0	0	2	0	1	1	3	21.0
f	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	0.0
g	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	0.0
h	4	12	2	0	0	2	0	1	1	2	21.0
i	4	12	4	0	0	2	0	0	1	2	22.0
j	4	12	4	0	0	2	0	0	1	2	22.0
k	5	11	3	0	0	2	0	0	1	3	21.0
l	2	10	3	0	0	2	0	0	11	3	17.0
m	4	13	3	0	0	2	0	0	1	3	22.0
n	4	10	3	0	0	2	0	0	1	3	19.0
o	3	12	3	0	0	2	0	0	1	2	20.0
p	3	12	3	0	0	2	0	1	2	3	21.0
q	4	19	5	0	0	2	0	2	2	3	32.0
r	5	15	2	0	0	2	0	0	1	2	24.0
s	3	21	3	0	0	2	0	2	2	4	31.0
t	3	8	3	0	0	2	0	0	1	2	16.0
u	3	14	3	0	0	2	0	0	1	3	22.0
v	3	7	3	0	0	2	0	0	1	3	15.0
w	4	10	3	0	0	2	0	0	1	2	19.0
x	4	12	2	0	0	2	0	2	2	4	22.0
y	3	9	3	0	0	2	0	0	1	2	17.0
z	2	10	2	0	0	2	0	0	1	2	16.0

Text

J.K.

	wr	lt	pt	vb	mt	ry	wm	pm	ab	gt	sumT
a	3	9	0	0	0	0	0	0	1	1	9.0
b	3	7	0	0	0	0	0	0	1	1	7.0
c	3	8	0	0	0	0	0	0	1	1	8.0
d	4	7	0	0	0	0	1	0	1	1	8.0
e	3	8	0	0	0	0	0	0	1	1	8.0
f	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	0.0
g	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	0.0
h	3	5	0	0	0	0	0	0	1	1	5.0
i	3	8	0	0	0	0	0	0	1	1	8.0
j	3	6	0	0	0	0	0	0	1	1	6.0
k	3	5	0	0	0	0	0	0	1	1	5.0
l	3	5	0	0	0	0	0	0	1	1	5.0
m	3	4	0	0	0	0	0	0	1	1	4.0
n	3	4	0	0	0	0	0	0	1	1	4.0
o	3	4	0	0	0	0	0	0	1	1	4.0
p	3	11	0	0	0	0	0	0	1	1	11.0
q	3	7	1	0	0	0	0	0	1	1	7.0
r	3	9	0	0	0	0	0	0	1	1	9.0
s	3	6	0	0	0	0	0	0	1	1	6.0
t	3	8	0	0	0	0	0	0	1	1	8.0
u	3	10	1	0	0	0	0	0	1	1	10.0
v	3	9	0	0	0	0	0	0	1	1	9.0
w	3	8	0	0	0	0	0	0	1	1	8.0
x	3	5	1	0	0	0	0	0	1	1	5.0
y	3	11	0	0	0	0	0	0	1	1	11.0
z	4	7	0	0	0	0	1	0	1	1	8.0

Drawing

	pt	vr	sd	sl	fo	3d	ed	ln	ab	gt	sumD
a	2	6	2	0	0	0	1	2	2	3	13.0
b	3	6	3	1	0	0	0	2	2	2	15.0
c	1	7	1	2	1	0	1	2	2	2	15.0
d	3	4	3	1	1	0	1	2	2	2	15.0
e	1	11	1	3	1	0	1	2	2	3	20.0
f	1	9	1	1	0	0	1	2	2	2	15.0
g	1	9	1	1	0	0	1	2	2	3	15.0
h	3	4	2	0	0	0	1	2	2	2	12.0
i	1	8	1	0	0	0	1	2	1	1	13.0
j	1	7	1	0	0	0	1	0	2	2	10.0
k	2	8	2	1	0	0	2	2	3	4	17.0
l	1	7	1	0	0	0	1	0	2	2	10.0
m	1	8	1	0	0	0	1	2	2	3	13.0
n	1	6	1	0	0	0	1	2	2	3	11.0
o	3	4	3	2	1	0	1	2	3	2	16.0
p	3	4	3	1	0	0	0	2	3	4	13.0
q	4	7	4	2	1	0	1	2	3	3	21.0
r	3	6	3	1	0	0	0	2	3	3	15.0
s	3	8	3	0	0	0	1	2	2	2	17.0
t	1	10	1	0	0	0	1	2	1	2	15.0
u	3	4	2	0	0	0	1	2	3	4	12.0
v	2	4	2	0	0	0	1	0	2	3	9.0
w	1	8	1	0	0	0	1	2	2	3	13.0
x	2	4	2	0	0	0	1	2	2	3	11.0
y	2	4	2	0	0	0	1	2	2	2	11.0
z	2	7	2	0	0	0	1	2	2	2	14.0

Text

M.N.

	wr	lt	pt	vb	mt	ry	wm	pm	ab	gt	sumT
a	8	6	1	2	0	0	0	1	1	2	7.0
b	9	9	1	1	0	2	1	1	1	2	13.0
c	7	5	1	1	0	1	2	0	1	2	8.0
d	8	4	1	2	0	2	0	1	1	3	7.0
e	7	6	1	1	0	0	0	0	1	2	6.0
f	8	4	1	1	0	0	0	1	1	2	5.0
g	8	7	1	1	0	0	0	1	1	3	8.0
h	5	9	1	1	0	0	0	0	1	2	9.0
i	7	10	1	1	0	2	0	1	4	2	13.0
j	5	6	1	1	0	0	0	0	1	2	6.0
k	12	6	2	3	0	2	1	2	1	2	11.0
l	7	6	1	1	0	0	0	1	1	2	7.0
m	6	8	1	1	0	0	0	0	1	3	8.0
n	5	9	1	1	0	0	1	0	2	2	10.0
o	7	4	1	1	0	0	0	1	1	2	5.0
p	8	7	1	2	0	0	1	0	4	2	8.0
q	6	5	1	1	0	2	0	1	1	2	8.0
r	8	8	1	2	0	0	0	0	2	2	8.0
s	9	7	1	2	0	2	1	1	1	2	11.0
t	5	8	1	1	0	0	1	1	1	2	10.0
u	8	8	1	1	0	2	0	1	1	2	11.0
v	8	6	1	2	0	2	1	1	4	3	11.0
w	8	5	1	1	0	0	0	1	1	3	7.0
x	9	5	2	1	0	0	1	1	1	2	5.0
y	5	8	2	1	0	2	0	0	3	2	11.0
z	9	5	1	1	0	2	0	1	1	2	7.0

Drawing

	pt	vr	sd	sl	fo	3d	ed	ln	ab	gt	sumD
a	1	10	1	1	1	0	1	2	4	4	17.0
b	3	6	1	2	1	0	1	2	3	4	16.0
c	1	7	1	1	1	0	1	2	3	3	14.0
d	1	9	1	3	0	0	1	2	3	4	17.0
e	1	10	1	2	1	0	1	2	3	4	18.0
f	1	9	1	2	1	0	1	2	3	4	17.0
g	1	12	1	2	1	0	1	2	3	4	20.0
h	1	14	1	0	1	0	1	2	3	3	20.0
i	1	8	1	0	1	0	1	2	3	3	14.0
j	1	9	1	2	1	0	1	2	3	4	17.0
k	1	10	1	1	1	0	1	2	3	4	17.0
l	1	4	1	1	1	0	1	2	3	4	11.0
m	1	10	1	2	1	0	1	2	3	3	18.0
n	1	8	1	0	0	0	1	2	3	2	13.0
o	2	4	2	0	1	0	1	2	3	4	12.0
p	2	5	2	2	1	0	1	2	3	4	15.0
q	3	4	3	0	1	0	1	2	3	3	14.0
r	2	8	2	2	0	0	1	2	3	2	17.0
s	1	8	1	2	1	0	1	2	3	3	16.0
t	1	9	1	2	1	0	1	2	3	4	17.0
u	1	12	1	2	0	0	1	2	3	4	19.0
v	1	8	1	0	1	0	1	2	3	4	14.0
w	1	11	1	0	0	0	1	2	3	4	16.0
x	2	9	2	0	0	0	1	2	3	3	16.0
y	1	12	1	0	1	0	1	2	3	3	18.0
z	1	10	1	0	0	0	1	2	3	3	15.0

Text

A.W.

	wr	lt	pt	vb	mt	ry	wm	pm	ab	gt	sumT
a	13	8	1	1	0	0	1	2	3	2	11.0
b	9	9	1	1	0	0	1	1	1	2	11.0
c	11	7	3	1	0	0	1	1	4	2	9.0
d	10	9	1	1	0	0	2	1	3	2	12.0
e	13	9	1	1	0	0	2	1	4	2	12.0
f	9	7	1	1	0	0	1	1	2	2	9.0
g	13	8	1	1	0	0	1	1	1	2	10.0
h	9	9	1	1	0	0	1	1	3	2	11.0
i	10	6	2	1	0	0	1	1	2	2	8.0
j	10	6	2	1	0	0	1	1	1	2	8.0
k	10	9	1	1	0	0	1	1	1	2	11.0
l	11	6	1	1	0	0	2	1	3	2	9.0
m	9	9	1	1	0	0	1	1	2	2	11.0
n	9	5	1	1	0	0	1	1	1	2	7.0
o	12	6	1	1	0	0	1	1	1	2	8.0
p	11	12	1	1	0	0	1	1	1	2	14.0
q	12	14	1	1	0	0	1	2	2	2	17.0
r	12	6	2	1	0	0	1	1	1	2	8.0
s	9	6	2	1	0	0	1	1	1	2	8.0
t	12	8	1	1	0	0	1	1	4	2	10.0
u	9	8	1	1	0	0	1	1	3	2	10.0
v	10	9	1	1	0	0	1	1	2	2	11.0
w	11	8	1	1	0	0	2	1	2	2	11.0
x	15	9	1	1	0	0	1	2	3	2	12.0
y	12	12	2	1	0	0	1	1	1	2	14.0
z	11	9	1	1	0	0	1	1			11.0

M.L.

	Drawing pt	vr	sd	sl	fo 3d	ed ln	ab gt	sumD	Text wr	lt	pt	vb	mt	ry	wm	pm	ab	gt	sumT
a	2	4	2	.1	0 0	0 0	4 3	8.0	6	8	1	2	0	0	0	0	3	2	8.0
b	3	4	3	0	0 0	0 0	3 3	10.0	16	8	1	3	0	0	0	3	2	2	11.0
c	2	4	2	0	0 0	0 0	4 3	8.0	4	14	1	2	0	0	0	0	1	1	14.0
d	2	4	2	0	0 0	0 0	3 3	8.0	6	8	1	2	0	0	0	0	3	2	8.0
e	4	4	2	0	0 0	0 0	4 4	10.0	13	11	1	3	0	0	2	2	4	3	15.0
f	3	4	3	0	0 0	0 0	4 4	10.0	7	10	1	2	0	0	1	0	3	2	11.0
g	3	4	3	0	0 0	0 0	4 3	10.0	12	9	1	2	0	0	3	2	3	2	14.0
h	3	6	2	0	0 0	0 1	3 2	12.0	11	8	1	2	0	0	3	1	3	2	12.0
i	1	4	1	0	0 0	0 0	1 2	6.0	17	8	1	4	0	0	1	4	3	2	13.0
j	2	6	2	0	0 0	0 1	3 3	11.0	6	8	1	2	0	0	0	0	3	2	8.0
k	3	4	3	0	0 0	0 2	3 3	12.0	6	6	1	1	0	0	0	0	1	1	6.0
l	2	4	2	0	0 0	0 0	2 2	8.0	12	8	1	2	0	0	0	0	2	2	8.0
m	3	4	2	0	0 0	0 2	3 4	11.0	16	8	1	4	0	0	1	5	3	2	14.0
n	3	4	3	0	0 0	0 0	2 3	10.0	18	9	1	4	0	0	1	4	1	2	14.0
o	2	4	2	0	0 0	0 2	3 4	10.0	15	8	1	5	0	0	2	3	2	2	13.0
p	2	4	2	0	0 0	0 0	3 3	8.0	10	10	1	4	0	0	0	2	1	2	12.0
q	2	4	2	0	0 0	0 0	3 3	8.0	4	11	1	2	0	0	0	0	1	2	11.0
r	3	5	2	0	0 0	0 0	3 3	10.0	8	8	1	2	0	0	0	0	1	2	8.0
s	11	4	2	0	0 0	1 0	2 2	18.0	6	8	1	2	0	0	1	0	1	2	9.0
t	2	4	2	0	0 0	0 0	2 3	8.0	7	8	1	2	0	0	0	0	1	2	8.0
u	3	6	2	0	0 0	0 1	3 2	12.0	6	12	1	2	0	0	0	1	3	2	13.0
v	2	4	2	0	0 0	0 0	3 3	8.0	5	8	1	2	0	0	0	0	2	2	8.0
w	3	4	2	0	0 0	0 2	3 4	11.0	9	8	1	2	0	0	1	0	3	2	9.0
x	2	4	2	0	0 0	1 0	1 2	9.0	4	8	1	2	0	0	0	0	1	2	8.0
y	2	4	2	0	0 0	1 2	3 4	11.0	6	8	1	2	0	0	0	1	3	2	9.0
z	3	4	2	0	0 0	0 0	1 2	9.0	10	8	1	2	0	0	1	1	2	2	10.0

C.C.

	Drawing pt	vr	sd	sl	fo 3d	ed ln	ab gt	sumD	Text wr	lt	pt	vb	mt	ry	wm	pm	ab	gt	sumT
a	1	10	1	0	1 0	1 1	3 4	14.0	9	5	0	3	1	1	0	2	1	3	9.0
b	3	10	1	0	1 0	1 1	2 4	17.0	9	5	0	3	1	1	0	2	1	3	9.0
c	1	16	1	0	1 0	1 1	2 4	21.0	9	7	0	3	1	1	0	2	1	3	11.0
d	1	14	1	0	1 0	1 1	2 4	19.0	9	7	0	3	1	1	1	2	1	3	12.0
e	1	20	1	0	1 0	1 1	2 3	25.0	8	6	0	3	1	1	1	2	1	3	11.0
f	1	17	1	0	1 0	1 1	2 3	22.0	9	7	0	2	1	1	0	2	1	3	11.0
g	1	19	1	0	1 0	1 1	2 3	24.0	8	6	0	3	1	1	1	1	1	3	10.0
h	1	20	1	0	1 0	1 1	2 3	25.0	9	5	0	3	1	1	0	2	1	3	9.0
i	1	20	1	0	1 0	1 1	2 2	25.0	8	5	0	3	1	1	1	2	1	3	10.0
j	1	20	1	0	1 0	1 1	2 3	25.0	6	5	0	2	1	1	0	1	1	2	8.0
k	1	17	1	0	1 0	1 1	2 4	22.0	9	7	0	3	1	1	0	2	1	3	11.0
l	1	11	1	0	1 0	1 1	2 2	16.0	8	7	0	2	1	1	1	1	1	2	11.0
m	1	18	1	0	1 0	1 1	2 3	23.0	7	8	0	2	1	1	0	1	1	2	11.0
n	1	16	1	0	1 0	1 1	2 4	21.0	8	6	0	2	1	1	1	1	1	3	10.0
o	2	8	1	0	1 0	1 1	2 4	14.0	9	7	0	2	1	1	1	1	1	3	11.0
p	2	11	1	0	1 0	1 1	2 4	17.0	8	7	0	2	1	1	1	1	1	3	11.0
q	2	12	1	0	1 0	1 1	2 4	18.0	9	6	0	2	1	1	1	1	1	3	10.0
r	1	14	1	0	1 0	1 1	2 4	19.0	9	5	0	2	1	1	2	1	1	3	10.0
s	1	14	1	0	1 0	1 1	2 3	19.0	9	5	0	2	1	1	0	2	1	3	9.0
t	1	10	1	0	1 0	1 1	2 4	15.0	9	5	0	2	1	1	1	1	1	3	9.0
u	1	16	1	0	1 0	1 1	2 3	21.0	8	7	0	2	1	1	0	1	1	2	10.0
v	1	8	1	0	1 0	1 1	2 4	13.0	7	7	0	2	1	1	0	1	1	3	10.0
w	1	18	1	0	1 0	1 1	2 3	23.0	9	5	0	2	1	1	0	2	1	3	9.0
x	1	20	1	0	1 0	1 1	2 4	25.0	8	6	0	3	1	1	0	2	1	3	10.0
y	1	15	1	0	1 0	1 1	2 3	20.0	8	6	0	2	1	3	0	2	1	3	12.0
z	1	16	1	0	1 0	1 1	2 4	21.0	9	6	0	2	1	3	0	2	1	3	12.0

Drawing

	pt	vr	sd	sl	fo	3d	ed	ln	ab	gt	sumD
a	3	6	2.1	2	1	0	0	1	3	4	15.0
b	3	4	2	0	0	0	0	0	2	2	9.0
c	2	6	2	0	0	0	0	0	4	1	10.0
d	2	6	2	0	0	0	0	0	3	2	10.0
e	4	6	2	0	0	0	0	0	1	1	12.0
f	3	4	2	1	0	0	0	0	3	2	10.0
g	3	6	2	0	0	0	0	0	4	3	11.0
h	3	6	2	0	0	0	0	0	1	1	11.0
i	3	6	2	0	0	0	0	0	1	1	11.0
j	2	4	2	0	0	0	0	0	3	2	8.0
k	3	6	2	0	0	0	0	0	3	4	11.0
l	2	6	2	0	0	0	0	0	2	1	10.0
m	3	4	2	0	0	0	0	0	3	3	9.0
n	3	4	2	0	0	0	0	2	2	3	11.0
o	2	6	2	0	0	0	0	0	1	2	10.0
p	3	6	2	0	0	0	0	0	2	3	11.0
q	3	6	2	0	0	0	0	0	2	2	11.0
r	4	6	2	1	0	0	0	1	3	4	14.0
s	4	6	2	0	0	0	0	0	3	2	12.0
t	2	4	2	0	0	0	0	1	3	3	9.0
u	3	4	2	0	0	0	0	1	2	2	10.0
v	2	3	2	0	0	0	0	0	4	3	7.0
w	3	4	2	0	0	0	0	1	3	4	10.0
x	4	4	2	0	0	0	0	0	4	2	10.0
y	2	4	2	0	0	0	1	0	3	4	9.0
z	4	3	2	0	0	0	0	1	3	2	10.0

Text

J.C.

	wr	lt	pt	vb	mt	ny	wm	pm	ab	gt	sumT
a	4	7	0	1	0	0	0	0	3	3	7.0
b	4	7	0	1	0	0	0	0	2	2	7.0
c	4	9	0	1	0	0	0	0	2	1	9.0
d	4	6	0	1	0	0	0	0	2	1	6.0
e	7	5	1	1	0	0	0	0	2	1	5.0
f	4	7	0	1	0	0	0	0	2	1	7.0
g	4	10	0	1	0	0	0	0	2	1	10.0
h	4	6	0	1	0	0	0	0	2	1	6.0
i	5	7	0	1	0	0	1	0	2	1	8.0
j	5	4	0	1	0	0	0	0	2	1	4.0
k	4	6	0	1	0	0	0	0	2	1	6.0
l	4	7	0	1	0	0	0	0	2	1	7.0
m	5	8	0	1	0	0	1	0	2	1	9.0
n	4	7	0	1	0	0	0	0	2	1	7.0
o	5	6	0	1	0	0	1	0	2	1	7.0
p	4	4	0	1	0	0	0	0	2	1	4.0
q	4	6	0	1	0	0	0	0	2	1	6.0
r	4	7	0	1	0	0	0	0	2	1	7.0
s	4	6	0	1	0	0	0	0	2	1	6.0
t	4	6	0	1	0	0	0	0	2	1	6.0
u	4	7	0	1	0	0	0	0	2	1	7.0
v	4	10	0	1	0	0	0	0	2	1	10.0
w	4	9	0	1	0	0	0	0	2	1	9.0
x	5	6	0	1	0	0	1	0	2	1	7.0
y	4	9	0	1	0	0	0	0	2	1	9.0
z	4	3	0	1	0	0	0	0	2	1	3.0

Drawing

	pt	vr	sd	sl	fo	3d	ed	ln	ab	gt	sumD
a	2	8	.9	.1	0	0	0	1	2	2	12.0
b	3	8	1	0	0	0	0	0	1	3	12.0
c	1	8	1	0	0	0	0	0	1	1	10.0
d	2	4	1	0	0	0	0	0	3	3	7.0
e	1	12	1	0	0	0	0	0	1	2	14.0
f	1	10	1	0	0	0	0	0	1	2	12.0
g	1	12	1	0	0	0	0	0	1	1	14.0
h	1	12	1	0	0	0	0	0	1	1	14.0
i	1	12	1	0	0	0	0	0	1	1	14.0
j	1	13	1	0	0	0	0	0	1	3	15.0
k	1	11	1	0	0	0	1	1	1	3	15.0
l	1	6	1	0	0	0	0	0	1	1	8.0
m	1	13	1	0	0	0	0	0	1	3	15.0
n	1	10	1	0	0	0	0	0	1	2	12.0
o	2	6	1	0	0	0	0	1	1	3	10.0
p	2	6	1	0	0	0	0	0	3	3	9.0
q	2	8	1	0	0	0	0	0	1	2	11.0
r	2	10	1	0	0	0	0	2	2	2	15.0
s	1	16	1	0	0	0	0	2	1	1	20.0
t	1	8	1	0	0	0	0	0	1	1	10.0
u	1	9	1	0	0	0	0	0	2	1	11.0
v	1	7	1	0	0	0	1	0	1	1	10.0
w	1	12	1	0	0	0	1	0	1	1	15.0
x	1	12	1	0	0	0	1	0	1	2	15.0
y	1	9	1	0	0	0	1	0	1	2	12.0
z	1	10	1	0	0	0	0	0	1	1	12.0

Text

A.L.

	wr	lt	pt	vb	mt	ny	wm	pm	ab	gt	sumT
a	4	5	0	1	0	0	0	0	1	1	5.0
b	4	9	0	1	0	0	0	0	1	1	9.0
c	4	9	0	1	0	0	0	0	1	1	9.0
d	5	7	0	1	0	0	1	0	1	1	8.0
e	4	6	0	1	0	0	0	0	1	1	6.0
f	4	4	0	1	0	0	0	0	1	1	4.0
g	5	7	0	1	0	0	1	0	1	1	8.0
h	5	5	0	1	0	0	1	0	1	1	6.0
i	4	11	0	1	0	0	0	0	2	1	11.0
j	4	4	0	1	0	0	0	0	3	1	4.0
k	5	4	0	1	0	1	1	0	3	2	6.0
l	5	4	0	1	0	1	1	0	4	2	6.0
m	4	3	0	1	0	0	0	0	1	1	3.0
n	4	4	0	1	0	0	0	0	1	1	4.0
o	4	7	0	1	0	0	0	0	1	1	7.0
p	5	5	0	1	0	0	1	0	3	2	6.0
q	4	5	0	1	0	0	0	0	2	1	5.0
r	4	7	0	1	0	0	0	0	1	1	7.0
s	4	5	0	1	0	0	0	0	1	1	5.0
t	5	6	0	1	0	1	1	0	2	1	8.0
u	4	9	0	1	0	0	0	0	1	1	9.0
v	4	6	0	1	0	0	0	0	1	1	6.0
w	5	9	0	1	0	0	1	0	1	1	10.0
x	4	10	0	1	0	0	0	0	1	1	10.0
y	4	7	0	1	0	0	0	0	1	1	7.0
z	4	8	0	1	0	0	0	0	1	1	8.0

E.O.

	Drawing pt	vr	sd	sl	fo	3d	ed	ln	ab	gt	sumD
a	2	8	1	1	0	0	0	0	1	3	12.0
*b	6	10	2	0	0	0	0	0	2	3	18.0
c	1	8	1	1	0	0	0	0	1	1	11.0
*d	2	13	1	0	0	0	0	0	2	3	16.0
e	1	12	1	1	0	0	2	0	1	3	17.0
*f	1	40	1	0	0	0	0	0	3	2	42.0
g	1	11	1	1	0	0	0	1	1	1	15.0
*h	5	8	2	0	0	0	0	0	3	2	15.0
i	1	12	1	1	0	0	0	0	1	1	15.0
*j	5	8	2	0	0	0	0	0	3	2	15.0
k	1	13	1	1	0	0	2	0	1	3	18.0
*l	8	6	2	0	0	0	0	0	2	3	16.0
m	1	12	1	1	0	0	2	0	1	2	17.0
*n	3	6	2	0	0	0	0	0	1	1	11.0
o	2	4	1	1	0	0	0	0	1	2	8.0
*p	6	7	3	0	0	0	0	0	2	3	16.0
q	3	6	1	21	0	0	0	0	1	1	31.0
*r	3	8	1	0	0	0	0	0	3	2	12.0
s	1	12	1	1	0	0	0	0	1	1	15.0
*t	2	5	1	0	0	0	0	0	2	2	8.0
u	1	8	1	1	0	0	0	0	2	3	11.0
*v	2	12	2	0	0	0	0	0	1	3	16.0
w	1	13	1	1	0	0	2	0	1	4	18.0
*x	8	10	2	0	0	0	0	0	1	2	20.0
y	1	10	1	1	0	0	2	0	1	2	15.0
*z	4	4	2	0	0	0	0	0	1	2	10.0

	Text wr	lt	pt	vb	mt	rv	wm	pm	ab	gt	sumT
a	4	7	.1	1	0	0	0	0	4	1	7.0
b	4	7	0	1	0	0	0	0	4	1	7.0
c	12	7	0	2	0	1	2	2	1	2	12.0
d	12	7	0	2	0	0	2	2	1	2	11.0
e	10	8	0	2	0	0	1	2	1	2	11.0
f	10	8	0	2	0	0	1	2	1	2	11.0
g	10	6	0	2	0	0	1	2	1	2	9.0
h	10	6	0	2	0	0	1	2	1	2	9.0
i	13	9	0	2	0	0	1	2	1	2	12.0
j	13	9	0	2	0	0	1	2	1	2	12.0
k	9	8	0	2	0	0	1	1	1	2	10.0
l	9	8	0	2	0	0	1	1	1	2	10.0
m	10	9	0	2	0	0	1	2	1	2	12.0
n	10	9	0	2	0	0	1	2	1	2	12.0
o	10	8	0	2	0	0	0	2	1	2	10.0
p	10	8	0	2	0	0	0	2	1	2	10.0
q	15	5	0	2	0	0	2	2	1	3	9.0
r	15	5	0	2	0	0	2	2	1	3	9.0
s	9	7	0	2	0	1	1	2	1	3	11.0
t	9	7	0	2	0	1	1	2	1	3	11.0
u	10	9	0	2	0	0	1	2	1	2	12.0
v	10	9	0	2	0	0	1	2	1	2	12.0
w	10	5	0	2	0	1	1	2	1	2	9.0
x	10	5	0	2	0	1	1	2	1	2	9.0
y	12	10	0	2	0	0	0	3	1	2	13.0
z	12	10	0	2	0	0	0	3	1	2	13.0

P.P.

	Drawing pt	vr	sd	sl	fo	3d	ed	ln	ab	gt	sumD
a	2	5	1	0	0	0	3	1	1	3	12.0
b	4	6	2	0	0	0	2	1	1	4	15.0
c	5	4	1	0	0	0	2	1	1	2	13.0
d	4	6	3	0	0	0	2	2	1	4	17.0
e	5	5	1	0	0	0	2	2	1	4	15.0
f	4	6	2	0	0	0	2	1	1	2	15.0
g	3	3	1	0	0	0	2	1	1	3	10.0
h	3	4	1	0	0	0	2	1	1	2	11.0
i	4	4	1	0	0	0	2	1	1	3	12.0
j	7	3	1	0	0	0	2	1	1	3	14.0
k	2	5	1	0	0	0	2	1	1	2	11.0
l	3	6	2	0	0	0	2	1	1	2	14.0
m	3	5	1	0	0	0	2	1	1	3	12.0
n	3	4	1	0	0	0	2	1	1	2	11.0
o	2	6	2	0	0	0	2	1	1	2	13.0
p	5	4	1	0	0	0	2	1	1	2	13.0
q	7	3	1	0	0	0	2	1	1	3	14.0
r	3	4	1	0	0	0	2	1	2	4	11.0
s	4	4	1	0	0	0	2	1	1	2	12.0
t	3	4	1	0	0	0	2	1	1	3	11.0
u	2	6	1	0	0	0	2	1	1	4	12.0
v	2	4	2	0	0	0	2	1	1	3	11.0
w	5	6	1	0	0	0	2	1	1	3	15.0
x	2	6	1	0	0	0	2	1	1	2	12.0
y	3	4	1	0	0	0	2	1	1	2	11.0
z	2	5	1	0	0	0	2	1	1	4	11.0

	Text wr	lt	pt	vb	mt	rv	wm	pm	ab	gt	sumT
a	7	7	2	1	0	0	1	2	3	2	10.0
b	7	7	2	1	0	0	1	2	3	2	10.0
c	7	7	2	1	0	0	1	2	1	2	10.0
d	7	7	2	1	0	0	1	2	4	2	10.0
e	7	7	2	1	0	0	1	2	1	2	10.0
f	7	7	2	1	0	0	1	2	1	2	10.0
g	7	7	2	1	0	0	1	2	1	2	10.0
h	7	7	2	1	0	0	1	2	1	2	10.0
i	7	7	2	1	0	0	1	2	2	2	10.0
j	7	7	2	1	0	0	1	2	1	2	10.0
k	7	7	2	1	0	0	1	2	1	2	10.0
l	7	7	2	1	0	0	1	2	1	2	10.0
m	7	7	2	1	0	0	1	2	1	2	10.0
n	7	7	2	1	0	0	1	2	1	2	10.0
o	7	7	2	1	0	0	1	2	3	2	10.0
p	7	7	2	1	0	0	1	2	1	2	10.0
q	7	7	2	1	0	0	1	2	1	2	10.0
r	7	7	2	1	0	0	1	2	1	2	10.0
s	7	7	2	1	0	0	1	2	1	2	10.0
t	7	7	2	1	0	0	1	2	1	2	10.0
u	7	7	2	1	0	0	1	2	3	2	10.0
v	7	7	2	1	0	0	1	2	4	2	10.0
w	7	7	2	1	0	0	1	2	1	2	10.0
x	7	7	2	1	0	0	1	2	2	2	10.0
y	7	7	2	1	0	0	1	2	1	2	10.0
z	7	7	2	1	0	0	1	2	1	2	10.0

Drawing

	pt	vr	sd	sl	fo	3d	ed	ln	ab	gt	sumD
a	2	8	2	2	0	0	0	0	2	1	14.0
b	3	13	2	2	0	0	0	0	2	3	20.0
c	3	12	2	2	0	0	0	0	2	1	19.0
d	2	8	2	2	0	0	0	0	2	3	14.0
e	2	8	2	2	0	0	0	0	2	2	14.0
f	2	10	2	2	0	0	0	0	2	2	16.0
g	2	12	2	2	0	0	0	0	2	1	18.0
h	2	12	2	2	0	0	0	0	2	1	18.0
i	2	12	2	2	0	0	0	0	2	1	18.0
j	2	10	2	2	0	0	0	0	2	1	16.0
k	2	13	2	2	0	0	0	0	2	3	19.0
l	2	6	2	2	0	0	0	0	2	2	12.0
m	2	15	2	2	0	0	0	0	2	3	21.0
n	2	10	2	2	0	0	0	0	2	1	16.0
o	2	8	2	2	0	0	0	0	2	1	14.0
p	2	12	2	2	0	0	0	0	2	2	18.0
q	2	14	2	2	0	0	0	0	2	3	20.0
r	2	9	2	2	0	0	0	0	2	1	15.0
s	2	11	2	2	0	0	0	0	2	1	17.0
t	2	10	2	2	0	0	0	0	2	2	16.0
u	2	8	2	2	0	0	0	0	2	2	14.0
v	2	6	2	2	0	0	0	0	2	1	12.0
w	2	15	2	2	0	0	0	0	2	2	21.0
x	2	12	2	2	0	0	0	0	2	1	18.0
y	2	9	2	2	0	0	0	0	2	1	15.0
z	2	12	2	2	0	0	0	0	2	1	18.0

Text

G.F.

	wr	lt	pt	vb	mt	ry	wm	pm	ab	gt	sumT
a	10	7	1	3	1	0	1	1	1	2	10.0
b	8	8	0	1	0	0	0	1	1	2	9.0
c	9	8	0	1	0	0	0	1	1	2	9.0
d	7	6	1	1	0	0	1	1	1	2	8.0
e	12	8	2	1	0	0	3	1	1	3	12.0
f	9	5	0	2	0	0	0	2	1	2	7.0
g	7	8	1	2	0	0	0	1	1	2	9.0
h	10	8	0	2	0	0	0	2	3	2	10.0
i	7	7	1	1	0	0	0	2	1	2	9.0
j	10	6	0	1	0	0	1	1	1	2	8.0
k	8	9	2	4	0	0	0	1	1	3	10.0
l	8	6	0	2	0	0	1	2	4	2	9.0
m	19	7	0	2	0	0	0	5	1	2	12.0
n	8	5	1	1	0	0	0	2	1	2	7.0
o	7	9	3	2	0	0	3	1	1	2	13.0
p	10	7	0	2	0	0	0	2	2	2	9.0
q	9	5	1	2	0	0	1	1	1	3	7.0
r	10	11	0	1	0	0	2	2	1	2	15.0
s	10	5	0	1	0	0	1	2	1	2	8.0
t	8	7	0	2	0	0	2	1	1	2	10.0
u	10	7	0	2	0	0	0	2	1	2	9.0
v	8	9	0	2	0	0	1	1	1	2	11.0
w	8	12	0	2	0	0	0	1	1	2	13.0
x	11	9	0	3	0	0	2	2	1	3	13.0
y	11	6	0	2	0	0	0	3	1	3	9.0
z	11	7	0	2	0	0	1	2	1	2	10.0

Drawing

	pt	vr	sd	sl	fo	3d	ed	ln	ab	gt	sumD
a	1	6	1	0	0	0	1	0	3	3	9.0
b	3	7	1	0	0	0	1	0	2	2	12.0
c	1	10	1	0	0	0	1	0	1	1	13.0
d	2	6	1	0	0	0	0	0	1	2	9.0
e	1	12	1	0	0	0	1	0	1	2	15.0
f	1	11	1	0	0	0	2	0	1	3	15.0
g	1	12	1	0	0	0	1	0	1	2	15.0
h	1	10	1	0	0	0	1	2	3	3	15.0
i	1	12	1	0	0	0	1	0	2	2	15.0
j	1	7	1	0	0	0	1	0	1	1	10.0
k	1	11	1	0	0	0	1	0	1	2	14.0
l	1	6	1	0	0	0	1	0	1	2	9.0
m	1	9	1	0	1	0	1	1	1	2	14.0
n	1	10	1	0	0	0	1	0	2	3	13.0
o	2	8	1	0	0	0	1	2	2	1	14.0
p	1	10	1	1	0	0	1	0	1	3	14.0
q	2	8	2	0	0	0	1	2	2	2	15.0
r	2	11	1	0	0	0	1	1	1	2	16.0
s	1	14	1	0	0	0	1	1	1	2	18.0
t	1	8	1	0	0	0	1	0	1	3	11.0
u	1	8	1	0	0	0	1	2	1	3	13.0
v	1	10	1	0	0	0	1	2	1	3	15.0
w	1	14	1	0	0	0	1	2	1	4	19.0
x	1	13	1	1	0	0	1	2	1	3	19.0
y	1	9	1	1	0	0	1	2	1	3	15.0
z	1	13	1	0	0	0	2	0	1	2	17.0

Text

B.D.

	wr	lt	pt	vb	mt	ry	wm	pm	ab	gt	sumT
a	14	10	1	4	0	0	3	3	1	2	16.0
b	9	7	1	1	0	0	2	1	1	2	10.0
c	6	8	0	2	0	0	1	1	1	2	10.0
d	7	8	0	2	0	0	2	1	1	2	11.0
e	18	9	0	2	0	0	2	5	1	2	16.0
f	12	10	1	1	0	0	2	2	1	2	14.0
g	11	8	0	2	0	0	2	1	1	2	11.0
h	8	8	0	2	0	0	1	3	1	2	12.0
i	15	12	1	1	0	0	0	2	1	2	14.0
j	9	12	0	1	0	0	0	2	1	2	14.0
k	12	9	0	3	0	0	1	1	1	2	11.0
l	8	8	1	1	0	0	0	1	1	2	9.0
m	14	8	1	2	0	0	2	2	1	2	12.0
n	16	8	1	1	0	0	1	3	1	2	12.0
o	10	7	0	2	0	0	1	1	1	2	9.0
p	7	12	0	2	0	0	2	2	1	2	16.0
q	10	10	2	1	0	0	0	1	1	2	11.0
r	7	6	0	2	0	0	2	1	1	2	9.0
s	7	8	0	2	0	0	2	1	1	2	11.0
t	7	11	0	2	0	0	2	2	1	2	15.0
u	11	8	1	3	0	0	2	3	1	2	13.0
v	13	8	0	3	0	0	1	3	1	2	12.0
w	11	10	0	3	0	0	1	1	1	2	12.0
x	13	9	0	1	0	0	1	3	1	2	13.0
y	9	7	0	1	0	0	1	3	1	2	11.0
z	13	10	0	1	0	0	2	3	1	2	15.0

Drawing

	pt	vr	sd	sl	fo	3d	ed	ln	ab	gt	sumD
a	2	7	1	0	1	0	0	1	1	2	12.0
b	3	7	1	0	0	0	0	0	1	1	11.0
c	1	7	1	0	0	0	0	1	1	1	10.0
d	2	5	1	0	1	0	0	0	2	1	9.0
e	1	12	1	0	0	0	0	0	1	1	14.0
f	3	4	1	0	1	0	0	1	1	1	10.0
g	5	4	1	0	1	0	0	1	1	2	12.0
h	3	4	1	0	0	0	0	0	1	1	8.0
i	3	4	1	0	0	0	0	0	1	1	8.0
j	3	4	1	0	0	0	0	0	1	1	8.0
k	3	4	1	0	1	0	0	1	1	2	10.0
l	1	6	1	0	0	0	0	0	1	1	8.0
m	1	12	1	0	0	0	0	0	1	1	14.0
n	1	8	1	0	0	0	0	0	1	1	10.0
o	1	4	1	0	0	0	0	0	1	1	6.0
p	3	4	1	0	0	0	0	1	2	2	9.0
q	3	4	1	0	0	0	0	1	1	1	9.0
r	4	6	1	0	0	0	0	1	1	1	12.0
s	1	10	1	0	1	0	0	1	1	1	14.0
t	2	4	1	0	0	0	0	0	1	1	7.0
u	1	8	1	0	0	0	0	1	1	1	11.0
v	1	8	1	0	0	0	0	0	1	2	10.0
w	1	12	1	0	0	0	0	0	1	1	14.0
x	1	12	1	0	0	0	0	0	1	1	14.0
y	1	9	1	0	0	0	0	0	1	1	11.0
z	1	10	1	0	0	0	0	0	1	1	12.0

Text

T.B.

	wr	lt	pt	vb	mt	ry	wm	pm	ab	gt	sumT
a	7	7	0	2	0	0	0	1	1	2	8.0
b	4	8	0	2	0	0	1	0	1	2	9.0
c	11	11	0	2	0	0	4	2	1	2	17.0
d	4	11	0	2	0	0	0	0	1	2	11.0
e	12	7	0	3	0	0	0	2	4	2	9.0
f	7	11	0	2	0	0	1	1	4	2	13.0
g	9	11	0	2	0	0	0	2	3	2	13.0
h	7	9	0	1	0	0	3	1	1	2	13.0
i	5	8	0	2	0	0	0	1	3	2	9.0
j	13	8	1	3	0	0	2	3	1	2	13.0
k	6	12	0	1	0	0	1	1	1	2	14.0
l	5	11	0	2	0	0	0	1	4	2	12.0
m	18	14	0	4	0	0	3	3	1	2	20.0
n	16	9	2	2	0	0	4	2	1	2	15.0
o	16	11	0	2	0	0	4	3	4	2	18.0
p	12	11	0	2	0	0	2	3	1	2	16.0
q	9	7	0	2	0	0	0	1	2	2	8.0
r	21	10	2	3	0	0	3	4	2	2	17.0
s	6	8	0	2	0	0	0	1	3	2	9.0
t	16	11	1	3	0	0	0	4	1	2	15.0
u	10	8	0	4	0	0	2	2	4	2	12.0
v	12	11	0	3	0	0	3	1	1	2	15.0
w	12	9	0	3	0	0	2	1	1	2	12.0
x	6	5	1	1	0	0	1	0	4	3	6.0
y	6	7	0	2	0	0	0	1	1	3	8.0
z	14	7	8	0	0	0	1	3	1	3	11.0

Drawing

	pt	vr	sd	sl	fo	3d	ed	ln	ab	gt	sumD
a	1	8	1	0	0	0	0	0	1	1	10.0
b	1	4	2	0	0	0	0	0	1	1	7.0
c	1	12	1	0	0	0	0	0	1	1	14.0
d	2	6	2	0	0	0	0	0	1	1	10.0
e	1	12	1	0	0	0	0	0	1	1	14.0
f	1	10	1	0	0	0	0	0	1	1	12.0
g	1	12	1	0	0	0	0	0	1	1	14.0
h	1	12	1	0	0	0	0	0	1	1	14.0
i	1	12	1	0	0	0	0	0	1	1	14.0
j	1	8	1	0	0	0	0	0	1	1	10.0
k	1	1	1	0	0	0	0	0	1	1	3.0
l	1	6	1	0	0	0	0	0	1	1	8.0
m	1	12	1	0	0	0	0	0	1	1	14.0
n	1	10	1	0	0	0	0	0	1	1	12.0
o	2	4	2	0	0	0	0	0	1	1	8.0
p	2	6	1	0	0	0	0	0	1	1	9.0
q	3	4	2	0	0	0	0	0	1	1	9.0
r	1	6	1	0	0	0	0	0	1	1	8.0
s	1	12	1	0	0	0	0	0	1	1	14.0
t	1	8	1	0	0	0	0	0	1	1	10.0
u	1	8	1	0	0	0	0	0	1	1	10.0
v	1	6	1	0	0	0	0	0	1	1	8.0
w	1	10	1	0	0	0	0	0	1	1	12.0
x	2	4	1	0	0	0	0	0	1	1	7.0
y	1	12	1	0	0	0	0	0	1	1	14.0
z	1	8	1	0	0	0	0	0	1	1	10.0

Text

D.K

	wr	lt	pt	vb	mt	ry	wm	pm	ab	gt	sumT
a	4	5	0	1	0	0	0	0	1	1	5.0
b	4	7	0	1	0	0	0	0	1	1	7.0
c	3	9	0	1	0	0	0	0	1	1	9.0
d	4	6	0	1	0	0	0	0	1	1	6.0
e	4	8	0	1	0	0	0	0	1	1	8.0
f	4	5	0	1	0	0	0	0	1	1	5.0
g	4	4	0	1	0	0	0	0	1	1	4.0
h	4	5	0	1	0	0	0	0	1	1	5.0
i	4	10	0	1	0	0	0	0	3	1	10.0
j	4	4	0	1	0	0	0	0	1	1	4.0
k	4	4	0	1	0	0	0	0	2	1	4.0
l	4	4	0	1	0	0	0	0	4	1	4.0
m	4	5	0	1	0	0	0	0	1	1	5.0
n	4	4	0	1	0	0	0	0	1	1	4.0
o	4	7	0	1	0	0	0	0	1	1	7.0
p	4	7	0	1	0	0	0	0	1	1	7.0
q	4	7	0	1	0	0	0	0	2	1	7.0
r	4	3	0	1	0	0	0	0	2	1	3.0
s	4	4	0	1	0	0	0	0	2	1	4.0
t	4	3	0	1	0	0	0	0	3	1	3.0
u	4	9	0	1	0	0	0	0	3	1	9.0
v	4	6	0	1	0	0	0	0	3	1	6.0
w	4	4	0	1	0	0	0	0	2	1	4.0
x	4	10	0	1	0	0	0	0	1	1	10.0
y	4	5	0	1	0	0	0	0	3	1	5.0
z	4	3	0	1	0	0	0	0	1	1	3.0

L.E.

Drawing

	pt	vr	sd	sl	fo	3d	ed	ln	sb	gt	sumD
a	3	9	3	2	0	0	0	2	2	3	19.0
b	5	4	2	1	0	0	0	2	2	2	14.0
c	3	10	2	0	0	0	0	2	1	2	17.0
d	4	11	4	1	0	2	1	2	3	3	25.0
e	1	14	1	0	1	0	1	2	1	3	20.0
f	2	8	2	0	0	0	0	0	1	2	12.0
g	3	10	2	0	0	0	1	2	2	2	18.0
h	8	7	3	0	0	1	1	2	2	1	22.0
i	2	12	2	0	0	0	1	2	3	3	19.0
j	10	13	3	0	0	2	1	2	1	2	31.0
k	8	4	2	0	0	2	1	2	3	3	19.0
l	3	13	2	1	0	2	1	2	4	4	24.0
m	6	14	2	2	0	2	1	2	3	3	29.0
n	5	5	2	1	0	2	1	2	2	2	18.0
o	3	5	3	0	0	0	1	2	1	1	14.0
p	8	13	2	1	0	2	0	2	2	2	28.0
q	7	18	5	0	0	2	1	2	4	4	35.0
r	5	12	2	2	0	2	1	2	1	1	26.0
s	4	9	2	0	0	2	1	2	1	3	20.0
t	5	19	4	0	0	2	1	2	4	4	33.0
u	3	12	2	0	0	2	1	2	1	1	22.0
v	4	7	2	0	0	2	0	0	1	1	15.0
w	3	12	3	0	0	2	1	2	2	3	23.0
x	8	4	2	0	0	2	0	2	2	2	18.0
y	5	7	3	0	0	2	1	2	3	3	20.0
z	7	15	3	1	0	2	1	2	2	3	31.0

Text

	wr	lt	pt	vb	mt	ry	wm	pm	sb	gt	sumT
a	9	10	1	3	1	3	0	0	1	2	14.0
b	10	6	1	2	1	2	1	0	1	2	10.0
c	9	8	1	1	1	2	0	0	1	2	11.0
d	10	7	1	2	1	2	1	1	1	2	12.0
e	8	11	2	1	1	2	1	1	4	3	16.0
f	8	6	1	2	1	2	1	1	4	3	11.0
g	8	7	1	2	1	2	0	1	1	2	11.0
h	9	8	1	2	1	2	0	1	4	2	12.0
i	8	9	1	2	1	2	1	0	4	2	13.0
j	9	8	1	2	1	2	0	2	1	3	13.0
k	9	9	1	3	1	2	1	1	4	2	14.0
l	8	6	1	3	1	2	1	1	1	3	11.0
m	7	10	1	2	1	2	0	0	1	2	13.0
n	10	6	1	2	1	2	1	0	3	2	10.0
o	10	7	2	2	1	2	1	0	1	3	11.0
p	8	6	1	2	1	2	0	0	3	2	9.0
q	7	8	2	1	1	2	0	1	4	2	12.0
r	15	7	5	5	1	2	1	1	2	4	12.0
s	13	8	0	3	1	2	2	1	4	3	14.0
t	8	7	1	2	1	2	1	1	4	2	12.0
u	9	6	1	2	1	2	1	1	4	2	11.0
v	8	7	1	2	1	2	0	0	1	3	10.0
w	9	6	0	3	1	2	0	0	1	3	9.0
x	9	7	1	3	1	2	0	2	4	3	12.0
y	10	4	0	3	1	2	0	1	1	2	8.0
z	8	11	1	1	1	2	0	1	4	3	15.0

C.C.

Drawing

	pt	vr	sd	sl	fo	3d	ed	ln	sb	gt	sumD
a	2	7	2	0	0	2	0	1	1	2	14.0
b	2	4	3	0	0	2	0	1	4	4	12.0
c	4	6	3	0	0	2	0	1	3	3	16.0
d	7	6	2	0	0	2	0	1	2	2	18.0
e	4	4	3	0	0	2	0	1	2	2	14.0
f	3	4	2	0	0	2	0	1	2	1	12.0
g	3	6	3	0	0	2	0	1	4	3	15.0
h	3	6	2	0	0	2	0	0	2	1	13.0
i	5	4	2	0	0	2	0	0	1	1	13.0
j	2	7	2	0	0	0	1	2	3	3	14.0
k	4	4	1	0	0	2	2	1	1	3	14.0
l	4	4	1	0	0	2	0	1	1	2	12.0
m	3	8	3	0	0	2	0	0	2	3	16.0
n	5	4	2	0	0	2	0	1	3	3	14.0
o	4	4	2	0	0	2	0	0	2	1	12.0
p	4	6	2	0	0	2	0	1	2	1	15.0
q	5	6	0	0	0	2	0	1	3	3	14.0
r	4	6	3	1	0	2	0	1	3	2	17.0
s	2	6	1	0	0	2	0	1	1	1	12.0
t	2	4	2	0	0	0	0	0	1	2	8.0
u	3	8	3	0	0	2	0	1	2	2	17.0
v	3	4	2	0	0	2	0	1	1	3	12.0
w	4	4	2	0	0	0	0	1	1	3	11.0
x	2	5	2	0	0	0	0	1	2	2	10.0
y	3	4	3	0	0	2	0	1	3	4	13.0
z	3	4	2	0	0	0	0	1	2	1	10.0

Text

	wr	lt	pt	vb	mt	ry	wm	pm	sb	gt	sumT
a	4	7	0	1	0	0	0	0	4	1	7.0
b	3	9	0	0	0	0	1	0	4	1	10.0
c	8	10	0	3	0	0	2	0	1	2	12.0
d	5	8	0	1	0	0	0	0	4	2	8.0
e	2	5	0	0	0	0	0	0	4	0	5.0
f	2	8	0	0	0	0	0	0	4	0	8.0
g	2	5	0	0	0	0	0	0	4	0	5.0
h	11	9	1	3	0	0	4	0	1	2	13.0
i	3	11	0	0	0	0	1	0	4	1	12.0
j	7	9	0	1	0	0	1	0	4	2	10.0
k	4	4	0	1	0	0	1	0	4	3	5.0
l	8	6	0	1	0	0	1	0	4	2	7.0
m	2	8	0	1	0	0	0	0	4	0	8.0
n	3	8	0	0	0	0	1	0	4	0	9.0
o	2	6	0	0	0	0	0	0	4	0	6.0
p	2	13	0	0	0	0	0	0	4	0	13.0
q	2	7	0	0	0	0	0	0	4	0	7.0
r	6	9	1	0	0	0	0	0	4	2	9.0
s	10	9	1	1	0	0	3	0	4	3	12.0
t	8	9	2	1	0	0	1	0	4	2	10.0
u	5	5	2	0	0	0	0	0	4	2	5.0
v	2	6	0	0	0	0	0	0	4	0	6.0
w	3	6	0	0	0	0	1	0	4	0	7.0
x	8	5	1	3	0	0	2	0	4	0	7.0
y	3	9	0	0	0	0	1	0	4	2	10.0
z	2	4	0	0	0	0	0	0	4	0	4.0

Drawing

	pt	vr	sd	sl	fo	3d	ed	ln	ab	gt	sumD
a	2	4	1	1	0	0	1	3	3	4	12.0
b	3	7	1	2	0	0	1	2	2	2	16.0
c	1	11	1	2	0	0	1	2	1	3	18.0
d	2	7	1	0	0	0	1	2	1	2	13.0
e	1	13	1	0	0	0	1	2	1	2	18.0
f	1	8	1	0	0	0	1	2	1	2	13.0
g	1	12	1	0	0	0	1	2	1	2	17.0
h	1	16	1	0	1	0	0	2	2	3	21.0
i	1	19	1	0	0	0	2	2	3	3	25.0
j	1	10	1	1	0	0	1	2	1	1	16.0
k	1	12	1	0	0	0	1	2	1	2	17.0
l	1	7	1	1	0	0	1	2	1	2	13.0
m	1	8	1	0	0	0	1	2	1	2	13.0
n	1	6	1	0	0	0	1	2	1	1	11.0
o	2	4	1	0	0	0	1	2	1	1	10.0
p	2	6	1	1	0	0	1	2	1	3	13.0
q	2	8	1	0	0	0	1	2	2	1	14.0
r	2	9	1	1	0	0	1	2	2	2	16.0
s	1	11	1	0	0	0	1	2	2	3	16.0
t	1	10	1	2	0	0	1	2	1	3	17.0
u	1	11	1	0	1	0	0	2	1	3	16.0
v	1	8	1	0	0	0	1	2	1	3	13.0
w	1	8	1	0	0	0	1	2	1	2	13.0
x	1	8	1	0	0	0	1	2	1	2	13.0
y	1	10	1	0	0	0	1	2	1	2	15.0
z	1	6	1	2	0	0	1	2	1	2	13.0

Text

Z.G.

	wr	lt	pt	vb	mt	ry	wm	pm	ab	gt	sumT
a	19	7	1	3	.9	3	2	4	1	3	16.9
b	21	5	1	4	1	2	2	4	1	3	14.0
c	24	5	1	3	1	2	0	5	1	2	13.0
d	20	5	1	4	1	2	3	4	1	2	15.0
e	18	8	1	4	1	2	0	3	1	2	14.0
f	20	6	1	4	1	2	1	3	1	2	13.0
g	21	6	2	5	1	2	3	2	1	2	14.0
h	17	8	1	3	1	2	2	2	1	2	15.0
i	20	6	1	3	1	2	1	2	1	1	12.0
j	18	7	2	3	1	2	1	2	1	2	13.0
k	16	5	1	3	1	2	4	0	1	2	12.0
l	20	6	1	4	1	2	3	3	1	3	15.0
m	17	9	1	4	1	2	3	4	1	2	19.0
n	16	15	1	2	1	2	3	2	1	1	23.0
o	22	8	1	3	1	2	2	5	1	2	18.0
p	16	10	2	4	1	2	2	2	1	2	17.0
q	18	12	1	3	1	2	3	1	1	3	19.0
r	19	6	1	4	1	2	3	2	1	1	14.0
s	20	5	1	4	1	2	1	3	1	2	12.0
t	19	7	1	4	1	2	3	2	1	2	15.0
u	18	9	1	4	1	2	2	2	1	2	16.0
v	17	7	1	4	1	2	2	1	1	3	13.0
w	19	7	3	3	1	2	3	3	1	3	16.0
x	16	9	1	3	1	2	3	1	1	2	16.0
y	21	10	1	4	1	2	2	3	1	2	18.0
z	20	8	1	4	1	2	3	3	1	2	17.0

Drawing

	pt	vr	sd	sl	fo	3d	ed	ln	ab	gt	sumD
a	2	7	1	0	0	0	0	0	1	1	10.0
b	2	5	1	0	0	0	0	0	1	1	8.0
c	1	8	1	0	0	0	0	0	1	1	10.0
d	2	4	2	0	0	0	0	2	3	3	10.0
e	1	12	1	0	0	0	0	1	1	1	15.0
f	1	10	1	0	0	0	0	0	1	1	12.0
g	1	12	1	0	0	0	0	0	1	1	14.0
h	3	4	1	0	0	0	1	1	1	2	10.0
i	4	4	1	0	0	0	0	1	1	1	10.0
j	3	6	2	0	0	0	1	1	1	1	13.0
k	1	11	1	0	0	0	0	0	1	1	13.0
l	1	6	1	0	0	0	0	0	1	1	8.0
m	1	10	1	0	0	0	0	0	1	1	12.0
n	1	8	1	2	0	0	0	0	1	1	12.0
o	2	4	1	0	0	0	0	2	2	3	9.0
p	2	4	1	0	0	0	0	0	1	2	7.0
q	2	4	1	0	0	0	0	0	1	1	7.0
r	3	6	2	0	0	0	0	0	1	2	11.0
s	3	5	2	0	0	0	0	20	1	1	30.0
t	2	4	1	0	0	0	0		1	1	7.0
u	1	8	1	0	0	0	0	0	1	1	10.0
v	1	6	1	0	0	0	0	0	1	1	8.0
w	1	10	1	0	0	0	0	0	1	1	14.0
x	2	4	2	1	0	0	0	2	1	1	9.0
y	1	9	1	0	0	0	0	0	1	1	11.0
z	1	8	1	0	0	0	0	0	1	1	10.0

Text

F.G.

	wr	lt	pt	vb	mt	ry	wm	pm	ab	gt	sumT
a	4.1	3	.1	.9	0	0	0	0	1	1	3.4
b	4	3	0	1	0	0	0	0	1	1	3.0
c	4	8	0	1	0	0	0	0	1	1	8.0
d	4	8	0	1	0	0	0	0	1	1	8.0
e	4	8	0	1	0	0	0	0	1	1	8.0
f	4	7	0	1	0	0	0	0	1	1	7.0
g	4	3	0	1	0	0	0	0	1	1	3.0
h	4	5	0	1	0	0	0	0	1	1	5.0
i	4	5	0	1	0	0	0	0	1	1	5.0
j	4	6	0	1	0	0	0	0	1	1	6.0
k	4	8	0	1	0	0	0	0	1	1	8.0
l	4	12	0	1	0	0	0	0	1	1	12.0
m	4	8	0	1	0	0	0	0	1	1	8.0
n	4	6	0	1	0	0	0	0	1	1	6.0
o	4	4	0	1	0	0	0	0	1	1	4.0
p	4	7	0	1	0	0	0	0	1	1	7.0
q	4	7	0	1	0	0	0	0	1	1	7.0
r	4	7	0	1	0	0	0	0	1	1	7.0
s	4	4	0	1	0	0	0	0	1	1	4.0
t	4	6	0	1	0	0	0	0	1	1	6.0
u	4	6	0	1	0	0	0	0	1	1	6.0
v	4	5	0	1	0	0	0	0	1	1	5.0
w	4	9	0	1	0	0	0	0	1	1	9.0
x	4	5	0	1	0	0	0	0	1	1	5.0
y	4	4	0	1	0	0	0	0	1	1	4.0
z	4	3	0	1	0	0	0	0	1	1	3.0

M.H.

Drawing

	pt	vr	sd	sl	fo	3d	ed	ln	ab	gt	sumD
a	5	5	3	0	0	0	1	2	4	4	16.0
b	6	6	2	0	0	0	2	2	4	4	18.0
c	3	4	3	0	0	0	2	1	3	4	13.0
d	5	6	3	0	0	0	2	2	4	4	18.0
e	4	4	3	0	0	0	1	2	3	3	14.0
f	6	7	3	0	0	0	0	2	3	3	18.0
g	4	7	3	0	0	0	0	2	4	4	16.0
h	2	8	2	0	0	0	2	2	4	4	16.0
i	4	3	2	0	0	0	2	2	3	4	13.0
j	2	3	2	0	0	0	0	2	2	2	9.0
k	4	3	3	0	0	0	0	2	3	3	12.0
l	2	5	2	0	0	0	0	2	2	3	11.0
m	6	4	2	0	0	0	0	2	2	2	14.0
n	4	4	3	0	0	0	0	2	3	1	13.0
o	4	4	2	0	0	0	1	2	2	1	13.0
p	3	7	2	0	0	0	1	2	2	3	15.0
q	4	5	5	0	0	0	0	2	3	3	16.0
r	4	6	4	0	0	0	1	2	4	4	17.0
s	2	8	2	0	0	0	1	2	4	3	15.0
t	4	7	3	0	0	0	1	2	4	4	17.0
u	3	7	3	0	0	0	2	2	3	2	17.0
v	4	4	3	0	0	0	2	2	4	4	15.0
w	3	9	3	0	0	0	2	2	1	3	19.0
x	5	4	3	0	0	0	1	0	2	4	13.0
y	5	6	3	0	0	0	1	2	4	4	17.0
z	3	12	3	0	0	0	0	2	3	4	20.0

Text

	wr	lt	pt	vb	mt	ry	wm	pm	ab	gt	sumT
a	5	6	0	1	0	0	0	0	2	1	6.0
b	6	10	0	0	0	0	1	0	1	1	11.0
c	5	10	0	0	0	0	0	0	1	2	10.0
d	5	5	0	0	0	0	0	0	0	1	5.0
e	6	9	1	0	0	0	1	0	4	1	10.0
f	5	9	0	0	0	0	0	0	1	1	9.0
g	5	6	0	0	0	0	0	0	1	1	6.0
h	5	10	0	0	0	0	0	0	2	1	10.0
i	5	15	0	1	0	0	0	0	2	1	15.0
j	5	11	0	0	0	0	1	0	1	1	12.0
k	6	9	1	0	0	0	0	0	3	1	9.0
l	7	16	0	0	0	0	0	1	4	2	17.0
m	5	23	0	0	0	0	0	0	4	3	23.0
n	6	11	0	0	0	0	1	0	1	1	12.0
o	6	16	0	0	0	0	1	0	1	1	17.0
p	5	11	0	0	0	0	0	0	4	1	11.0
q	5	11	0	0	0	0	0	0	1	1	11.0
r	5	12	0	0	0	0	0	0	4	2	12.0
s	5	16	0	0	0	0	0	1	1	1	17.0
t	5	12	0	0	0	0	0	0	1	2	12.0
u	5	14	0	0	0	0	0	0	3	1	14.0
v	5	15	0	0	0	0	0	0	4	2	15.0
w	5	16	0	0	0	0	0	0	3	2	16.0
x	5	11	0	0	0	0	1	0	2	2	12.0
y	5	10	0	0	0	0	0	0	1	1	10.0
z	5	13	0	0	0	0	1	0	3	2	14.0

C.T.

Drawing

	pt	vr	sd	sl	fo	3d	ed	ln	ab	gt	sumD
a	2	8	1	1	0	0	1	0	2	3	13.0
b	3	8	1	1	0	0	1	0	2	2	14.0
c	1	8	1	2	0	0	1	0	2	2	13.0
d	2	5	1	2	0	0	1	0	2	3	11.0
e	1	12	1	2	0	0	1	0	2	3	17.0
f	1	10	1	2	0	0	1	0	2	3	15.0
g	1	12	1	2	0	0	1	0	2	4	17.0
h	1	12	1	3	0	0	1	1	2	3	19.0
i	1	12	1	3	0	0	1	1	2	3	19.0
j	1	12	1	4	0	0	1	1	2	2	20.0
k	1	11	1	1	0	0	1	1	2	3	16.0
l	1	6	1	1	0	0	1	0	2	2	10.0
m	1	12	1	1	0	0	1	0	2	3	16.0
n	1	10	1	2	0	0	1	0	2	2	15.0
o	2	4	1	3	0	0	1	1	2	3	12.0
p	2	8	1	3	0	0	1	0	2	3	15.0
q	2	8	1	3	0	0	1	1	2	3	16.0
r	2	11	1	3	0	0	1	1	2	3	19.0
s	1	12	1	2	0	0	1	0	2	2	17.0
t	1	8	1	2	0	0	1	0	2	2	13.0
u	1	8	1	2	0	0	1	0	2	2	13.0
v	1	7	1	2	0	0	1	0	2	3	12.0
w	1	13	1	2	0	0	1	0	2	3	18.0
x	1	12	1	2	0	0	1	1	2	3	18.0
y	1	9	1	1	0	0	1	1	2	3	14.0
z	1	9	1	1	0	0	1	0	2	2	13.0

Text

	wr	lt	pt	vb	mt	ry	wm	pm	ab	gt	sumT
a	23	13	0	2	0	0	5	4	4	3	22.0
b	3	5	0	0	0	0	1	0	4	1	6.0
c	17	12	4	2	0	0	3	4	1	2	19.0
d	17	12	2	3	0	0	1	3	4	2	16.0
e	16	10	0	3	0	0	2	3	3	2	15.0
f	10	11	0	2	0	0	2	2	4	2	15.0
g	11	8	0	2	0	0	3	2	3	2	13.0
h	16	8	0	1	0	0	3	4	1	2	15.0
i	9	8	1	1	0	0	1	1	3	2	10.0
j	21	10	2	3	0	0	4	4	1	2	18.0
k	11	10	2	2	0	0	2	2	1	2	14.0
l	8	13	4	1	0	0	0	1	3	1	14.0
m	4	8	0	0	0	0	2	0	1	3	10.0
n	13	7	1	2	0	0	1	4	3	2	12.0
o	6	9	0	1	0	0	1	1	4	2	11.0
p	17	8	0	3	0	0	2	4	4	2	14.0
q	36	11	5	3	0	0	7	5	2	2	23.0
r	15	12	1	1	0	0	3	3	2	2	18.0
s	15	8	4	1	0	0	0	3	4	2	11.0
t	10	10	1	1	0	0	3	1	1	2	14.0
u	6	12	0	0	0	0	1	1	4	2	14.0
v	14	10	1	1	0	0	2	3	1	2	15.0
w	8	8	0	2	0	0	1	2	4	2	11.0
x	15	9	2	2	0	0	1	3	3	3	13.0
y	15	12	0	1	0	0	3	4	1	2	19.0
z	24	9	1	1	0	0	3	5	1	2	17.0

APPENDIX C
COMPUTER TOOLS

Two sets of Logo procedures, written by the researcher, are shown here.

The *AutoMOVE* workspace has one procedure associated with each letter of the alphabet. The procedure **A** uses the subprocedure **DRAW** to provide a single-key-stroke environment for drawing. A summary of *AutoMOVE* commands may be found in Appendix D2.

The *ComPOSER* workspace contains a set of two-letter labels which point to words in a lexicon. The first letter of each label signifies the part of speech and the second letter of that label signifies the first letter of the word in the lexicon. (e.g. the label **A.B** points to the **adjective** in the lexicon which starts with **B**.) *ComPOSER* also includes a set of procedures for word transformation and procedures that expand scores into paragraphs.

AutoMOVE

Procedures A through Z

```
TO A
  ; ** AUTOMOVE **
  IF :N < 0 [MAKE "N 1 PR `
      Automatic Drawing is off`
  PR `   *** Welcome back to Logo  ***`
      TOPLEVEL]
  IF MEMBER? `Edit` WINDOWS
      [CLOSEWINDOW "EDIT]
  SETWSIZE "TURTLE [480 240]
  SETWPOS "TURTLE [20 40]
  SETWSIZE "LOGO [480 55]
  SETWPOS "LOGO [20 300]
  ST Z
  PR ` Automatic Drawing is on;
      type  N A  to return to Logo`
  DRAW
END

TO B
  ; ** BLACK **
  MAKE "MEM "B
  IF :BW = "B [MAKE "PP 1 MAKE "BW "W
      PR `The pen is BLACK`]
      [MAKE "PP 20 MAKE "BW "B
       PR `The  pen is WHITE`]
  SETPPATTERN :PP
END

TO C
  ;  ** CIRCLE **
  MAKE "MEM "C
  SETPP :PP
  IF :N < 1 [CC] [FILLSH [CC] PENPAINT]
END

TO D
  ;  ** DRAW **
  MAKE "MEM "D
  IF PENDOWN? [PU PR `The pen is UP`]
      [PD PR `The pen is DOWN`]
END

TO E
  ; ** ERASE **
  PR ` do you really want to
      ERASE it  (Y/N) ?`
  MAKE "E RC
  IF ( OR ASCII :E = 121 ASCII :E = 89 )
      [CG PRINT `ZAP`] [PRINT ` OK `]
END

TO F
  ;  ** FRACTILE **
  MAKE "MEM "F
  IF :N = 1 [RUN []]
  IF :N = -1 [RUN [PENERASE]]
  FF :S
  PENPAINT
END

TO G
  ; ** GREY **
  MAKE "MEM "G
  IF :GV = "G [MAKE "PP 4 MAKE "GV "V
      PR `The pen is dark GREY`]
      [MAKE "PP 23 MAKE "GV "G PR
      `The pen is light GREY`]
  SETPPATTERN :PP
END

TO H
  ; ** HOME **
  MAKE "TP POS
  MAKE "TH HEADING
  MAKE "MEM [SETPOS :TP SETH :TH]
  HOME
END

TO I
  ; ** INVISIBLE **
  IF :I > 0 [HT MAKE "I 0] [ST MAKE "I 1]
END


TO J
  MAKE "MEM "J
  ; ** JUMP **
  RT 90 FD :N * :S LT 90
END
```

AutoMOVE

```
TO K
  ; ** KEY **
  MAKE "MEM "K
  SETPP :PP
  MAKE "P PENDOWN?
  PD
  MAKE "K 2
  IF :N < 0 [RT 90 KYY
       FD :N * :S * ( :K - ( 2 / 3 ) )]
       [FD :N * :S * :K RT 90 KYY]
  PU  IF :P [RUN [PD]]
END

TO L
  ; ** LEAP **
  MAKE "MEM "L
  FD :N * :S
END

TO M
  ;  ** MAGNIFY **
  MAKE "MEM "M
  IF :N > 0 [MAKE "S :S + 5]
  IF :N < 0 [MAKE "S :S - 5]
  SIZE?
END

TO N
  ; ** NEGATE **
  IF :N < 0 [MAKE "N 1 PR ` NOT is off`]
[MAKE "N -1 PR ` NOT is on`]
END

TO O
  ;  ** ORNATE **
  IF :OB = "O [MAKE "PP 32 MAKE "OB "B
       PR `The pen is ornate`]
       [MAKE "PP 17 MAKE "OB "O
       PR `The  pen is ostentatious`]
  SETPPATTERN :PP
END

TO P
  ; ** PETAL **
  MAKE "MEM "P
  SETPP :PP
  IF :N < 1 [PETAL] [FILLSH [PETAL]]
END

TO Q
  ; ** QUARTER CIRCLE **
  MAKE "MEM "Q
  SETPP :PP
  QC
END

TO R
  ; ** STAR **
  MAKE "MEM "R
  SETPP :PP
  IF :N < 1 [STAR] [FILLSH [STAR] PENPAINT]

END

TO S
  ; ** SQUARE **
  MAKE "MEM "S
  SETPP :PP
  IF :N < 1 [SQ] [FILLSH [SQ] PENPAINT]
END

TO T
  ; ** TRIANGLE **
  MAKE "MEM "T
  SETPP :PP
  IF :N < 1 [TR] [FILLSH [TR] PENPAINT]
END

TO U
  ; ** UNDO **
  PENERASE
  IF ( OR :MEM = "T :MEM = "S :MEM = "C
       :MEM = "R :MEM = "V )
       [PR `Whoops` RUN ( SE :MEM )]
       [PR `Whoops` NN RUN ( SE :MEM ) NN]
  PENPAINT MAKE "MEM "~
END

TO V
  ; ** VALENTINE **
  MAKE "MEM "V
  SETPP :PP
  IF :N < 1 [HEART] [FILLSH [HEART]]
END
```

AutoMOVE

```
TO W
  ; ** WIDTH **
  MAKE "P1 FIRST PENSIZE
  IF :N > 0 [MAKE "P1 :P1 + 1]
  IF :N < 0 [IF :P1 > 0 [MAKE "P1 :P1 - 1]
      [MAKE "P1 0]]
  SETPENSIZE :P1 :P1
  PR SENTENCE [THE PEN WIDTH IS] :P1
END

TO X
  ; ** X-AXIS **
  MAKE "XX XCOR
  MAKE "MEM [SETX :XX]
  IF :S > 75 [MAKE "S 75 PR `The turtle
      can't go sideways more than ±225`] []
  SETX :N * :S * 3
  PR SENTENCE `The turtle's horizontal
      location  is ` :N * :S * 3
END

TO Y
  ; ** Y-AXIS **
  MAKE "YY YCOR
  MAKE "MEM [SETY :YY]
  IF :S > 35 [MAKE "S 35 PR `The turtle can't

      go higher than ±105`] []
  SETY :N * :S * 3
  PR SENTENCE `The turtle's vertical location
      is ` :N * :S * 3
END

TO Z
  ; ** ZERO **
  ; -- Sets the initial conditions --
  PENDOWN  PENPAINT  SETPS 1 1  SETPP 1
  ;Set the pen patterns choices
  MAKE "BW "B MAKE "OB "O MAKE "GV "G
  MAKE "S 15  MAKE "T 15  MAKE "PP 1
  MAKE "N 1     ;Turn off not
  MAKE "I 1     ;Show the Turtle
  PD  PRINT ` The turtle has been reset `
  SIZE?
END

TO .
  ; ** TURN RIGHT **
  RT :N * :S * 3
END

TO ,
  ; ** TURN LEFT **
  LT :N * :S * 3
END

TO ?
  ; ** QUESTION **
  IF :S > 45 [MAKE "T :S MAKE "S 0] []
  RUN LIST WORD "? :S
  MAKE "S :T
END
```

AutoMOVE

Procedures for Shapes

```
TO CC
  MAKE "P PENDOWN?
  PU FD :S RT 95 PD
  REPEAT 36 [FD :S * 2 * SIN 5 RT 10]
  PU LT 95 BK :S
  IF :P [RUN [PD]]
END

TO FF :S
  MAKE "P PENDOWN?
  REPEAT 6 [FD 2 * :S / 3 * COS 30
      HX :S / 5 FD :S / 3 * COS 30
      HX :S / 10
      BK 2 * :S / 3 * COS 30
      IF :S > 40 [FF :S / 2] []
      BK :S / 3 * COS 30 RT 60]
  PU  IF :P [RUN [PD]]
END

TO HX :S
  PU FD :S RT 120 PD
  REPEAT 6 [FD :S * COS 30 RT 60]
  PU LT 120 BK :S PD
END

TO HEART
  MAKE "P PENDOWN?
  MAKE "H :S * 0.1
  PD REPEAT 21 [FD :H RT 10]
  REPEAT 8 [FD :H * 2 RT 4]
  PU LT 242 FD :H * 13.333 PD
  REPEAT 21 [FD :H LT 10]
  REPEAT 8 [FD :H * 2 LT 4]
  PU RT 242 FD :H * 13.333
  IF :P [RUN [PD]]
  PR ` You break my heart `
END

TO KY
  MAKE "P PENDOWN?
  MAKE "K 3
  IF :N < 0
      [RT 90 KYY FD :N * :S * (:K -1 )]
      [FD :N * :S * :K RT 90 KYY]
  IF :P [RUN [PD]]
END

TO KYY
  MAKE "K 2
  REPEAT 3 [FD :S * :N * :K RT 90
      MAKE "K :K - ( 2 / 3 )]
  MAKE "K ( 2 / 3 )
  FD :S * :N * :K LT 90
  REPEAT 3 [FD :S * :N * :K LT 90
      MAKE "K :K + ( 2 / 3 )]
END

TO PETAL
  MAKE "P PENDOWN?
  LT :N * 20 PD
  REPEAT 9 [FD :S * 2.6 * SIN 2.5 RT :N *
5]
  RT :N * 135
  REPEAT 9 [FD :S * 2.6 * SIN 2.5 RT :N *
5]
  RT :N * 155
  IF :P [RUN [PD]]
END

TO QC
  MAKE "P PENDOWN?
  RT 5 * :N PD
  REPEAT 9 [FD :N * :S * 2 * SIN 5 RT :N *
10]
  LT 5 * :N
  PU  IF :P [RUN [PD]]
END
```

```
TO SQ
  MAKE "P PENDOWN?
  PU RT 45 FD :S RT 135 PD
  REPEAT 4 [FD :S * 2 * COS 45 RT 90]
  PU LT 135 BK :S LT 45
  IF :P [RUN [PD]]
END

TO STAR
  MAKE "P PENDOWN?
  PU FD :S RT 162 PD
  REPEAT 5 [FD :S * 2 * COS 18 RT 144]
  PU LT 162 BK :S
  IF :P [RUN [PD]]
END

TO TR
  MAKE "P PENDOWN?
  PU FD :S RT 150 PD
  REPEAT 3 [FD :S * 2 * COS 30 RT 120]
  PU LT 150 BK :S
  IF :P [RUN [PD]]
END
```

AutoMOVE

Utility Procedures

```
TO DRAW
  CLEARKEYS
  MAKE "X RC
  IF NUMBER? :X [MAKE "S :X * 5 SIZE?
       DRAW]  [IF ASCII :X > 96
       [MAKE "X CHAR ( ( ASCII :X ) - 32 )]
       [] IF  OR AND ASCII :X > 62
       ASCII :X < 91
       OR ASCII :X = 44 ASCII :X = 46
       [RUN  PARSE ( STRING :X ) DRAW]]
  DRAW
END

TO NN
  ; ** NEGATE, Without comment **
  IF :N < 0 [MAKE "N 1] [MAKE "N -1]
END

TO SCALE :R
  ;  ** MULTIPLY SIZE **
  MAKE "MEM "M
  IF :N > 0 [MAKE "S :S * :R]
  IF :N < 0 [MAKE "S :S / :R]
  SIZE?
END

TO SIZE :T
  MAKE "S :T * 5
  SIZE?
END

TO SIZE?
  PR SENTENCE ` The size is now` :S / 5
END

TO ~
  ; **empty**
END

MAKE "N 0
```

ComPOSER

Procedures for Word Transformations

```
TO MK.AV :ADJ
  ; * Make an Adverb from an Adjective*
  MAKE WORD "AV. LAST
  FIRST :ADJ ( STRING THING
  FIRST :ADJ `ly` )
END

TO MK.NN :NM :LLIST
  ; ** Make a New Noun **
  MAKE :NM ( SENTENCE FIRST :LLIST
       `which` LAST :LLIST )
END

TO MK.PN :NOUN
  ; ** Make a Plural Noun **
  MAKE WORD "P FIRST :NOUN ( STRING
      THING FIRST :NOUN `s` )
END

TO MK.PV :VERB
  ; ** Make a Plural Verb **
  MAKE WORD "P FIRST :VERB STRING
      BUTLAST THING FIRST :VERB
END

TO MK.NA :VERB
  ; ** Make a New Adverb from a Verb **
  MAKE WORD "NA BUTFIRST
       FIRST :VERB ( STRING BUTLAST
       THING FIRST :VERB `ing` )
END
```

Procedures for Score Expansion

```
TO EXPAND :SEN
  ; ** Expands sentence definitions **
  PR []
  MAKE "NUM 1
  PRINT1 `Level 1 :  ` PRINT1 :SEN
  PRINT []
  MAKE "LZ 0 MAKE "LF 1
  EX1 :SEN
  ERNAME [LZ LF NUM SSEN IT]
END


TO EX1 :META
  ;  ** Subprocedure for EXPAND **
  IF :LZ = :LF [STOP]
  IF :META = [] [STOP]
  MAKE "SSEN []
  MAKE "LZ COUNT :META
  EX2 :META
  MAKE "LF COUNT :SSEN
  PRINT1 WORD `Level` :NUM + 1 PRINT1 `: `
  PRINT1 :SSEN
  PR [] PR []
  MAKE "META :SSEN
  MAKE "NUM :NUM + 1
  EX1 :META
END


TO EX2 :SEN
  ;  ** Subprocedure for EXPAND **
  ;  ** This is the heart of the expansion**
  IF :SEN = [] [STOP]
  IF :SEN = `` [STOP]
  MAKE "IT FIRST :SEN
  IF BUTFIRST :IT = ".X  [MAKE "IT WORD
       BUTLAST :IT  CHAR ( 65 +
        RANDOM 23 )]
  IF WORD? :IT [MAKE "SSEN
       SE :SSEN ( THING :IT )]
       [MAKE "SSEN SE :SSEN :IT]
  EX2 BUTFIRST :SEN
END
```

ComPOSER

Procedures for Making a Paragraph

```
TO MK.PG :SENTENCES
  ;  ** Punctuate a set of sentences
  ;       to make a paragraph**
  MAKE "N 0
  MAKE "PARAGRAPH []
  PARA :SENTENCES
  PR :PARAGRAPH
  ERNAME [PARAGRAPH WRD PUNCSEN CAP
IT]
END

TO PARA :SENTENCES
  ;  ** Subprocedure for MK.PG **
  IF :SENTENCES = [] [KILLNAMES :N STOP]
  MAKE "N :N + 1
  MAKE "IT LIST FIRST :SENTENCES
  E&P :IT
  MAKE WORD "SEN :N :PUNCSEN
  MAKE "PARAGRAPH
       SE :PARAGRAPH :PUNCSEN
  PARA BUTFIRST :SENTENCES
END

TO KILLNAMES :N
  ;  ** Subprocedure for MK.PG **
  IF :N < 1 [STOP]
  ERNAME WORD "SEN :N
  KILLNAMES :N - 1
END

TO E&P :SEN
  ;  **Expand and Punctuate **
  ;  ** Subprocedure for MK.PG **
  PR []
  MAKE "NUM 1
  MAKE "LZ 0 MAKE "LF 1
  E&P.1 :SEN
  ERNAME [LZ LF SSEN NUM]
END

TO E&P.1 :META
  ;  ** Subprocedure for E&P **
  IF :LZ = :LF [PR [] PUNCTUATE STOP]
  IF :META = [] [STOP]
  MAKE "SSEN []
  MAKE "LZ COUNT :META
  EX2 :META
  MAKE "LF COUNT :SSEN
  MAKE "META :SSEN
  MAKE "NUM :NUM + 1
  E&P.1 :META
END

TO PUNCTUATE
  ; ** Capitolize and add periods **
  ;  ** Subprocedure for E&P.1 **
  MAKE "CAP UPPERCASE FIRST
  FIRST :SSEN
  MAKE "WRD WORD :CAP BUTFIRST
       FIRST :SSEN
  MAKE "PUNCSEN ( SE :WRD BUTLAST
       BUTFIRST  :SSEN
       WORD LAST :SSEN `.` )
END
```

ComPOSER
Lexicon

```
MAKE "A.A `all`
MAKE "A.B `big`
MAKE "A.C `complete`
MAKE "A.D `dangerous`
MAKE "A.E `equivalent`
MAKE "A.F `female`
MAKE "A.G `good`
MAKE "A.H `human`
MAKE "A.I `inside`
MAKE "A.J `joyous`
MAKE "A.K `kind`
MAKE "A.L `liquid`
MAKE "A.M `metal`
MAKE "A.N `not`
MAKE "A.O `obscure`
MAKE "A.P `pretty`
MAKE "A.Q `quick`
MAKE "A.R `real`
MAKE "A.S `successor to`
MAKE "A.T `true`
MAKE "A.U `uniform`
MAKE "A.V `violent`
MAKE "A.W `warm`
MAKE "A.X `RANDOM`
MAKE "A.Y `young`
MAKE "A.Z `zeroth`

MAKE "AR.A `a`
MAKE "AR.S `some`
MAKE "AR.T `the`
MAKE "CHOICE "\c
MAKE "CJ.A `and`
MAKE "CJ.O `or`

MAKE "N.A `air`
MAKE "N.B `box`
MAKE "N.C `creature`
MAKE "N.D `day`
MAKE "N.E `earth`
MAKE "N.F `fire`
MAKE "N.G `group`
MAKE "N.H `hole`
MAKE "N.I `institution`
MAKE "N.J `journey`
MAKE "N.K `knowledge`
MAKE "N.L `leader`
MAKE "N.M `money`
MAKE "N.N `nothing`
MAKE "N.O `object`
MAKE "N.P `part`
MAKE "N.Q `question`
MAKE "N.R `road`
MAKE "N.S `song`
MAKE "N.T `tool`
MAKE "N.U `umbra`
MAKE "N.V `vehicle`
MAKE "N.W `water`
MAKE "N.X `RANDOM `
MAKE "N.Y `yard`
MAKE "N.Z `zealot`

MAKE "PN.A `airs`
MAKE "PR.A `around`
MAKE "PR.B `beside`
MAKE "PR.I `in`
MAKE "PR.O `on`
MAKE "PR.T `to`
MAKE "PR.U `under`
MAKE "PR.W `with`

MAKE "V.A `acts`
MAKE "V.B `builds`
MAKE "V.C `connects`
MAKE "V.D `does`
MAKE "V.E `eats`
MAKE "V.F `feels`
MAKE "V.G `goes`
MAKE "V.H `hears`
MAKE "V.I `is`
MAKE "V.J `joins`
MAKE "V.K `knows`
MAKE "V.L `loves`
MAKE "V.M `moves`
MAKE "V.N `neglects`
MAKE "V.O `opens`
MAKE "V.P `possesses`
MAKE "V.Q `quarrels`
MAKE "V.R `resides`
MAKE "V.S `sees`
MAKE "V.T `thinks`
MAKE "V.U `uses`
MAKE "V.V `verifies`
MAKE "V.W `walks`
MAKE "V.Y `yields`
MAKE "V.Z `zaps`
```

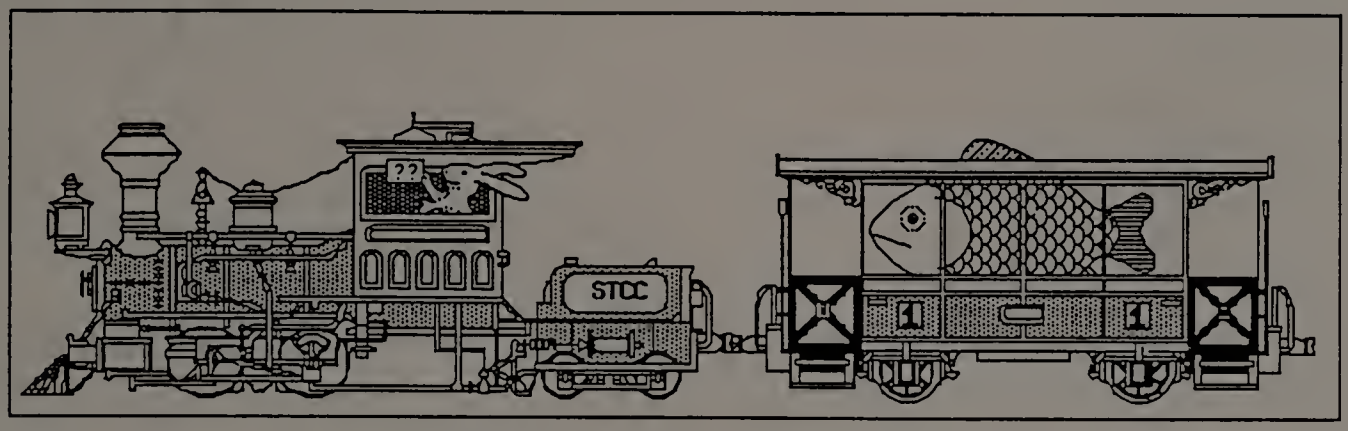
Example

```
MAKE "NPX [AR.A A.X N.Q]
MAKE "NPY [AR.T A.X A.F N.X]
MAKE "VPX [V.T PPX]
MAKE "PPX [PR.T NPX]
MAKE "SNX [NPY VPX]
```

APPENDIX D

COMPOSITIONS AND SCORES

Six visual compositions and six verbal compositions are show here, along with the scores which generate them. Scores which generate the drawings are in the form of Logo procesures. Scores which generate the paragraphs are sets of rules expressed as lists of Logo names.



Guide Picture for F.F.'s Paragraph

EXPAND [SN1 SN2 SN3 SN4]

Level 1 : SN1 SN2 SN3 SN4
Level 2 : NPE VPE NP4 NP4.5 NP5 VP6 NP6.5 NP7.5 VP8 NP6.5 NP9 VP9 WORMS PR.O NP10

Level 3 : AR.T A.B N.V V.M AV.U PR.O AR.A A.W A.M N.R AR.T PASSENGER AR.T A.I PN.J AV.Q PR.T AR.T COLLEGE AR.A FOLLOWERS V.G A.N PR.T AR.T COLLEGE AR.S NA.K N.N AV.T PV.E N.E PN.C which VP10 on AR.A HOOKS

Level 4 : the big vehicle moves uniformly on a warm metal road the N.C which VP5 the inside journeys quickly through the N.I which VP15 a N.G which VP7 goes not to the N.I which VP15 some knowing nothing truely eat earth creatures which PV.M AV.V PR.A on a A.M N.O which VP11

Level 5 : the big vehicle moves uniformly on a warm metal road the creature which V.I PR.O the inside journeys quickly through the institution which V.B AV.C PP20 a group which V.R AV.D PP7 goes not to the institution which V.B AV.C PP20 some knowing nothing truely eat earth creatures which move violently around on a metal object which V.Z PR.T AV.C

Level 6 : the big vehicle moves uniformly on a warm metal road the creature which is on the inside journeys quickly through the institution which builds completely PR.W N.K a group which resides dangerously PR.U NP7 goes not through the institution which builds completely PR.W N.K some knowing nothing truely eat earth creatures which move violently around on a metal object which zaps through completely

Level 7 : the big vehicle moves uniformly on a warm metal road the creature which is on the inside journeys quickly through the institution which builds completely with knowledge a group which resides dangerously under AR.S A.W N.W goes not through the institution which builds completely with knowledge some knowing nothing truely eat earth creatures which move violently around on a metal object which zaps through completely

Level 8 : the big vehicle moves uniformly on a warm metal road the creature which is on the inside journeys quickly through the institution which builds completely with knowledge a group which resides dangerously under some warm water goes not through the institution which builds completely with knowledge some knowing nothing truely eat earth creatures which move violently around on a metal object which zaps through completely

Expansion of F.F.'s Score

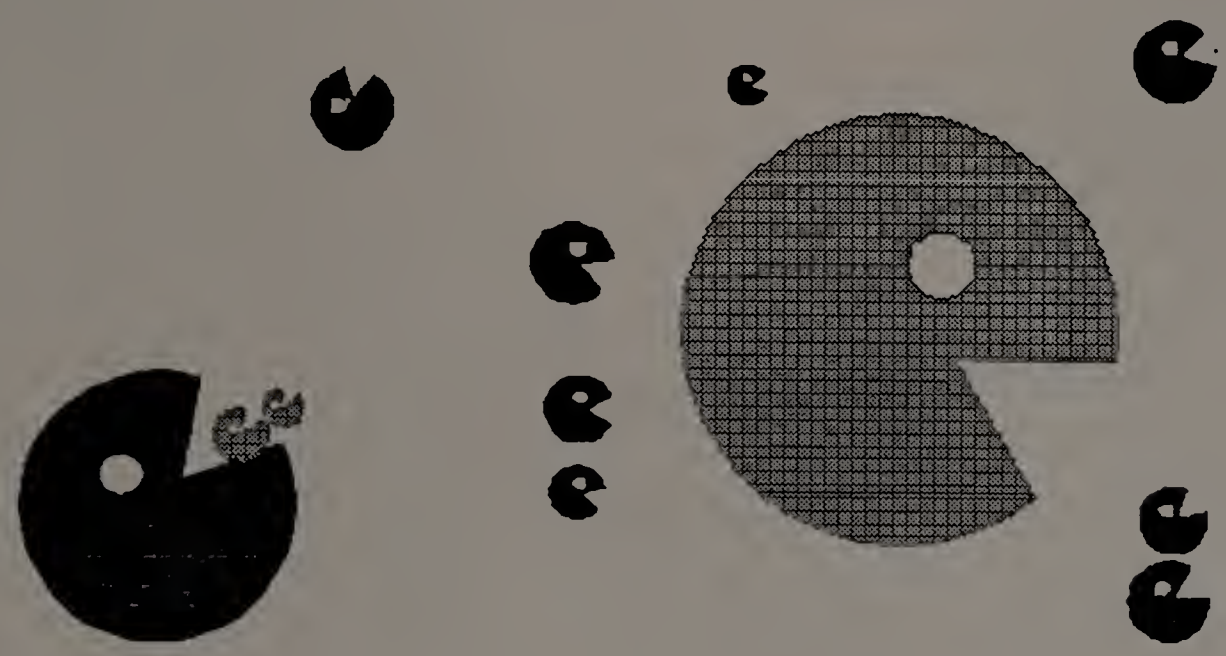
MK.PG [SN1 SN2 SN3 SN4]

The big vehicle moves uniformly on a warm metal road. The creature which is on the inside journeys quickly through the institution which builds completely with knowledge. A group which resides dangerously under some warm water goes not through the institution which builds completely with knowledge. Some knowing nothing truely eat earth creatures which move violently around on a metal object which zaps through completely.

F.F.'s Paragraph

```
MAKE "NA.K `knowing`
MAKE "SN1 [NPE VPE NP4]
MAKE "NP9 [AR.S NA.K N.N]
MAKE "VP9 [AV.T PV.E]
MAKE "PV.G `goe`
MAKE "VP11 [V.Z PR.T AV.C]
MAKE "COLLEGE [N.I `which` VP15]
MAKE "NP10 [AR.A HOOKS]
MAKE "NP8 [AR.T A.K N.I]
MAKE "VP8 [V.G A.N PR.T]
MAKE "VP10 [PV.M AV.V PR.A]
MAKE "VP13 [V.I PR.2 N.Q]
MAKE "PPC [PR.W N.K]
MAKE "SN3 [NP7.5 VP8 NP6.5]
MAKE "PN.E `earths`
MAKE "PV.E `eat`
MAKE "VP12 [PR.2 AV.R PV.N]
MAKE "SN2 [NP4.5 NP5 VP6 NP6.5]
MAKE "NP15 [AR.T N.J PP15]
MAKE "SN5 [VP12 NP15 VP13 VP16]
MAKE "PN.C `creatures`
MAKE "VP15 [V.B AV.C PP20]
MAKE "PR.2 `to`
MAKE "SN4 [NP9 VP9 WORMS PR.O NP10]
MAKE "NP17 [N.Q AR.T VP16]
MAKE "HOOKS [A.M N.O `which` VP11]
MAKE "NP16 [AR.T COLLEGE]
MAKE "VP16 [AR.T PV.L PR.F N.M]
MAKE "PG [SN1 SN2 SN3]
MAKE "PN.O `objects`
MAKE "PV.N `neglect`
MAKE "SN8 [NP8 VP8]
MAKE "ENGINE [NPF `which` VPF]
MAKE "NP3 [AR.T A.T N.L]
MAKE "VP3 [V.M AV.U PP.T]
MAKE "PV.M `move`
MAKE "AV.D `dangerously`
MAKE "PV.L `love`
MAKE "NP2 [AR.T N.K N.I]
MAKE "VP2 [V.M PP2]
MAKE "PN.L `leaders`
MAKE "AV.C `completely`
MAKE "VP5 [V.I PR.O]
MAKE "NP [AR.T N.K N.I]
MAKE "NP5 [AR.T A.I]
MAKE "PASSENGER [N.C `which` VP5]
MAKE "PN.J `journeys`
MAKE "NP4 [AR.A A.W A.M N.R]
MAKE "NP7 [AR.S A.W N.W]
MAKE "VP7 [V.R AV.D PP7]
MAKE "NP6 [AR.T N.K N.I]
MAKE "WORMS [N.E PN.C `which` VP10]
MAKE "VP6 [PN.J AV.Q PR.T]
MAKE "PR.F `of`
MAKE "PP10 [PR.O HOOKS]
MAKE "PP2 [PR.T NP]
MAKE "NP7.5 [AR.A FOLLOWERS]
MAKE "PP15 [PR.T NP16]
MAKE "PP7 [PR.U NP7]
MAKE "PP20 [PR.W N.K]
MAKE "FOLLOWERS [N.G `which` VP7]
MAKE "NP6.5 [AR.T COLLEGE]
MAKE "AV.V `violently`
MAKE "PP8 [PR.T NP8]
MAKE "AV.U `uniformly`
MAKE "AV.T `truely`
MAKE "VP [V.M AV.C PR.T]
MAKE "VPE [V.M AV.U PR.O]
MAKE "NPE [AR.T A.B N.V]
MAKE "AV.R `really`
MAKE "AV.Q `quickly`
MAKE "VPF [V.I AR.A N.L]
MAKE "NPF [AR.T A.B ENGINE]
MAKE "NP4.5 [AR.T PASSENGER]
```

Score for F.F.'s Paragraph

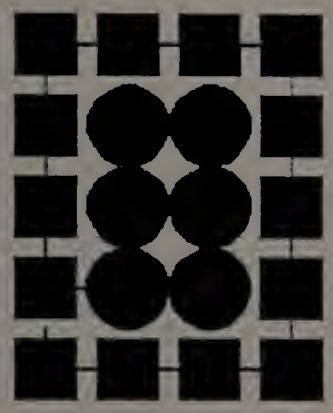


D.K.'s Drawing

```
TO PAC
 PU SETX 100 PD SIZE 16 G FOUR
 PU SETX -20 PD SIZE 3 FOUR
 PU SETY -61 PD SIZE 2 FOUR
 PU SETY -30 PD SIZE 2.5 FOUR
 PU SETY -150 PD PU SETX 44
 PD SIZE 1.5 FOUR
 PU SETX 200 PD PU SETY -140 PD FOUR
 PU SETY -100 PD FOUR
 PU SETY -70 PD PU SETX 200 PD SIZE 2.5 FOUR
 PU SETX -170 PD SIZE 10 FOUR
 PU SETX -140 PD PU SETY -40 SIZE 2 G FOUR
 PU SETX -125 PD PU SETY -30 SIZE 1.5 G FOUR
 PU SETY 80 PD PU SETX -100 FOUR
 Z
END
```

```
TO FOUR
 C RT 120
 SCALE 7 / 9 L RT 180
 SCALE 0.6 B B T
 D L RT 50 L
 SCALE 0.3 B B C
 Z
END
```

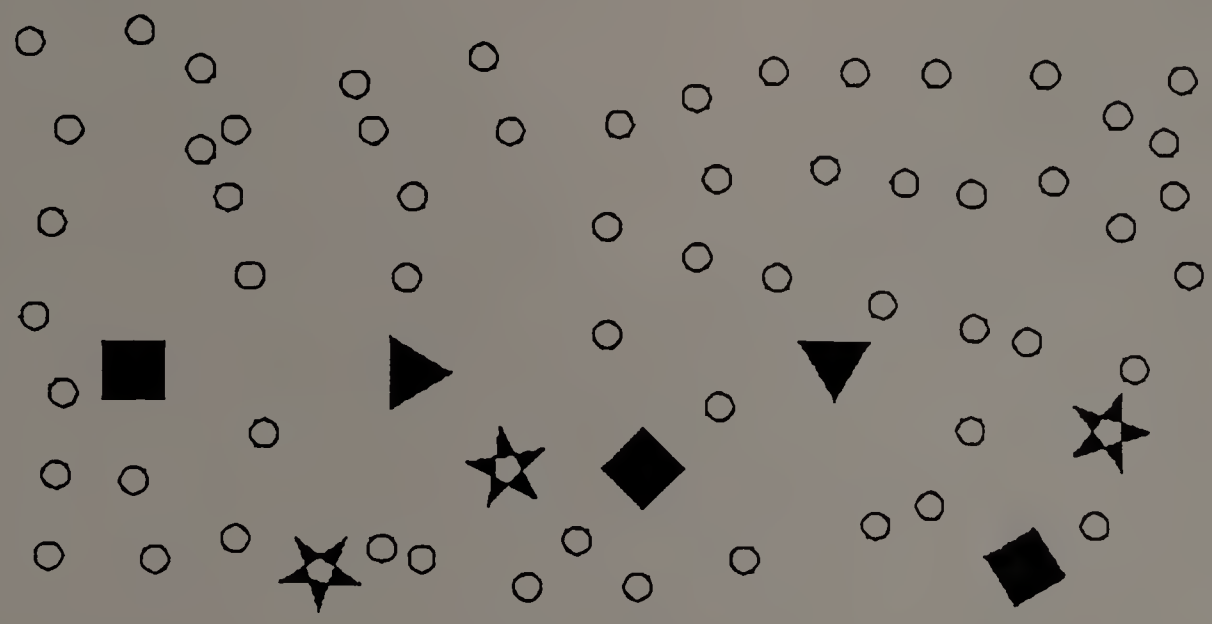
Score for D.K's Drawing



M.I.'s Drawing #1

```
TO JAIL
 C L L C RT 90 L L C RT 90
 L L C L L C RT 90 L L C L L S
 RT 90 L L S L L S L L S RT 90
 L L S L L S L L S RT 90
 L L S L L S L L S L L S RT 90
 L L S L L S L L S RT 90 L
 Z
END
```

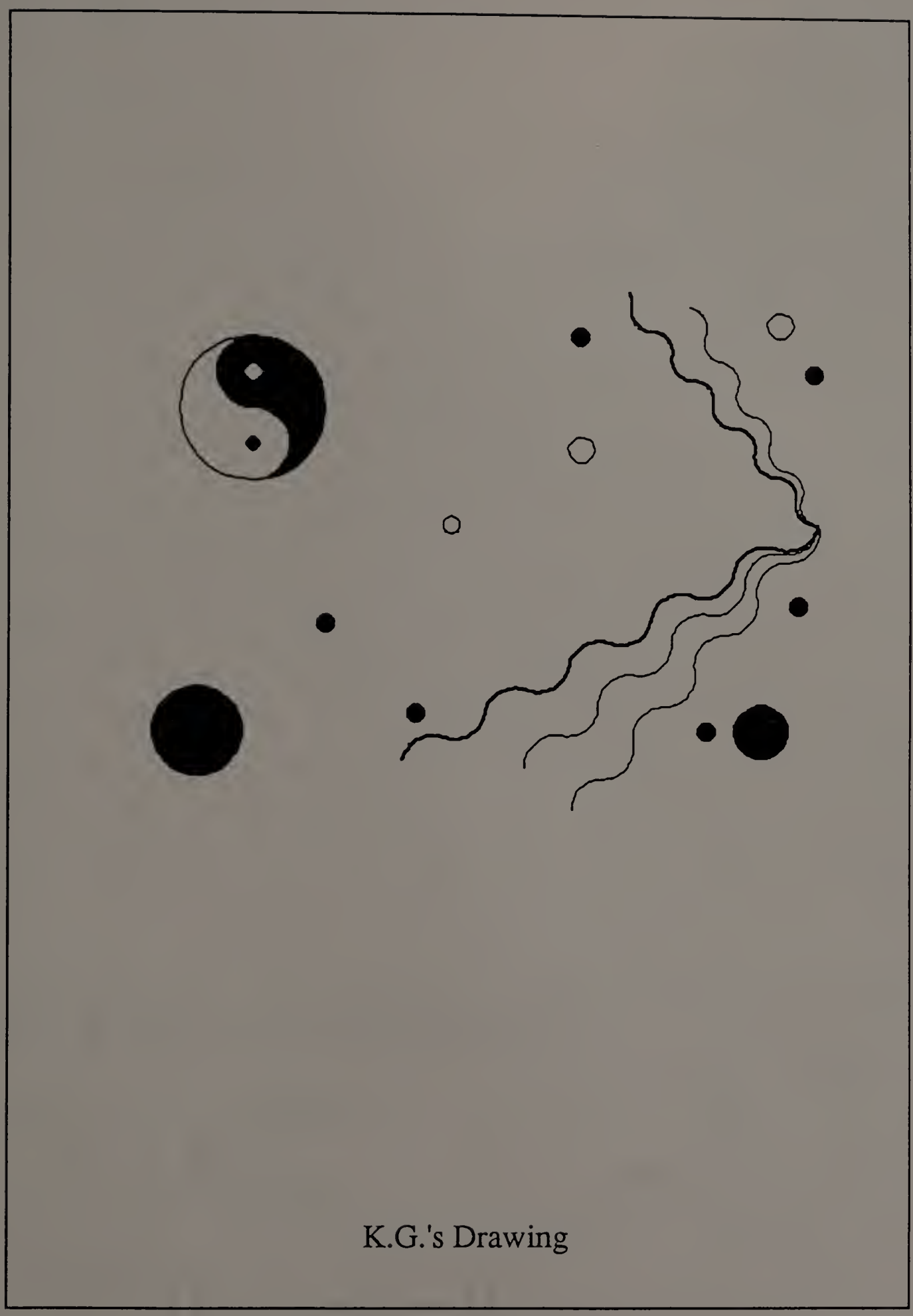
Score for M.I.'s Drawing #1



M.I.'s Drawing #2

```
TO SHAPES
 SIZE 1 N C D FD 40 C LT 45 FD 50 C LT 45
 FD 50 C FD 50 C FD 60 C LT 80 FD 35 C FD 35 C LT 30 FD 30 C
 RT 25 FD 30 C FD 30 C LT 25 FD 50 LT 50 FD 40 C RT 70 FD 30
 C LT 30 FD 20 C RT 15 FD 30 C FD 40 RT 30 FD 20 C FD 40 C
 RT 60 FD 30 C RT 90 FD 30 C RT 15 FD 40 SIZE 3 N S RT 90
 FD 100 T RT 45 FD 50 R LT 45 FD 50 RT 45 S LT 45 FD 70 LT 90
 FD 40 RT 180 T FD 25 LT 90 FD 100 R SIZE 1 N LT 180 FD 50 C
 LT 45 FD 50 C RT 30 FD 50 C FD 40 C RT 15 FD 40 C RT 15
 FD 40 C FD 15 C RT 80 FD 100 C FD 30 C RT 65 FD 80 C FD 30
 C FD 30 C RT 20 FD 30 C FD 30 C FD 40 C RT 30 FD 30 C FD 20
 C RT 50 FD 20 C FD 30 C RT 135 FD 30 C FD 30 C LT 45 FD 30
 C RT 19 FD 25 C FD 30 C LT 15 FD 40 C LT 70 FD 30 C LT 90
 FD 30 C FD 40 C FD 35 C FD 20 C FD 40 C RT 90 FD 60 C RT 45
 FD 30 SIZE 3 N S RT 35 FD 200 LT 20 FD 60 R SIZE 1 N RT 110
 FD 180 C LT 80 FD 80 C LT 20 FD 40 C LT 160 FD 100 LT 30
 FD 70 C RT 65 FD 150 RT 80 FD 20 C RT 195 FD 210 C RT 20
 FD 400 RT 100 FD 30 C RT 90 FD 130 C
 Z
END
```

Score for M.I.'s Drawing #2



K.G.'s Drawing

```
TO KELLYCOMP
 PART1
 PART2
 PART3
END

TO PART1
 Z CG HT SIZE 3
 PU SETX 0 SETY -120
 PD REPEAT 4 [CURVE]
 RT 170 REPEAT 4 [CURVE]
 PU SETX 100 SETY -100
 PD SIZE 1 C PU SETX 130
 SETY -100 PD SIZE 3 C
 PU SETX 150 SETY -30
 SIZE 1 PD C PU
 SETX 161.286 SETY 15.335
 RT 20 SIZE 3 W PD
 REPEAT  5 [CURVE]
 PU SETX 161 SETY 15.335
 SETH 270 PD SIZE 2
 REPEAT 4.5 [CURVE]
 PU Z PU SETX 161.286
 SETY 15.335 SETH  280
 PD SIZE 2 REPEAT 4 [CURVE]
 PU SETX 159 SETY 100
 SIZE 1 C PU
 SETX 140 SETY 120 PD
 SIZE 3 HOLE
 PU SETX 30
 SETY 120 PD SIZE 1 C PU
 SETX 30 SETY 50
 PD SIZE 3 HOLE
END

TO PART2
 PU Z PU SETX -150 SETY 120 PD
 YIN PU SETX -150 SETY 100 PD B B
 SIZE  0.75 N C PU SETX -150
 SETY 60 PD B C PU
END

TO PART3
 Z PU SETX -180 SETY -100 SIZE 5 C
 PU SETX -110 SETY -40 SIZE 1 PD C
 PU SETX -60 SETY -90 PD C PU
 SETX -40 SETY 10 SIZE 2 PD HOLE
END

TO YIN
 SETPP :PP
 IF :N < 1 [YI] [FILLSH [YI] PENPAINT]
 N SIZE 8 Q Q
END

TO YI
 SETH 90 SIZE 8 Q Q N SIZE 4
 Q Q N RT 180 Q Q
END

TO CURVE
 REPEAT 20 [FD :S / 10 RT 5]
 REPEAT 20 [FD :S / 10  LT 5]
END

TO HOLE
 REPEAT 30 [FD :S / 10 RT 12]
END
```

Score for K.G.'s Drawing

F.F.'s Drawing

```
TO WINTER
 VILLAGE
 SNOWMAN
 ROAD
 SNOW
END

TO HOUSE
 G PU S L T G
 . . . . . .
 SCALE ( 1 / 3 )
 L L L L S
 . . . . . .
 L L , , , , , L
 SCALE ( 1 / 2 )
 S . . . . . .
 L L L L S
 Z
END

TO ROAD
 PU SETX -70 SETY -120
 PD SIZE 9 . L . . L . L
 , L , L L . L PU SETX 20
 SETY -120 SETH 0
 PD . L . . L . L , L , L L . L
 Z
END

TO VILLAGE
 CG G PU SIZE 10 SETY -70 SETX -180
 HOUSE
 PU SETH 0 SETX -90 SETY 0 G
 SIZE 9 HOUSE
 PU SETH 0 SETY 30 SETX -10
 SIZE 7 HOUSE
 PU SETH 0 SETY 60 SETX -210
 SIZE 5 G HOUSE
 PU SETH 0 SETY 70 SETX -150
 SIZE 4 HOUSE
 PU SETH 0 SETY 90 SETX -50
 SIZE 3 HOUSE SETH 0
 Z
END

TO SNOWMAN
 PU G G
 SETY -90 SETX 180
 SIZE 5 C SETY -50 SIZE 4 C SETY -20
 SIZE 3 C SETY -18 SIZE 0.75 B
 SETX 185 C
 SETX 175 C SETY -50 SETX 180
 C SETY -65 C SETY -35 C PU
 SETX 160 SETY -50 , , , PD L L L L L
 , , L L N L L N . . . . PD L L PU
 SETY -50 SETX 200 . . . . PD L L L L L , ,
 L L N L L N . . . . PD L L PU
 SETH 0 SETX 180 SETY 1 SIZE 3 S
 SETY -4 SETX 168 SIZE 1 S
 SETX 190 S SETX 192 S
 Z
END

TO SNOW
 PU SETX -230 SETY 110 SETH 0
 SIZE 1 G G F SETX -200 F SETX -180 F
 SETX -140 SETY 100 F SETX -180
 SETY 90 F SETX -110 F SETX -70
 SETY 100 F SETX -20 F SETY 80 F
 SETY 110 F SETX 60 SETY 90 F
 SETX 150 F SETX 130 F SETX 200 F
 SETY 110 SETX 190 F SETX 220 F
 SETX 90 F SETX 160 F SETY 70 F
 SETX 230 F SETX 205 F SETX 180
 SETY 95 F SETY 20 SETX 230 F SETY 40
 SETX 200 F SETY 0 F SETX 150 F SETY 40
 F SETX 170 F SETY 60 F SETX 190 F
 SETX 40 F SETY 100 F SETY 20 F
 Z
END
```

Score for F.F.'s Drawing

A.P.'s Drawing

```
TO MAGIC.VILLAGE
 MAGIC VILLAGE
END

TO MAGIC
 Z D SETY 75 SETX -50 SCALE 2 SAD
 SETX -150 SETY 50 SCALE 1.5 SAD
 SETX -75 SETY 15 SCALE 0.5 SAD
 SETX -210 SETY 90 SCALE 0.5 SAD
 SETY 0 SAD SETY -25 SETX -150 SAD Z
END

TO VILLAGE
 PU SETX 190 SETY -100 SCALE 1 PD G HOUSE PU
 B SETX 120 SETY -90 SCALE 2 PD HOUSE PU
 SETX 160 SETY -20 SCALE 0.33 PD HOUSE PU
 SETX 10 SETY -70 SCALE 2.2 PD HOUSE PU
 SETY 0 SETX 60 SIZE 2.5 PD G HOUSE Z
END

TO HOUSE
 S L T
END

TO SAD
 REPEAT 3 [B R LT 60 G R LT
60]
END
```

Score for A.P.'s Drawing

D.P.'s Drawing

```
TO WHOLE.THING
 WALT
 ADD
END

TO WALT
 VALENTINE
 D SETX 200
 N SETY -60 N D
 SQUARE D SETX -200
 SETY -60 D CIRC D
 SETX -120 , , N
 L L L L L L N D
 TRI D SETX 120
 . . . . N
 L L L L L L
 D N TRI
END

TO ADD
 D L L L
 , , , , , D
 TRI D
 SETX -153 SETY 20
 , , D TRI
END
```

```
TO
 SQUARE
 D M M S
 L L N M M
 S
 N L L N M
 M S
 Z
END

TO CIRC
 D M M C
 L L N M M
 C
 N L L N M
 M C
 Z
END

TO TRI
 D M M T
 L L N M M
 T
 N L L N M
 M T
 Z
END
```

```
TO VALENTINE
 D M M V
 L L N M M V
 N L L N M M V
 Z
END
```

Score for D.P's Drawing

MK.PG [SN1 SN2 SN3 SN4]

The warm female human object moves the good institution with a pretty song. Earth connects roads equivalent joyous love inside a violent fire. The leader neglects the true question and walks around the young creatures yard. The journey knows nothing and feels through money.

M.I.'s Paragraph

```
MAKE "SN1 [NP1 VP1]
MAKE "SN3 [NP5 VP3]
MAKE "SN2 [NP4 VP2]
MAKE "PN.C `creatures`
MAKE "SN4 [NP6 VP5]
MAKE "VP1 [V.M NP2]
MAKE "NP1 [AR.T A.W A.F A.H N.O]
MAKE "VP3 [V.W PR.A AR.T A.Y PN.C N.Y]
MAKE "NP3 [AR.A A.P N.S]
MAKE "PV.L `love`
MAKE "VP2 [PV.L A.I AR.A A.V N.F]
MAKE "NP2 [AR.T A.G N.I PP1]
MAKE "VP5 [V.F PR.T N.M]
MAKE "PN1 [PN.R]
MAKE "NP5 [AR.T N.L V.N AR.T A.T N.Q CJ.A]
MAKE "NP4 [N.E V.C PN.R A.E A.J]
MAKE "PN [N.R]
MAKE "NP6 [AR.T N.J V.K N.N CJ.A]
MAKE "PP1 [PR.W NP3]
MAKE "PN.R `roads`
MAKE "PV [V.L]
MAKE "PV1 [PV.L]
```

Score for M.I.'s Paragraph

EXPAND [SN1 SN2 SN3 SN4]

Level 1 : SN1 SN2 SN3 SN4
Level 2 : NP1 VP1 NP4 VP2 NP5 VP3 NP6 VP5

Level 3 : AR.T A.W A.F A.H N.O V.M NP2 N.E V.C PN.R A.E A.J PV.L A.I AR.A A.V N.F AR.T N.L V.N AR.T A.T N.Q CJ.A V.W PR.A AR.T A.Y PN.C N.Y AR.T N.J V.K N.N CJ.A V.F PR.T N.M

Level 4 : the warm female human object moves AR.T A.G N.I PP1 earth connects roads equivalent joyous love inside a violent fire the leader neglects the true question and walks around the young creatures yard the journey knows nothing and feels to money

Level 5 : the warm female human object moves the good institution PR.W NP3 earth connects roads equivalent joyous love inside a violent fire the leader neglects the true question and walks around the young creatures yard the journey knows nothing and feels to money

Level 6 : the warm female human object moves the good institution with AR.A A.P N.S earth connects roads equivalent joyous love inside a violent fire the leader neglects the true question and walks around the young creatures yard the journey knows nothing and feels to money

Level 7 : the warm female human object moves the good institution with a pretty song earth connects roads equivalent joyous love inside a violent fire the leader neglects the true question and walks around the young creatures yard the journey knows nothing and feels through money

Expansion of M.I.'s Score

MK.PG [SN1 SN2 SN3]

The true dangerous creature possesses all knowledge. The true dangerous creature sees the group and hears all. Fire and the institution is successor to the leader.

D.P.'s Paragraph

```
MAKE "SN1 [NP4 VP4]
MAKE "VP9 [V.I NP7]
MAKE "VP8 [VP6 CJ.A VP7]
MAKE "SN3 [NP6 VP9]
MAKE "SN2 [NP4 VP8]
MAKE "NP [A.S AR.T N.L]
MAKE "NP5 [A.A N.K]
MAKE "VP4 [V.P NP5]
MAKE "NP4 [AR.T A.T A.D N.C]
MAKE "NP7 [A.S AR.T N.L]
MAKE "VP7 [V.H A.A]
MAKE "NP6 [N.F CJ.A AR.T N.I]
MAKE "VP6 [V.S AR.T N.G]
```

Score for D.P.'s Paragraph

EXPAND [SN1 SN2 SN3]

Level 1 : SN1 SN2 SN3
Level 2 : NP4 VP4 NP4 VP8 NP6 VP9

Level 3 : AR.T A.T A.D N.C V.P NP5 AR.T A.T A.D N.C VP6 CJ.A VP7 N.F CJ.A AR.T N.I V.I NP7

Level 4 : the true dangerous creature possesses A.A N.K the true dangerous creature V.S AR.T N.G and V.H A.A fire and the institution is A.S AR.T N.L

Level 5 : the true dangerous creature possesses all knowledge the true dangerous creature sees the group and hears all fire and the institution is successor to the leader

Expansion of D.P.'s Score

MK.PG [SN1 SN2 SN3 SN4]

The young zealot acts on knowledge and loves. Knowledge sees all around the earth. Loves builds dangerous institution. All creature knows loves journey.

A.P.'s Paragraph

```
MAKE "SN1 [NP1 VP1]
MAKE "SN3 [NP3 VP3]
MAKE "SN2 [NP2 VP2]
MAKE "SN4 [NP4 VP4]
MAKE "VP1 [V.A PR.O N.K CJ.A V.L]
MAKE "NP1 [AR.T A.Y N.Z]
MAKE "VP3 [A.D N.I]
MAKE "NP3 [V.L V.B]
MAKE "VP2 [PR.A AR.T N.E]
MAKE "NP2 [N.K V.S A.A]
MAKE "VP4 [V.K V.L N.J]
MAKE "NP4 [A.A N.C]
```

Score for A.P.'s Paragraph

EXPAND [SN1 SN2 SN3 SN4]

Level 1 : SN1 SN2 SN3 SN4
Level 2 : NP1 VP1 NP2 VP2 NP3 VP3 NP4 VP4

Level 3 : AR.T A.Y N.Z V.A PR.O N.K CJ.A V.L N.K V.S A.A PR.A AR.T N.E V.L V.B A.D N.I A.A N.C V.K V.L N.J

Level 4 : the young zealot acts on knowledge and loves knowledge sees all around the earth loves builds dangerous institution all creature knows loves journey

Expansion of A.P.'s Score

MK.PG [SN1 SN2 SN3]

Inside the hole the young female moves through the liquid. The warm water feels good on a human. The pretty female hears and sees the vehicle on the road.

D.K.'s Paragraph

```
MAKE "SN1 [NP1 VP1]
MAKE "SN3 [NP3 VP3]
MAKE "SN2 [NP2 VP2]
MAKE "VP1 [V.M PR.T AR.T A.L]
MAKE "NP1 [A.I AR.T N.H AR.T A.Y A.F]
MAKE "VP3 [V.S AR.T N.V PR.O AR.T N.R]
MAKE "NP3 [AR.T A.P A.F V.H CJ.A]
MAKE "VP2 [V.F A.G PR.O AR.A A.H]
MAKE "NP2 [AR.T A.W N.W]
```

Figure 5.19(b)
Score for D.K.'s Paragraph

EXPAND [SN1 SN2 SN3]

Level 1 : SN1 SN2 SN3
Level 2 : NP1 VP1 NP2 VP2 NP3 VP3

Level 3 : A.I AR.T N.H AR.T A.Y A.F V.M PR.T AR.T A.L AR.T A.W N.W V.F A.G PR.O AR.A A.H AR.T A.P A.F V.H CJ.A V.S AR.T N.V PR.O AR.T N.R

Level 4 : inside the hole the young female moves through the liquid the warm water feels good on a human the pretty female hears and sees the vehicle on the road

Expansion of D.K.'s Score

MK.PG [SN1 SN2 SN3 SN4]

The roads which some human creatures move on quickly are dangerous to the journey which builds knowledge. The human creature which walks truely on the roads building real knowledge feels it is a journey to fire. Good institutions which build knowledge connect leaders which love all knowledge with human creatures with questions. Human creatures which really think goe on to verifie knowledge in the institutions on earth and possess money and knowledge.

K.G.'s Paragraph

```
MAKE "NP11 [AR.T PN.R]
MAKE "PV.G `goe`
MAKE "SN1 [STUDENTS VP2 EDUCATION NP4]
MAKE "VP11 [NA.B]
MAKE "NP10 [AR.T A.H N.C]
MAKE "VP10 [V.W AV.T PP10]
MAKE "NP13 [AR.A N.J PP11]
MAKE "SN3 [STCC COLLEGES NP7]
MAKE "NP12 [A.R N.K]
MAKE "SN2 [PEOPLE VP11 NP12 VP12]
MAKE "VP12 [V.F AR.I V.I NP13]
MAKE "NP23 [N.M CJ.A N.K]
MAKE "PV.C `connect`
MAKE "PN.C `creatures`
MAKE "NP22 [AR.T PN.I PP21]
MAKE "SN4 [WE NP21 VP21]
MAKE "PV.B `build`
MAKE "NP21 [N.K PP20]
MAKE "VP21 [CJ.A PV.P NP23]
MAKE "NP20 [A.H PN.C]
MAKE "VP20 [AV.R PV.T PV.G PR.O PR.Z PV.V]
MAKE "NP1 [A.D PR.Z AR.T N.J]
MAKE "VP1 [V.B]
MAKE "NA.B `building`
MAKE "NP3 [PN.V]
MAKE "VP3 [PP1 PV.M PR.O AV.Q]
MAKE "PV.M `move`
MAKE "WE [NP20 `which` VP20]
MAKE "NP2 [AR.T PN.R]
MAKE "PN.L `leaders`
MAKE "PV.L `love`
MAKE "VP2 [PV.I]
MAKE "NP5 [A.G PN.I]
MAKE "VP5 [PV.B N.K PV.C]
MAKE "AV.B [V.B]
MAKE "VP4 [PP1 PV.P]
MAKE "PR.Z `to`
MAKE "NP4 [N.K]
MAKE "STCC [NP5 `which` VP5]
MAKE "PN `2s`
MAKE "PR.Y `by`
MAKE "PN.I `institutions`
MAKE "PV.I `are`
MAKE "NP7 [A.A N.K PP2 PP3]
MAKE "VP6 [PV.L]
MAKE "NP6 [PN.L]
MAKE "PV.W `walk`
MAKE "PP1 [AR.S A.H PN.C]
MAKE "PP11 [PR.T N.F]
MAKE "PV.V `verifie`
MAKE "PN.V `vehicles`
MAKE "COLLEGES [NP6 `which` VP6]
MAKE "PP10 [PR.O NP11]
MAKE "PP3 [PR.W PN.Q]
MAKE "PV.T `think`
MAKE "PP2 [PR.W A.H PN.C]
MAKE "PN.R `roads`
MAKE "AR.I `it`
MAKE "PP21 [PR.O N.E]
MAKE "PN.Q `questions`
MAKE "PP20 [PR.I NP22]
MAKE "PV.P `possess`
MAKE "PEOPLE [NP10 `which` VP10]
MAKE "EDUCATION [NP1 `which` VP1]
MAKE "NA.Q `quicing`
MAKE "STUDENTS [NP2 `which` VP3]
MAKE "AV.T `truely`
MAKE "AV.R `really`
MAKE "AV.Q `quickly`
MAKE "PR.H `that`
```

Score for K.G.'s Paragraph

EXPAND [SN1 SN2 SN3 SN4]

Level 1 : SN1 SN2 SN3 SN4
Level 2 : STUDENTS VP2 EDUCATION NP4 PEOPLE VP11 NP12 VP12 STCC COLLEGES NP7 WE NP21 VP21

Level 3 : NP2 which VP3 PV.I NP1 which VP1 N.K NP10 which VP10 NA.B A.R N.K V.F AR.I V.I NP13 NP5 which VP5 NP6 which VP6 A.A N.K PP2 PP3 NP20 which VP20 N.K PP20 CJ.A PV.P NP23

Level 4 : AR.T PN.R which PP1 PV.M PR.O AV.Q are A.D PR.Z AR.T N.J which V.B knowledge AR.T A.H N.C which V.W AV.T PP10 building real knowledge feels it is AR.A N.J PP11 A.G PN.I which PV.B N.K PV.C PN.L which PV.L all knowledge PR.W A.H PN.C PR.W PN.Q A.H PN.C which AV.R PV.T PV.G PR.O PR.Z PV.V knowledge PR.I NP22 and possess N.M CJ.A N.K

Level 5 : the roads which AR.S A.H PN.C move on quickly are dangerous to the journey which builds knowledge the human creature which walks truely PR.O NP11 building real knowledge feels it is a journey PR.T N.F good institutions which build knowledge connect leaders which love all knowledge with human creatures with questions human creatures which really think goe on to verifie knowledge in AR.T PN.I PP21 and possess money and knowledge

Level 6 : the roads which some human creatures move on quickly are dangerous to the journey which builds knowledge the human creature which walks truely on AR.T PN.R building real knowledge feels it is a journey to fire good institutions which build knowledge connect leaders which love all knowledge with human creatures with questions human creatures which really think goe on to verifie knowledge in the institutions PR.O N.E and possess money and knowledge

Level 7 : the roads which some human creatures move on quickly are dangerous to the journey which builds knowledge the human creature which walks truely on the roads building real knowledge feels it is a journey to fire good institutions which build knowledge connect leaders which love all knowledge with human creatures with questions human creatures which really think goe on to verifie knowledge in the institutions on earth and possess money and knowledge

Expansion of K.G.'s Score

MK.PG [SN1 SN2 SN3 SN4]

The young zealot acts on knowledge and loves. Knowledge sees all around the earth. Loves builds dangerous institution. All creature knows loves journey.

A.P.'s Paragraph

```
MAKE "SN1 [NP1 VP1]
MAKE "SN3 [NP3 VP3]
MAKE "SN2 [NP2 VP2]
MAKE "SN4 [NP4 VP4]
MAKE "VP1 [V.A PR.O N.K CJ.A V.L]
MAKE "NP1 [AR.T A.Y N.Z]
MAKE "VP3 [A.D N.I]
MAKE "NP3 [V.L V.B]
MAKE "VP2 [PR.A AR.T N.E]
MAKE "NP2 [N.K V.S A.A]
MAKE "VP4 [V.K V.L N.J]
MAKE "NP4 [A.A N.C]
```

Score for A.P.'s Paragraph

EXPAND [SN1 SN2 SN3 SN4]

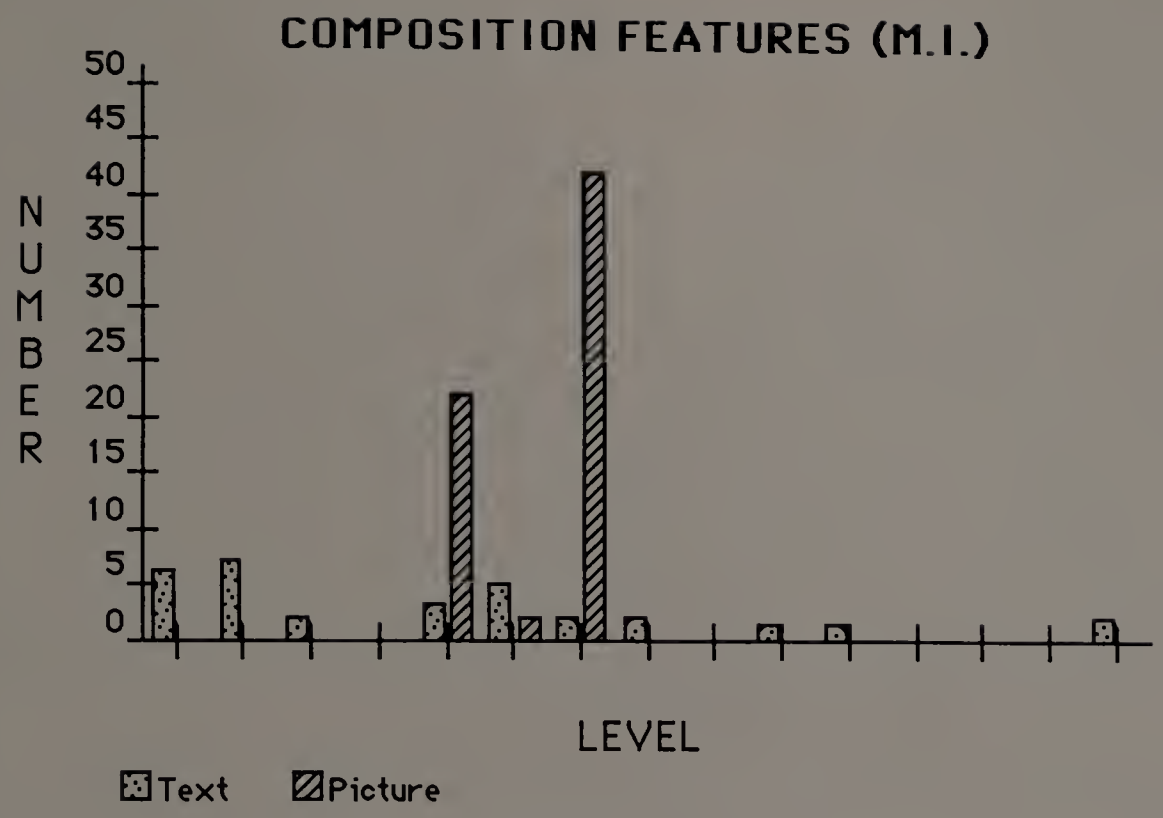
Level 1 : SN1 SN2 SN3 SN4
Level 2 : NP1 VP1 NP2 VP2 NP3 VP3 NP4 VP4

Level 3 : AR.T A.Y N.Z V.A PR.O N.K CJ.A V.L N.K V.S A.A PR.A AR.T N.E V.L V.B A.D N.I A.A N.C V.K V.L N.J

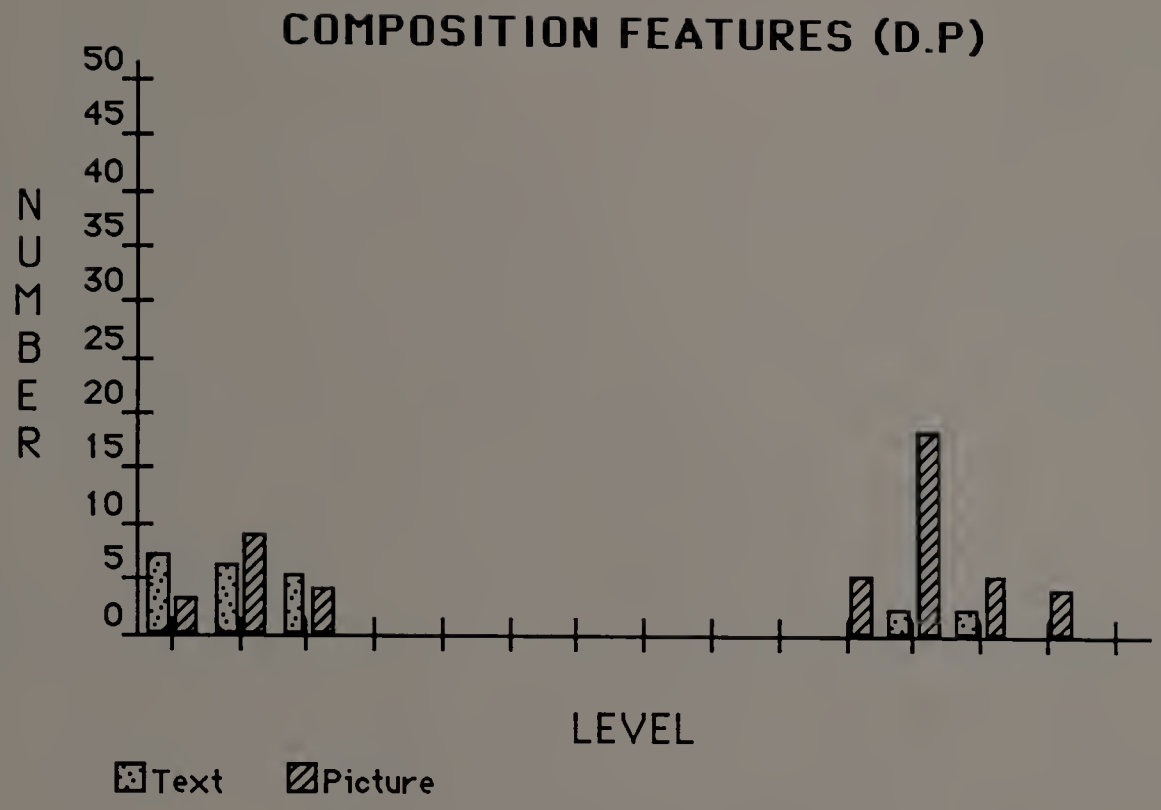
Level 4 : the young zealot acts on knowledge and loves knowledge sees all around the earth loves builds dangerous institution all creature knows loves journey

Expansion of A.P.'s Score

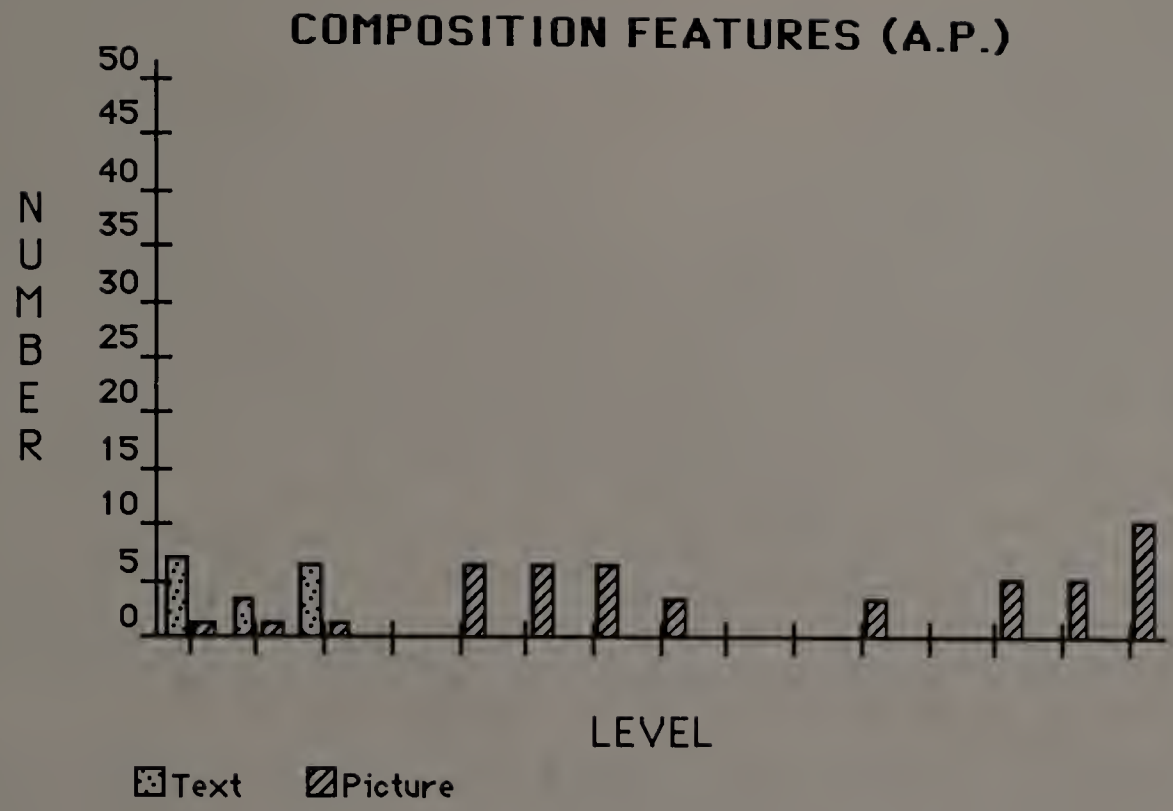
APPENDIX E
COMPOSITION-PAIR DATA



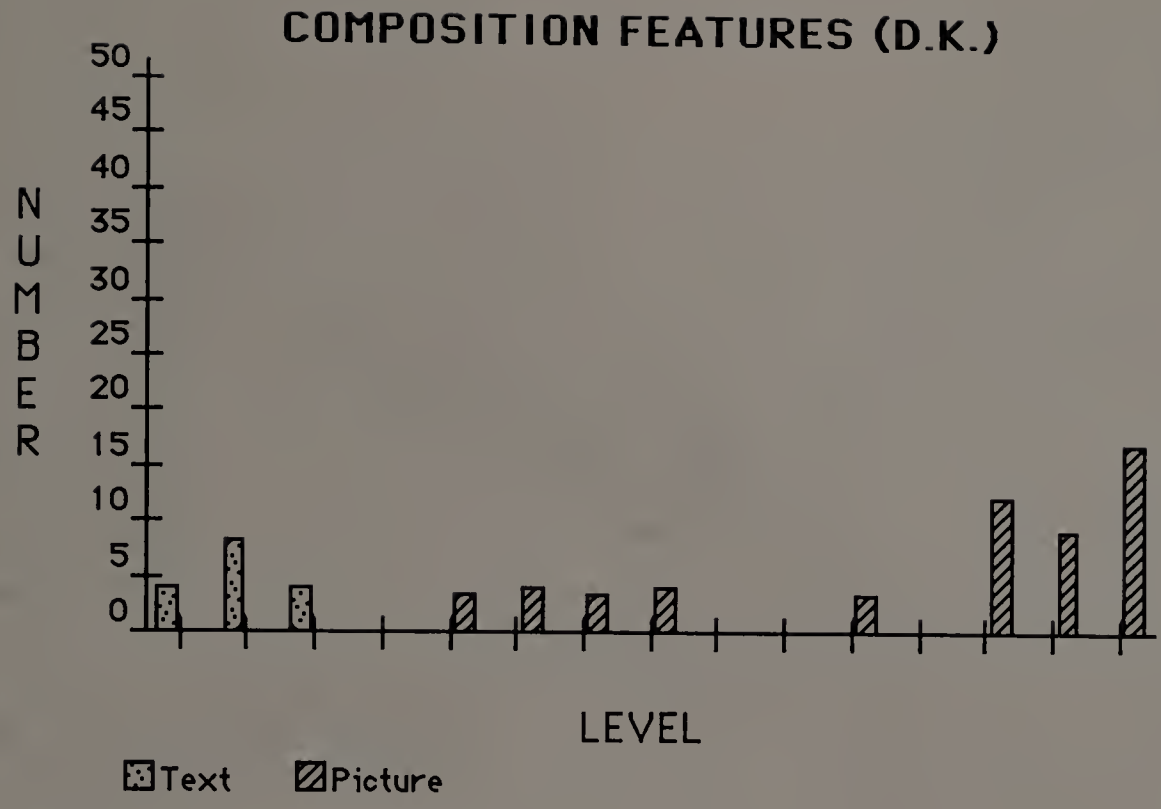
1					M.I. Composition Pair Data											
2																
3		vocabulary			transformed					phrases						
4	**Text**	Level One-->			Level Two ----->					Level Three--------->						
5	(total)	N	A	V	N	V	A	TW		N	A	V	TW	NN	Ph	
6	**Text**	6	7	2	3	5	2	2		1	1	0	0	0	2	
7																
8		vocabulary			numerical ops.					assemblies						
9	**Picture**	Level One-->			Level Two ----->					Level Three--------->						
10	(largest)	S	T	A	S	T	A	Op		S	T	A	Obj	Scl	Pos	
11	**Picture**	0	0	0	22	2	42	0		0	0	0	0	0	0	
12																
13	KEY:	N=noun A=adj V=verb						S=shape T=attribute A=action								
14		TW= transformed word						Op=operator								
15		NN= new noun						Obj=object								
16		Ph= phrase w. phrase						Scl=scaler								
17								Pos= positioner								
18																



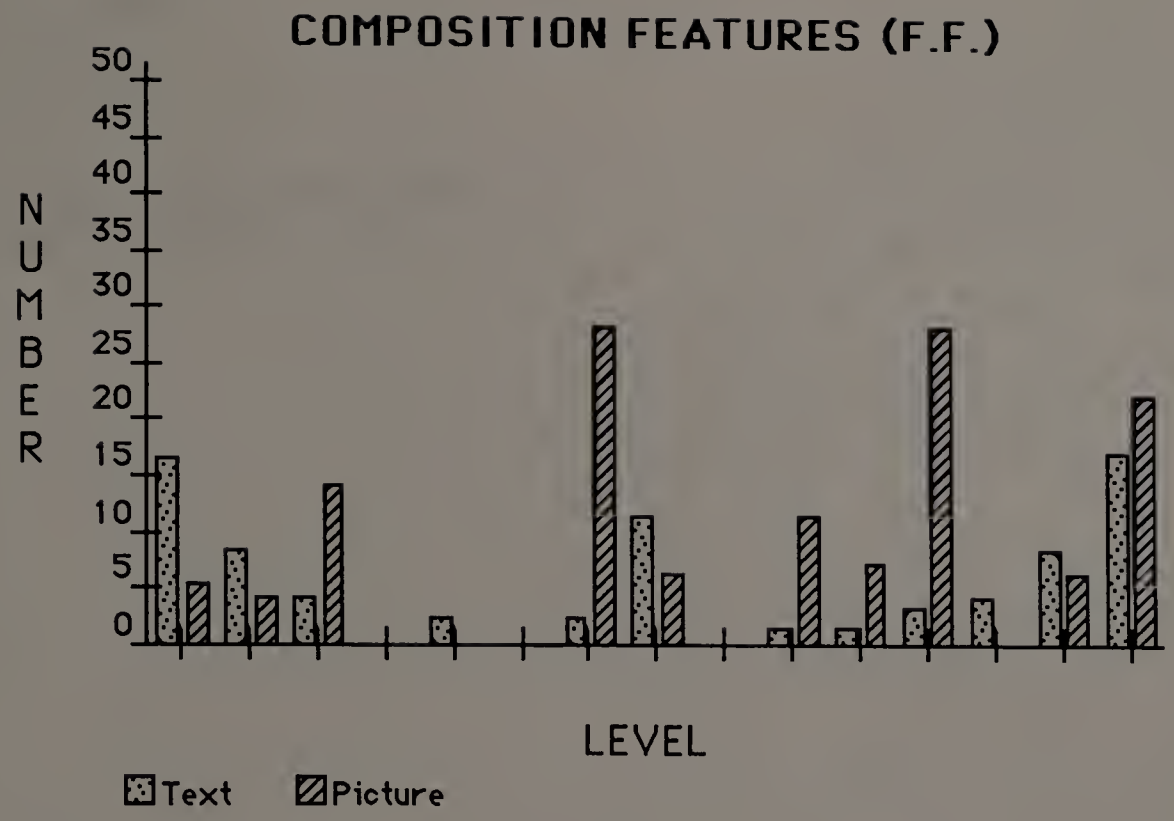
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1					D.P. Composition Pair Data											
2																
3		vocabulary				transformed					phrases					
4	**Text**	Level One-->				Level Two ----->					Level Three --------->					
5	(total)	N	A	V		N	V	A	TW		N	A	V	TW	NN	Ph
6	**Text**	7	6	5		0	0	0	0		0	0	2	2	0	0
7																
8		vocabulary				numerical ops.					assemblies					
9	**Picture**	Level One-->				Level Two ----->					Level Three --------->					
10	(largest)	S	T	A		S	T	A	Op		S	T	A	Obj	Scl	Pos
11	**Picture**	3	9	4		0	0	0	0		0	5	18	5	4	0
12																
13	KEY:	N=noun A=adj V=verb							S=shape T=attribute A=action							
14		TW= transformed word							Op=operator							
15		NN= new noun							Obj=object							
16		Ph= phrase w. phrase							Scl=scaler							
17									Pos= positioner							
18																



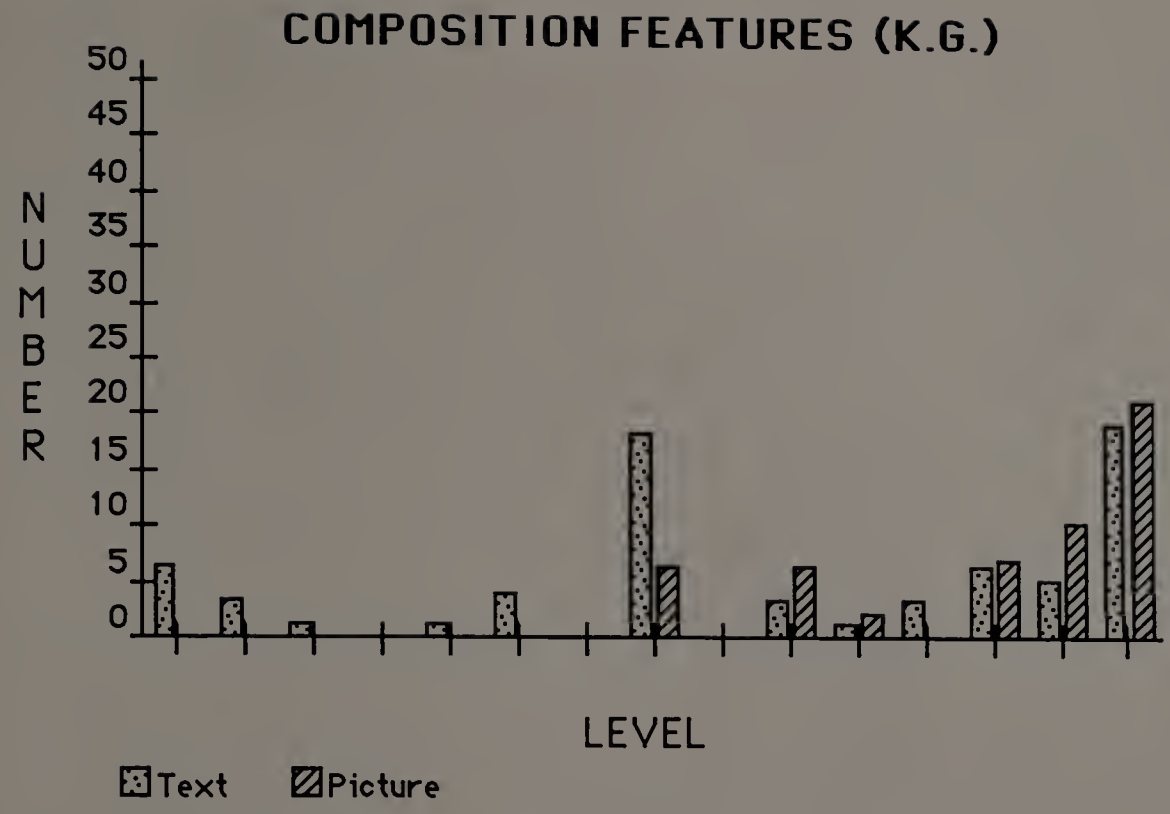
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1					A.P. Composition Pair Data											
2																
3		vocabulary				transformed					phrases					
4	**Text**	Level One-->				Level Two ----->					Level Three --------->					
5	(total)	N	A	V		N	V	A	TW		N	A	V	TW	NN	Ph
6	**Text**	7	3	6		0	0	0	0		0	0	0	0	0	0
7																
8		vocabulary				numerical ops.					assemblies					
9	**Picture**	Level One-->				Level Two ----->					Level Three --------->					
10	(largest)	S	T	A		S	T	A	Op		S	T	A	Obj	Scl	Pos
11	**Picture**	1	1	1		6	6	6	3		0	3	0	5	5	10
12																
13	KEY:	N=noun A=adj V=verb							S=shape T=attribute A=action							
14		TW= transformed word							Op=operator							
15		NN= new noun							Obj=object							
16		Ph= phrase w. phrase							Scl=scaler							
17									Pos= positioner							
18																



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1					D.K. Composition Pair Data											
2																
3		vocabulary				transformed					phrases					
4	**Text**	Level One-->				Level Two ----->					Level Three ·-------->					
5	(total)	N	A	V		N	V	A	TW		N	A	V	TW	NN	Ph
6	**Text**	4	8	4		0	0	0	0		0	0	0	0	0	0
7																
8		vocabulary				numerical ops.					assemblies					
9	**Picture**	Level One-->				Level Two ----->					Level Three -------->					
10	(largest)	S	T	A		S	T	A	Op		S	T	A	Obj	Scl	Pos
11	**Picture**	0	0	0		3	4	3	4		0	3	0	12	9	17
12																
13	KEY:	N=noun A=adj V=verb							S=shape T=attribute A=action							
14		TW= transformed word							Op=operator							
15		NN= new noun							Obj=object							
16		Ph= phrase w. phrase							Scl=scaler							
17									Pos= positioner							
18																



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1					F.F. Composition Pair Data											
2																
3		vocabulary			transformed						phrases					
4	**Text**	Level One-->			Level Two ----->						Level Three --------->					
5	(total)	N	A	V	N	V	A	TW			N	A	V	TW	NN	Ph
6	**Text**	16	8	4	2	0	2	11			1	1	3	4	8	17
7																
8		vocabulary			numerical ops.						assemblies					
9	**Picture**	Level One-->			Level Two ----->						Level Three --------->					
10	(largest)	S	T	A	S	T	A	Op			S	T	A	Obj	Scl	Pos
11	**Picture**	5	4	14	0	0	28	6			11	7	28	0	6	22
12																
13	KEY:	N=noun A=adj V=verb						S=shape T=attribute A=action								
14		TW= transformed word						Op=operator								
15		NN= new noun						Obj=object								
16		Ph= phrase w. phrase						Scl=scaler								
17								Pos= positioner								
18																



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1					K.G. Composition Pair Data											
2																
3		vocabulary				transformed					phrases					
4	**Text**	Level One-->				Level Two ----->					Level Three--------->					
5	(total)	N	A	V		N	V	A	TW		N	A	V	TW	NN	Ph
6	**Text**	6	3	1		1	4	0	18		3	1	3	6	5	19
7																
8		vocabulary				numerical ops.					assemblies					
9	**Picture**	Level One-->				Level Two ----->					Level Three -------->					
10	(largest)	S	T	A		S	T	A	Op		S	T	A	Obj	Scl	Pos
11	**Picture**	0	0	0		0	0	0	6		6	2	0	7	10	21
12																
13	KEY:	N=noun A=adj V=verb							S=shape T=attribute A=action							
14		TW= transformed word							Op=operator							
15		NN= new noun							Obj=object							
16		Ph= phrase w. phrase							Scl=scaler							
17									Pos= positioner							
18																

APPENDIX F
CURRICULUM

F1; Class Assignments for Desktop Publishing

These assignments use two software applications, MacDraw and Ready-Set-Go. MacDraw is used for designing the drawn letters, and Ready-Set-Go is a desk top publishing application which is used for assembling the Alphabet Book.

CONTENTS

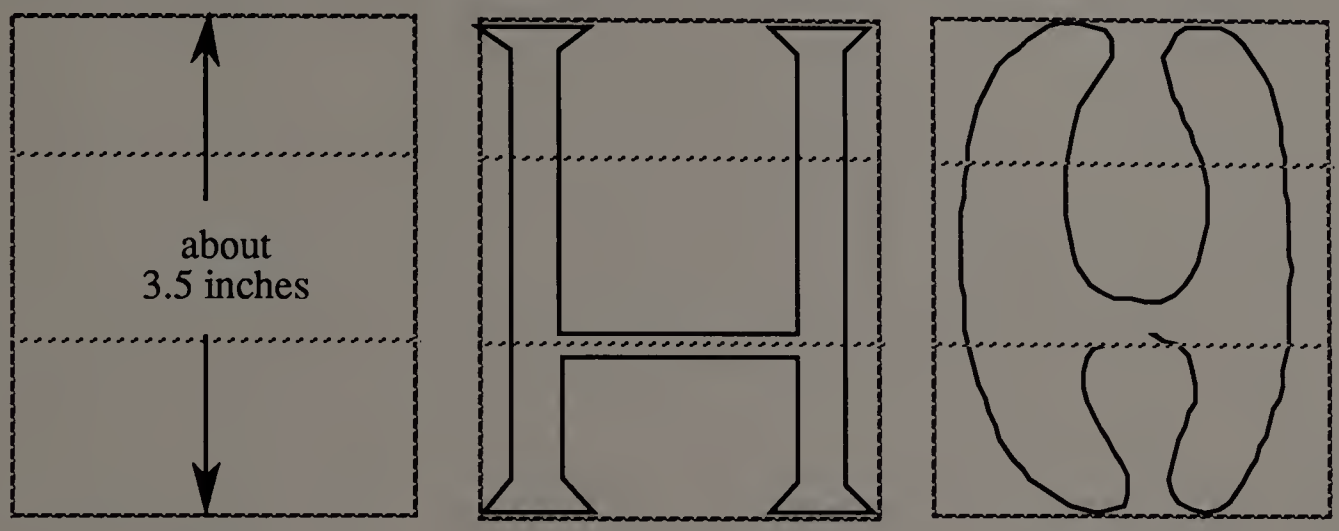
Assignment 4.1

ALPHABET BOOK

Be sure you have a system folder on your disk. Either get one from your instructor or copy one from another student.

Open MacDraw and make a new file.

I suggest that you first make a rectangle for a template so you can make all your letters the same size. The template should nearly fill the screen vertically.



template

drawn with a
segmented line

drawn with a
free-form spline
(not recommended)

You may use any of the tools to create your letters. Freehand sketching usually, but not always, looks crummy. You cannot fill figures drawn with lines Segmented lines work well for letters. If you want a freehand effect you can smooth segmented lines.

After a letter is finshed, throw away its template and group the letter.

Make all 26 letters. You can fit four on a page. Extra pages may be added to a drawing with **Drawing Size** under the **Layout** Menu.

When you have finished the alphabet, print out a copy to hand in.

Assignment 4.2

ALPHABET TO SCRAPBOOK

First open the MacDraw document which has your letters in it. Select your A, **Copy** it and open the scrapbook. (The scrapbook is under the Apple menu.) Now **Paste**, and your A will be placed in the scrapbook. Go back to your MacDraw letters and get the next one. Continue this process until all your letters are in the scrapbook. The computer will automatically put your scrapbook file in your system folder. Items in the scrapbook may be copied into any application. You will copy your scrapbook letters into a Ready-Set-Go document.

Assignment 4.3

SCRAPBOOK TO READY-SET-GO

Quit MacDraw and eject the disk by throwing it into the Trash. Put in the Ready-Set-Go disk and open it up. Drag copies of **ABC front** and **ABC back** onto your disk. These are templates for the Alphabet Book. Close all the windows except your disk's, then open up your copy of ABC back. Copy scrapbook letters into the appropriate graphics blocks. When ABC back is complete, **Save as** with a new name (like Back.???), and **Close** it.

WARNING: Open only one Ready-Set-Go file at a time. The computer does not have enough memory to deal with two, and you may lose information.

Open ABC front and fill it with letters. **Save as** with a new name like (Front.???).

To get credit for assignment 4.3, have your instructor copy your **Front** and **Back** onto a class backup disk.

Assignment 4.4

LETTERS TO WORDS

Think of your alphabet of letters as symbols for a collection of objects, ideas, or feelings. Perhaps your collection will be people or places you know. You might collect poems or Greek gods. When you have decided what to collect, find or invent one for each letter. Entries must be at least a complete sentence, and should not be much more than six lines. More can fit using smaller font size.

example:

A is ALWAYS.
I always admire abstract art.

Create the complete collection (A through Z) of texts to go with your letters.
Print them and hand them in as assignment 4.4

Assignment 4.5

FIRST DRAFT

Open your **Back** pages and add the appropriate texts. Now do the same for your **Front** pages.

Make a title page:
Add a new page to the beginning of either Front pages or Back pages .
(Look under **Special** in Ready-Set-Go)

Design a cover for your book using text, pictures, or both.

Print copies of both **Back** and **Front** so you can check for mistakes. Fold it together as a draft of your booklet and hand it in as assignment P3e.

Assignment 4.6

A B C BOOK AT LAST

Laser print your book:

Turn on the computer. Put your disk in the drive.

Open your eight page "ABC" document, the one which has the COVER.
Under the **File** menu; choose Page setup, then **OK.**

Print three copies of the cover.
Put three sheets of colored paper in the printer.
Print 3 copies; pages 1 to 1.

Print two copies of pages 2 to 8

Open the other "ABC" document. Fix the page setup.

Alphabetize the stack of pages.

Put these printed pages in the paper tray **bottom side up**.

Print two copies.

Hand in one copy of you ABC book and take one home to put on display.

F2; Class Assignments in Computer Graphics

These assignments use the Logo workspace "AutoMOVE" as an environment for composing pictures. This workspace contains a vocabulary of basic shapes and a master procedure (program) which allows for drawing on the screen with single key commands.

CONTENTS

Assignment 2.1

PLAY

Your disk should have a system folder on it. If it doesn't, get one from a friend or your instructor. Put your disk (with a system folder) in the main drive and start up the computer. Put the MacDraw & Logo disk in the external drive. Open Logo. It will automatically load the AutoMOVE workspace. This workspace provides a vocabulary of simple shapes and moves which can be used for the composition of pictures.

Try out the AutoMOVE commands listed on the next page. The automatic drawing mode is activated by typing **A** and the pressing the **enter** key.

Use the automatic mode to make a picture or a design.

Return to Logo from automatic mode with **N A**. Print out your picture.

The command for printing pictures is: **PRINTWINDOW "TURTLE**

AutoMOVE Commands

A .....Automatic (on/off)
B .....Black / white
C.....Circle
D.....Draw lines (on/off)
E.....Erase
F.....Fractal
G.....Grey
H.....Home
I .....Invisible / visible
J.....Jump
K.....Key
L.....Leap
M.....Magnify size
N.....Negate
O.....Ornate
P.....Petal
Q.....Quarter circle
R.....staR
S.....Square
T.....Triangle
U.....Undo
V.....Valentine
W.....Wider lines
X.....X position
Y.....Y position
Z..... reset (to Zero)
. ..... turn right
, ...turn left

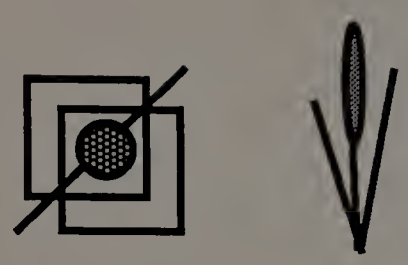
Numbers from 0 to 9 change the scale of the action.

When not in automatic mode, the command **SIZE** must be used to change scale.

Assignment #2.2

OBJECTS

Make two or three compound objects out of basic AutoMOVE shapes (S, T, C, etc).



Sketch on the screen until you produce a "good" object. Keep it simple, you can get complicated later.

Express your objects as procedures. Write the procedures so that the turtle ends where it started. Put a reset (Z) at the end of each procedure.
Test your procedures. Each one should pass these tests:

a) The procedure draws the object.
b) The size of the object can be changed.
c) The object can be drawn in different places.

Repair your procedures until they pass these tests. Repair like this is called debugging. Save the workspace which contains your compound objects. Use a name like OBJECTS.WS.

Procedure Writing

A procedure (computer program) is an instruction list. A completed procedure is a new, custom-made, command for Logo. The command **To**, followed by a procedure name, will put you in the **Editor** ready to type in an instruction list. When you have finished writing your procedure in the Editor, pressing the **enter** key will define your procedure as a new command for the turtle and then take you back to Logo. Once back to Logo, **enter**ing the name of your procedure will make the turtle follow the instructions in the procedure. Once a procedure has been written, it may be changed by putting it back into the editor with the command **EDIT** ***"procedurename.*** When you are finished editing, press the **enter** key to redefine your procedure. Numbers may not be used directly in a procedure. Numbers can only follow a command which expects an input. AutoMOVE has an extra command named **SIZE**, which expects an input. For example, the command **SIZE 8** used in a procedure is the same typing **8** in automatic mode.

Two sample procedures are listed below. Notice that all commands must be separated by spaces. Write these procedures for practice.

```
TO SQUARE
  FD 20 RT 90
  FD 20 RT 90
  FD 20 RT 90
  FD 20 RT 90
END
```

```
TO LSQUARE
  SIZE 6
  REPEAT 4 [L .]
END
```

Logo Primitives

(Return to Logo from automatic mode before trying to use these commands)

Turtle Control

HT .....**H**ide the **T**urtle
ST .....**S**how the **T**urtle
CG .....**C**lear **G**raphics
PU .....pick the **P**en **U**p
PD .....put the **P**en **D**own
HOME ....go **Home** to the center of the screen

Commands which Require Inputs

(the # shows where a number is required)

FD # .....go **F**orwar**D** example: **FD 50**
RT # .....tur**n** **R**ig**h**T example: **RT 90**
REPEAT # [***list of commands***] .....repeat these commands
example: **REPEAT 4 [FD 20 RT 90]**

Command Key Combinations

(Hold the command key down while pressing the other)

 E ..... make a new Edit window **G** .....Stop it!

Commands to the PRINTER

The only way to print on the network is to print using Shift 4

Commands to the WORKSPACE

POTS .....prints a list of all procedure names in the workspace.
EDIT "***procedurename*** ...opens an edit window containing this procedure.
EDALL ..... opens an edit window containing all procedures.
ERASE "***procedurename*** ... throws away the procedure.
ERALL .....erases all the procedures in the workspace.

Commands to the DISK

SAVEPICT "***picturename*** ..... saves the graphics window to disk.
LOADPICT "***picturename*** .....gets a picture from disk.
LOAD "***workspacename*** ..... gets a workspace from disk.
SAVE "***workspacename*** ..... saves the workspace to disk.

Assignment 2.3

SCALE & PLACE

Load your workspace which contains your compound objects. POTS to check and see that they are there and test them to be sure they still work.

Design a "picture" using only your compound objects. This picture must have at least two instances of each object. They must be in different places, have different sizes. They might also be at at different angles. Your picture may be represent something or be abstract.

Express your picture as one procedure, test it and debug it.

Save your picture procedure in the workspace along with your compound object procedures. Print your picture for assignment P2a.3

Positioning Commands

The turtle is positioned locally (with respect to where it is already) by commands like FD 60 and RT 20. Its absolute position in the graphics window may also be controlled. The AutoMOVE window is 480 pixels wide and 240 pixels high. The center of the window is taken to be the origin of an x-y coordinate system, making the horizontal (x) range from -240 to +240, and the vertical (y) range from -120 to +120. The heading of the turtle is taken to be zero when it points straight up, and increases in the clockwise direction.

SETX # .....moves the turtle to this horizontal location.
XCOR ..... prints the current x -coordinate of the turtle.

SETY # .....moves the turtle to this vertical location.
YCOR ..... prints the current y -coordinate of the turtle.

SETH # .....turns to turtle to this heading.
HEADING ..... prints the current heading of the turtle.

Assignment 2.4

COMPOSITION

Load the workspace which contains your objects.

Compose a better picture. Choose one of the sentences listed on the next page as a guide for your composition. Use the basic AutoMOVE shapes and Logo primitives along with your compound objects.

This composition should be done carefully. I will look for these design features:
Consistency, balance, repetition, detail, complexity, and use of space.

Express your composition as a procedure, test it and debug it.

Save your composition procedure in the workspace along with your compound shapes using a new name like COMPOSITION.WS.

Print a picture of your composition and a copy of its workspace.

Guide Sentences for Composition

Circles gather to watch the dancing lines.

Space compresses space, then pieces break free and drift away

like icebergs from the face of a glacier.

Stars watch a village nestled in the valley.

The magic egg hatches shapes of wondrous complexity.

A fragile line separates good and evil.

Bubbles ascend from the deep and burst triumphant at the surface.

Comic masks watch a tragic struggle.

Spruce trees beside the lake mimic the mountains beyond.

Big ones eat the little ones; the little ones eat the tiny ones; the tiny ones flee.

Loyal subjects salute their leader.

Strange shapes dance to the tune of falling snow.

Triangles, working together, capture beauty.

F3; Class Assignments in Linguistics with List Processing

These Assignments use the Logo workspace "ComPOSER" as an environment for composing paragraphs. This workspace contains a vocabulary of basic words, which are referenced by symbol, with which to compose sentences. Along with procedures for transforming works, it contains a procedure which will expand symbols into words, phrases, or sentences. The assignments (except for 3.1) and instructions for this section were written as a HyperCard stack. Assignment 3.1 and the cards of this stack are printed here.

CONTENTS

Assignment 3.1

CONSTRUCTED WRITING

Write some sentences using only the base vocabulary of words listed in the Lexicon which is attached. You may produce new words by using the base words as roots. You may define new words in terms of the base vocabulary, and newer words using words you created.

EXAMPLE

Words by production:

leader -> leaders; thinks -> thinking; complete -> completely
eats -> eat; hears -> hears

Words by definition:

parts which eat -> TEETH
parts which hear -> EARS
successor to zeroth -> FIRST
not good -> BAD
not big -> LITTLE
not joyful -> DREARY
young female human creature -> GIRL

Words using other defined words:

successor to first -> SECOND
dangerous creature with big teeth -> WOLF
creature which possesses big ears and is not dangerous -> RABBIT

Sentences:

A violent wolf eats the second rabbit. A little girl feels bad and quarrels with the wolf. The wolf goes in a dreary hole and feels nothing.

This writing exercise should fit on one page. It might have a half page of new words and a half page of sentences. It will be "scored" in terms of these criteria.

a) number of words b) percentage of unique words
c) percentage of produced words d) percentage of defined words
e) percentage of words defined in terms of defined words

LEXICON

(Base Vocabulary)

Nouns	Verbs	Adjectives	Prepositions
A air	A acts	A awesome	A around
B box	B builds	B big	B beside
C creature	C connects	C complete	I in
D day	D does	D dangerous	O of
E earth	E eats	E equivalent	T to
F fire	F feels	F female	U under
G group	G goes	G good	W with
H hole	H hears	H human	
I institution	I is	I intellegent	
J journey	J judges	J joyous	**Articles**
K knowledge	K kills	K kind	
L leader	L loves	L liquid	A a
M money	M moves	M metal	S some
N nothing	N neglects	N not	T the
O object	O opens	O oppressive	
P part	P possesses	P pretty	**Conjunctions**
Q question	Q quarrels	Q quick	
R road	R resides	R real	A and
S song	S sees	S successor	B but
T tool	T thinks	T true	O or
U umbra	U uses	U uniform	
V vehicle	V verifies	V very	
W water	W walks	W warm	
X (random)	X (random)	X (random)	
Y yard	Y yields	Y young	
Z zealot	Z zaps	Z zeroth	

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ASSIGNMENT

? 1. 2. 3. 4. 5.

This stack contains Project 2B, "Linguistic Composition". For the project you must use a Logo workspace called "ComPOSE" to build a descriptive paragraph. ComPOSE contains a small vocabulary and several procedures for creating and transforming words. The vocabulary consists of the nouns, verbs, and adjectives listed in the lexicon. The procedures are for creating new words, and expanding the sentences you construct using the rules of the grammar. You must construct sentences for a paragraph based on one of the guide pictures provided in this stack. Click the numbers on the left to see the assignments, or the words at the bottom to move around in this stack. You must Quit this stack to use Logo

— Assignment — Lexicon — Rules — Pictures — PrintCard - Quit —

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ASSIGNMENT

.CREATING WORDS

? 1. 2. 3. 4. 5.

Use the ComPOSE workspace to create two adverbs, two plural nouns, two plural verbs, and two new adjectives.

Plurals, adverbs, and adjectives are created by applying transformation rules to words in the lexicon.

The procedure MK.PN creates a plural noun, and MK.PV makes a plural verb. MK.NA makes a new adjective out of a verb and MK.AV makes an adverb from an adjective.

Go to Logo, choose ComPOSER, and make a workspace which contains these 24 new words. Save this workspace with the name WORDS. Use the EXPAND procedure to express your new words and print them for assignment P2B.1.

(Print the Logo window with Command-Shift-4)

— Assignment — Lexicon — Rules — Pictures — PrintCard - Quit —

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ASSIGNMENT

CREATING PHRASES

? 1. 2. 3. 4. 5.

Use the ComPOSE workspace to create six phrases, two prepositional phrases, two noun phrases, and two noun phrases. Phrases are made using [replacement rules].

The replacement rule [PP <- PR NP] is for creating prepositional phrases. [NP <- AR (A) N] is for noun phrases and the rule for verb phrases is [VP <- V (AV) (PP)].

Go to Logo, choose ComPOSER, and make a workspace which contains these six new phrases. Save this workspace with the name PHRASES. Use the [EXPAND] procedure to express your phrases and print them for assignment P2B.3.

(Print the Logo window with Command-Shift-4)

— Assignment — Lexicon — Rules — Pictures — PrintCard - Quit —

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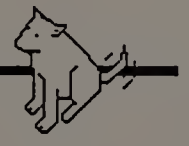
ASSIGNMENT

CREATING NEW NOUNS



? 1. 2. 3. 4. 5.

Use the ComPOSE workspace to create six new nouns.

The procedure [MK.NN] may be used to create new nouns. Each new noun requires a name, a N and a VP.

Go to Logo, choose ComPOSER, and make a workspace which contains these six new nouns. Save this workspace with the name N.NOUNS. Use the [EXPAND] procedure to express your new words and print them for assignment P2B.2.

(Print the Logo window with Command-Shift-4)

— Assignment — Lexicon — Rules — Pictures — PrintCard - Quit —

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ASSIGNMENT

CREATING SENTENCES

? 1. 2. 3. 4. 5.

Use the ComPOSE workspace to create two sentences.

A sentence is made from a verb phrase and a noun phrase. This rule is [SN <- NP VP]. Both phrases must be constructed by applying the appropriate replacement rules.

Go to Logo, choose ComPOSER, and make a workspace which contains your sentences. Save this workspace with the name SENTENCES. Use the [EXPAND] procedure to express your sentences and print them for assignment P2B.4.

(Print the Logo window with Command-Shift-4)

— Assignment — Lexicon — Rules — Pictures — PrintCard - Quit —

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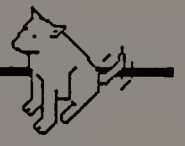
ASSIGNMENT

CREATING A PARAGRAPH



? 1. 2. 3. 4. 5.

Use the ComPOSE workspace to create a paragraph. Construct several (at least two) sentences derived from one of the [guide pictures] in this stack. The procedure [MK.PG] is a transformation rule which punctuates sentences. You must start by constructing phrases. You must use only words listed in the lexicon or words you create based on the lexicon words. A good paragraph will have more than two sentences, the sentences will be complex and contain words which have been created.

Use the [EXPAND] procedure to express your paragraph. Print it and hand in a "soft" copy of your workspace for assignment P2B.5.

— Assignment — Lexicon — Rules — Pictures — PrintCard - Quit —

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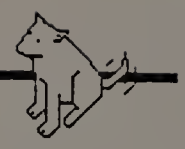
ASSIGNMENT



? 1. 2. 3. 4. 5.

The Logo procedure EXPAND will "open up" a list to its lowest level.

If NP1 is [AR.A A.T N.L], NP2 is [AR.T N.K], and VP1 is [V.V NP2], then EXPAND [NP1 VP1] yields:

level 1: NP1 VP1
level 2: a true leader verifies NP2
level 3: a true leader verifies the knowledge

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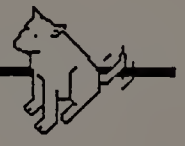
LEXICON



? N U A P

A lexicon is the vocabulary of a lingusitic system.
This system has nouns, verbs, adjectives, and prepositions.
Each of these words is named with a letter to indicate the part of speech and the first letter of the word.

The word ZEALOT, for example, is a noun beginning with the letter Z. Its name is N.Z.

The names N.X, V.X, and A.X produce random words.

The words of the lexicon may be combined using the rules of the system to form the sentences of the language.

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LEXICON

? N U A P ouns

A	Air	J	Journey	S	Song
B	Box	K	Knowledge	T	Tool
C	Creature	L	Leader	U	Umbra
D	Day	M	Money	V	Vehicle
E	Earth	N	Nothing	W	Water
F	Fire	O	Object	X	(Random)
G	Group	P	Part	Y	Yard
H	Hole	Q	Question	Z	Zealot
I	Institution	R	Road		

— Assignment — Lexicon — Rules — Pictures — PrintCard - Quit —

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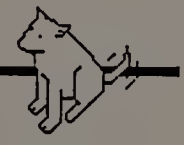
LEXICON



? N U A P erbs

A	Acts	J	Joins	S	Sees
B	Builds	K	Knows	T	Thinks
C	Connects	L	Loves	U	Uses
D	Does	M	Moves	V	Verifys
E	Eats	N	Neglects	W	Walks
F	Feels	O	Opens	X	(Random)
G	Goes	P	Possesses	Y	Yields
H	Hears	Q	Quarrels	Z	Zaps
I	Is	R	Resides		

— Assignment — Lexicon — Rules — Pictures — PrintCard - Quit —

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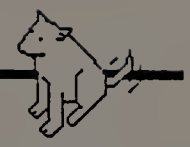
LEXICON



? N U A P djectives

A	All	J	Joyous	S	Successor to
B	Big	K	Kind	T	True
C	Complete	L	Liquid	U	Uniform
D	Dangerous	M	Metal	V	Violent
E	Equivalent to	N	Not	W	Warm
F	Female	O	Opposite of	X	(Random)
G	Good	P	Pretty	Y	Young
H	Human	Q	Quick	Z	Zeroth
I	Inside	R	Real		

— Assignment — Lexicon — Rules — Pictures — PrintCard - Quit —

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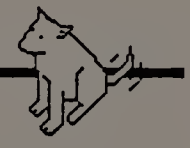
LEXICON



? N U A P repositions
Articles
Conjunctions

A	around
B	beside
I	in
O	on
T	through
U	under
W	with

A	a
S	some
T	the

A	and
O	or

— Assignment — Lexicon — Rules — Pictures — PrintCard - Quit —

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LEXICON

?
N
U
A
P

— Assignment — Lexicon — Rules — Pictures — PrintCard - Quit —

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RULES

?
R eplacement Rules
T
L

SN <- NP VP
PP <- PR NP
NP <- AR (A) (A) N (PP)
NP <- NP CJ NP
VP <- V (AV) (PP)
VP <- VP CJ VP

<- means "may be replaced by"

( ) means "optional"

Click on a rule to see an example in Logo:

SN = sentence
NP = noun phrase
VP = verb phrase
PP = prepositional phrase
N = noun
V = verb
A = adjective
AR = article
CJ = conjunction
PR = prepositon
AV = adverb

— Assignment — Lexicon — Rules — Pictures — PrintCard - Quit —

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RULES

? R T L

The sentences of the language are produced by combining the vocabulary words according to the rules (usually called the grammar). This small language has two kinds of rules. Replacement rules build up sentences by successive replacement. A noun phrase, for example, is replaced by an article, adjective, and noun. Rules of transformation are used to create new words and punctuate paragraphs. For example, plural nouns are formed by a transformation rule which adds an "s" to the singular form.

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Sentence

? R T L

Rule: SN <- NP VP

Logo:
```
MAKE "SN1 [ NP1  VP1 ]
MAKE "NP1 [ AR.A  N.R ]
MAKE "NP2 [ AR.T  A.G  N.S ]
MAKE "VP1 [ V.M PR.B  NP2 ]
```

The following lexical entries are used:

AR.A is 'a'	N.R is 'road'	V.M is 'moves'
AR.T is 'the'	N.S is 'song'	A.G is 'good'
PR.B is 'beside'		

a road moves beside the good song

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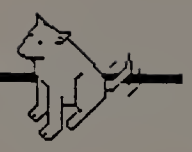
Prepositional Phrase



? R T L

Rule: PP <- PR NP

Logo: MAKE "PP1 [PR.B NP3]
MAKE "NP3 [AR.T A.W N.C]

The following lexical entries are used:

PR.B is 'beside'
AR.T is 'the'
A.W is 'warm'
N.C is 'creature'

beside the warm creature

— Assignment — Lexicon — Rules — Pictures — PrintCard - Quit —

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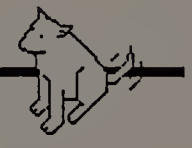
Noun Phrase



? R T L

Rule: NP <- AR (A) N

Logo: MAKE "NP1 [AR.A A.Q N.Z]

The following lexical entries are used:

AR.A is 'a', an article
N.Z is 'zealot', a noun
A.Q is 'quick', an adjective

a quick zealot

— Assignment — Lexicon — Rules — Pictures — PrintCard - Quit —

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Noun Phrase (conj)

? R T L

Rule: NP <- NP CJ NP

Logo:
```
MAKE "NP4 [NP5  CJ.O  NP6]
MAKE "NP5 [AR.A  A.M  N.T]
MAKE "NP6 [AR.A  A.V  N.F]
```

The following lexical entries are used:

CJ.O is 'or'
AR.A is 'a'
A.M is 'metal'
A.V is 'violent'
N.T is 'tool'
N.F is 'fire'

a metal tool or a violent fire

— Assignment — Lexicon — Rules — Pictures — PrintCard - Quit —

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Verb Phrase

? R T L

Rule: VP <- V (AV) (PP)

Logo:
```
MAKE "VP2 [V.Q  PP2]
MAKE "PP2 [PR.U  NP6]
MAKE "NP6 [AR.T  A.D  N.Q]
```

The following lexical entries are used:

V.Q is 'quarrels'
PR.U is 'under'
AR.T is 'the'
A.D is 'dangerous'
N.G is 'question'

quarrels under the dangerous question

— Assignment — Lexicon — Rules — Pictures — PrintCard - Quit —

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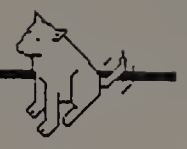
Verb Phrase (conj)



? R T L

Rule: VP <- VP CJ VP

Logo:
```
MAKE "VP3[VP4 CJ.A VP5]
MAKE "VP4[V.K NP7]
MAKE "NP7[AR.T A.C N.J]
MAKE "VP5[V.P NP8]
MAKE "NP8[N.F]
```

The following lexical entries are used:

CJ.A is 'a'	AR.T is 'the'	N.J is 'journey'
V.K is 'knows'	A.C is 'complete'	V.P is 'possesses'
		N.F is 'fire'

knows the complete journey and possesses fire

— Assignment — Lexicon — Rules — Pictures — PrintCard - Quit —

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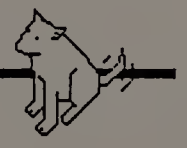
RULES



? R T L

Transformation Rules

NN <- N 'which' VP	MK.NN — creates a new noun
PN <- N 's'	MK.PN — creates a plural noun
PV <- V drop 's'	MK.PV — creates a plural verb
NA <- V 'ing'	MK.NA — creates a new adjective
AV <- A 'ly'	MK.AV — creates an adverb
PG <- SN1 SN2 SN3 ...	MK.PG — punctuates a paragraph

<- means "may be replaced by"

Click on a rule to see an example in Logo:

— Assignment — Lexicon — Rules — Pictures — PrintCard - Quit —

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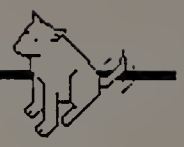
New Noun



? R T L

Rule: NN <- N 'which' VP

Logo:
```
MK.NN "CAGE [N.B  VP9]
MAKE "VP9 [V.C  NP9]
MAKE "NP9 [AR.A  A.D  N.C]
```

The procedure MK.NN takes a Word for the new name and a list containing a N and a VP. It inserts the string 'which' and assigns the new list to the new name.

"CAGE 'box which contains a dangerous creature'

— Assignment — Lexicon — Rules — Pictures — PrintCard - Quit —

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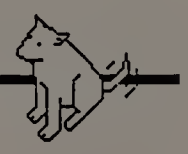
Plural Noun



? R T L

Rule: PN <- N 's'

Logo: MK.PN "N.G

The procedure MK.PN takes a Word containing a noun and adds an 's'. The plural noun is given the name PN. _
In this case PN.G

groups

— Assignment — Lexicon — Rules — Pictures — PrintCard - Quit —

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Plural Verb

? R T L

Rule: PV <- V drop 's'

Logo: MK.PV "V.T

The procedure MK.PV takes a Word containing a verb and drops the 's'. The plural verb is given the name PV. _ In this case PV.T

think

— Assignment — Lexicon — Rules — Pictures — PrintCard - Quit —

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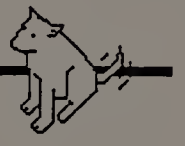
New Adjective



? R T L

Rule: NA <- V 'ing'

Logo: MK.NA "V.L

The procedure MK.NA takes a Word containing a verb, drops the 's' and adds 'ing'. The new adjective is given the name NA. _, in this example NA.L

loving

— Assignment — Lexicon — Rules — Pictures — PrintCard - Quit —

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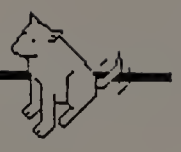
Adverb



? R T L

Rule: AV <- A 'ly'

Logo: MK.AV "A.H

The procedure MK.AV takes a Word containing an adjective and add 'ly'. The adverb which is created is given the name AV._, in this case AV.H

humanly

— Assignment — Lexicon — Rules — Pictures — PrintCard - Quit —

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Paragraph

? R T L

Rule: PG <- SN1 SN2 SN3 ...

Logo: If: SN1 is 'hear no evil',
SN5 is 'speak no evil',
SN8 is 'see no evil', and
SN9 is 'do no evil,

then: MK.PG [SN8 SN5 SN 9 SN1]
yeilds:

See no evil. Speak no evil. Do no evil. Hear no evil.

— Assignment — Lexicon — Rules — Pictures — PrintCard - Quit —

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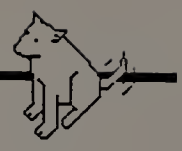
LOGO NAMING



?
R
T
Logo

Logo has objects of three types;
the STRING, the WORD, and the LIST.
A String is just a sequence of letters and/or numbers.
Words may be used for naming Strings or Lists, and
Lists are just lists of Words.

Examples:
'this is a string 24 long' "NANCY [CAT DOG BANANA]

To name a string, ———— MAKE "NANCY 'my friend'
To print the contents of the word "NANCY, — PRINT :NANCY
To print a list of words in the workspace, ———— NAMES
To edit a list of names, —— EDNAME [NANCY CAT BANANA]
To erase a list of names, — ERNAME [CAT DOG BANANA]

— Assignment — Lexicon — Rules — Pictures — PrintCard - Quit —

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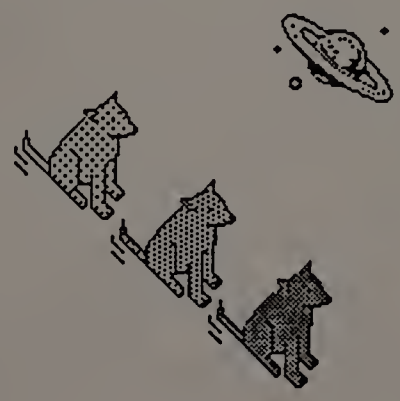
PICTURES

Dragon
Haulin' Fish
Boys will be boys
Song
Five Fish Hitch
Fantasy
Desserted
Bosch
Bounty
Sun City
Guns or Butter
Beaks

These pictures are designed
as guides for the composition
of paragraphs.



— Assignment — Lexicon — Rules — Pictures — PrintCard - Quit —

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PICTURES

— Assignment — Lexicon — Rules — Pictures – PrintCard - Quit –

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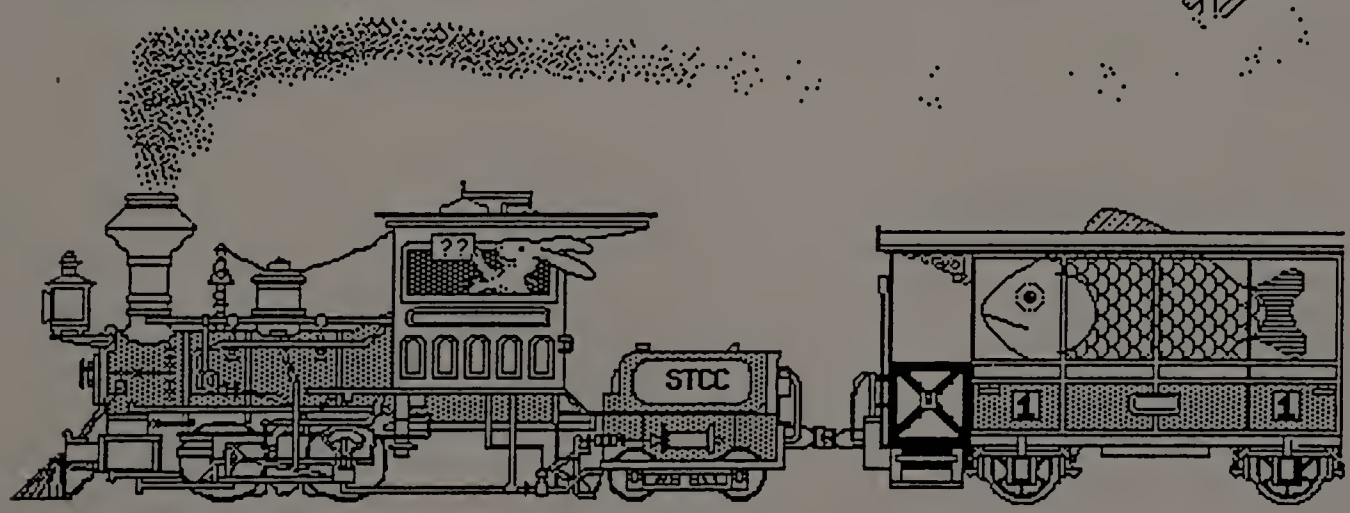
PICTURES



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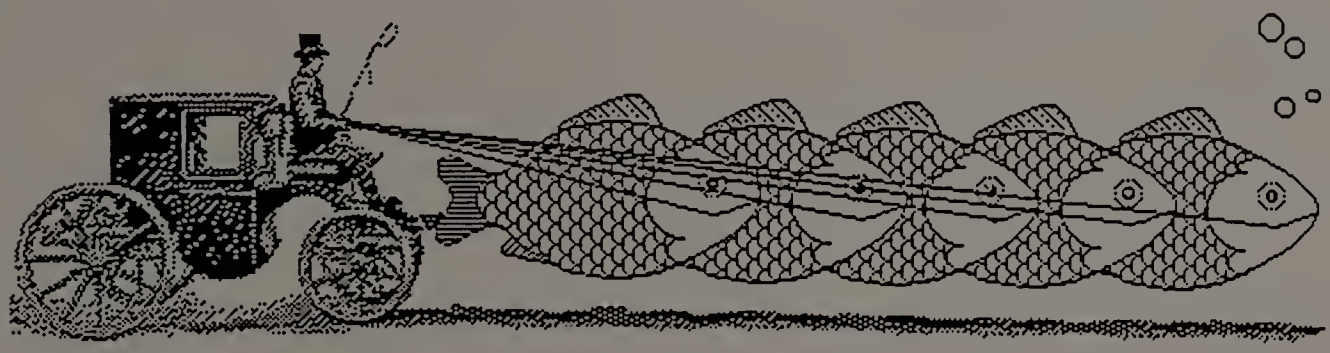

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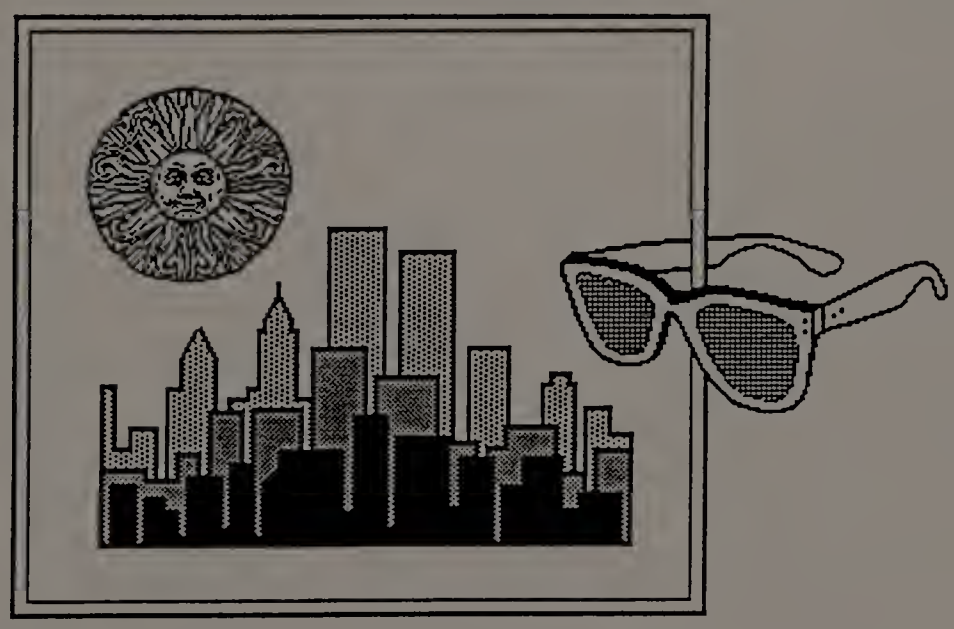

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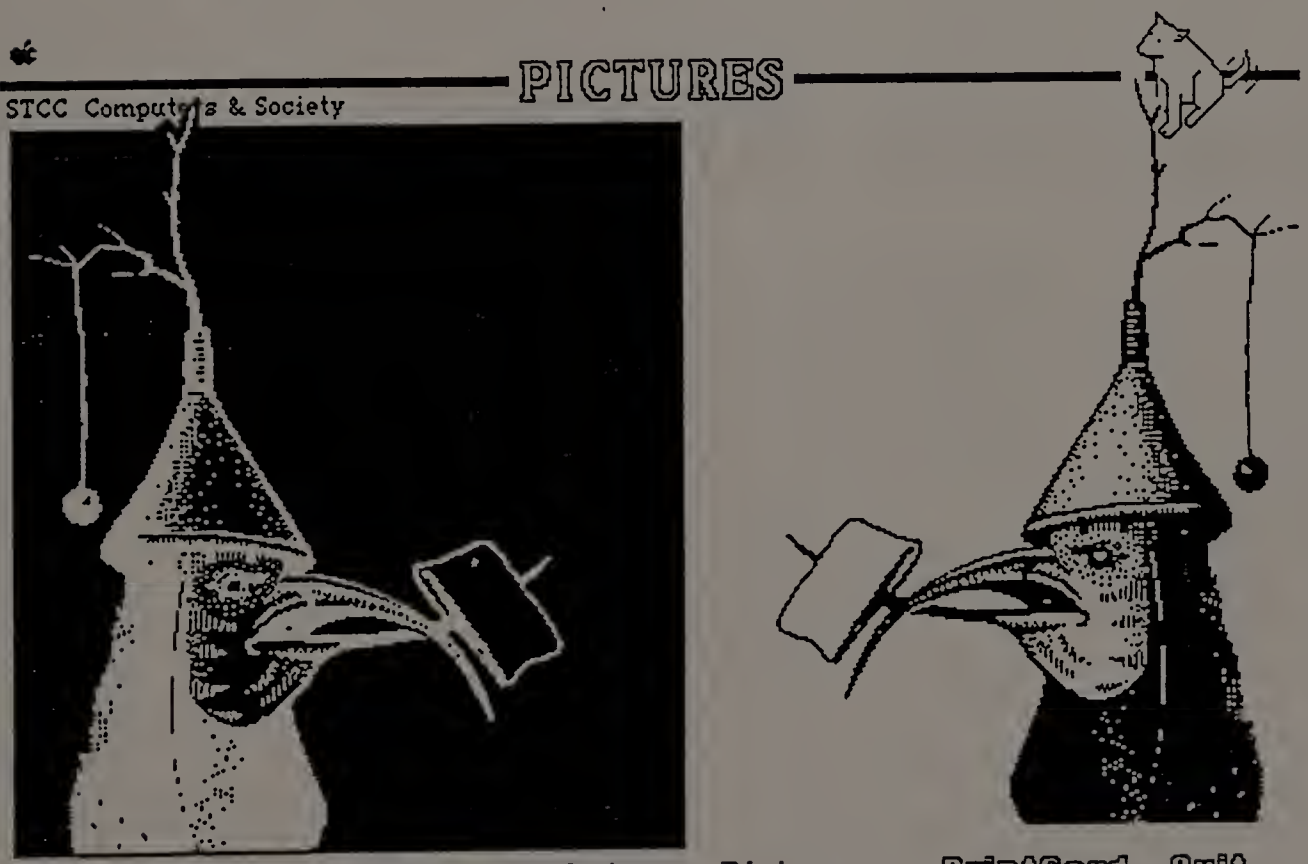

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