MAP USE

READING ANALYSIS INTERPRETATION

Phillip C. Muehrcke, Juliana O. Muehrcke & A. Jon Kimerling

Revised Fourth Edition

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Reading, Analysis, and Interpretation

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In previous editions of *Map Use*, we acknowledged the importance of contributions made by special teachers and colleagues, teaching assistants, students at the Universities of Washington and Wisconsin, and the staff of the University of Wisconsin Cartography Laboratory. We continue to be grateful for the inspiration and assistance provided by these people. With this revised edition, we further acknowledge the contributions of similar individuals and facilities at Oregon State University.

To our delight, hundreds of people have taken the time to comment on these earlier editions. Some of these people were merely lovers of maps; others were professors responsible for teaching introductory courses in map reading, analysis, and interpretation; and a number were students who had occasion to use the book in their studies. We were especially moved by letters from people who stumbled upon *Map Use* by accident at a friend's house or library and felt compelled to let us know how pleased they were with their discovery.

All these responses were gratefully received, and many were useful in making revisions for this revised fourth edition. We alone, of course, bear full responsibility for errors in the text and controversial statements. This work reflects our deep love of maps and a desire to help others bring maps into their lives.

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My object in living is to unite
My avocation and my vocation
As my two eyes make one in sight.

—Robert Frost

PREFACE

Readers of earlier editions of *Map Use* will notice major differences in this fourth revised edition. A new author brings strong computer-mapping and information-age skills to the text. Electronic technology continues to have a profound impact on the way maps are used. We have addressed these issues by updating chapters devoted to mapping software, GIS mapping applications, map resources on the Internet, and GPS. Useful appendixes on remote sensing and navigational instruments have also been updated. We've revised text and illustrations in these sections to incorporate changes that have occurred since the fourth edition was published.

In recent years, electronic aids for map use have become widely available at prices most people can afford. GPS receivers vastly simplify position and route-finding, while computers loaded with mapping software and databases let us use maps interactively. Such innovations are rapidly transforming the way we use maps. They also provide the focus for this revised edition.

And yet, we have retained much information from earlier editions because it is still useful today. Most of what you need to know about using maps isn't new.

The philosophy behind *Map Use* also remains the same. As in earlier editions, we stress that a good map user must understand what goes into the making of a map. From map makers, we ask for little less than a miracle. We want the overwhelming detail, complexity, and size of our confusing surroundings reduced to a simple representation which is convenient to carry around. We also want that abstract map to provide us with a meaningful basis for relating to the environment.

It's fair to say that cartographers have given us what we asked for. They have mapped a vast array of subjects in a variety of clever, even ingenious, ways. Maps not only cover almost any topic of interest for all parts of the world, but they're also remarkably low in cost.

This is no surprise to the many people who love maps and are intrigued with all aspects of the mapping process. Those falling in this group constantly find themselves surrounded by maps, collecting more maps, or daydreaming with a map in hand. If you're one of those people, our aim is to get you to think about maps in still new ways, to broaden your total mapping experience so that you get more pleasure from less activity.

But sadly, many of us have acquired neither the interest nor the basic skills necessary to take full advantage of the broad range of available maps. Too often we blunder through the environment, not appreciating what it has to offer, causing hardship for ourselves and others, and relating to our surroundings in a destructive way. This need not be the case. Learning to use a map is a relatively easy and painless process, with an immense payoff.

Many books have been written on map making. But since map use isn't the simple reverse of map making, most of these books are of limited value to you as a map user. In contrast, this book has been written strictly for the person who wants to use maps. Academics have tended to treat maps as indoor things, rarely including in their textbooks the fact that one of the most exciting ways to use maps is in the field. Conversely, military manuals and field guides to map and compass use have focused narrowly on way finding, virtually ignoring the role maps play in the way we think about and communicate environmental information. In this book, we bridge the gap between these two extremes, pulling fragments of information from many fields into a coherent view of the environment. We offer a comprehensive,

philosophical, and practical treatment of map appreciation. To do so, we've had to deviate in several ways from approaches taken in previous cartographic literature.

First, we define a map as a graphical representation of the environment that shows relations between geographical features. This encompassing definition lets us include a variety of important map forms which are otherwise awkward to categorize. Our definition should also accommodate any new cartographic forms which might be developed in the future. Throughout this book, we have integrated discussions of standard planimetric maps, perspective diagrams, environmental photographs, and satellite images, rather than partitioning each into a separate category.

Second, we have made a clear distinction between the tangible cartographic map and the mental or cognitive map of the environment which we hold in our heads. Ultimately, it is the map in our minds, not the map in our hands, with which we make decisions. Throughout the text, we stress the point that cartographic maps are valuable aids for developing better mental maps. We should strive to become so familiar with the environment that we can move through it freely in both a physical and mental sense. Ideally, our cartographic and mental maps should merge into one.

In a third departure from tradition, we have, where appropriate, made extensive reference to commercial products of special interest to the map user. A few years ago this would have seemed strange, since most mapping was done by large government agencies. But times have changed. The field of mapping is rapidly being commercialized. Computer software and digital data for mapping are being developed and sold by private industry. What you do with maps in the future will be strongly influenced by the nature of these commercial products.

Finally, this book is not written in traditional textbook style. Only sparing reference is made within the text to the professional cartographic literature, and the selected readings at the end of each chapter are chosen as much for their general accessibility as their content. Whenever possible, examples and illustrations have been taken from popular sources. Maps touch so many aspects of our daily lives that it is simple and natural to make points and reinforce ideas with advertisements, cartoons, and quotations from everyday communications. These illustrations and examples are included to demonstrate and reinforce basic mapping and map use principles. They are thus an integral part of the book and should be given as much consideration as the text.

The book was designed for both the specialized and the general map user. It could be used as a basic reference work or as the textbook for a beginning map appreciation course in any of the environmental sciences. It has been specifically designed and tested for use in a three-credit semester course of 15 weeks at the college freshman level. Material is presented at the upper high school to intermediate college level.

Our aim has been to cut through the plethora of confusing terms and details that characterize so many cartographic texts. Readers can obtain an overview of the most important concepts and how they fit together by glancing through the beginning outline included for each chapter.

We have structured the material into three main sections under the headings *Map Reading* (Part I), *Map Analysis* (Part II), and *Map Interpretation* (Part III). In most books, these terms have not had more than vague definitions and are often used interchangeably. Here they have been defined precisely, and the relationship of each to the others has been made clear.

In *Part I, Map Reading,* we discuss the geographical data which make up a map, the process required to transform that information from environment to map, mapping techniques (image mapping, landform portrayal, attribute mapping, and statistical mapping), the temporal aspect of maps, software for map retrieval, and access to map resources on the Internet. The goal in this section is to give the reader an appreciation of how the cartographer represents the environment in the reduced, abstract form of a map. In map reading, in a sense, we're trying to "undo" the mapping process in our minds.

Once we grasp the degree to which cartographic procedures can influence the appearance and form of a map, we're in a position to use maps to analyze the spatial structure and relations of the mapped environment. *Part II, Map Analysis,* includes chapters on reference systems, direction, distance, map and compass use, GPS, cartometrics, form and structure, pattern comparison, software for map analysis, and map accuracy. With each of these topics, the concern is on estimating, counting, measuring, data manipulation, and pattern-seeking activities.

Map analysis in itself serves some engineering functions but intellectually is rather sterile. The results of map analysis come alive when we try to explain why the environment takes on one spatial character over another. This is the subject of *Map Interpretation (Part III).* The material has been divided into five chapters: Interpreting the Physical Environment, Interpreting the Human Environment, Interpreting Environmental Interactions, Image Map Interpretation, and Maps and Reality. The emphasis in this final section is on environmental comprehension and understanding, for it is our surroundings, not the map, which is the real subject of map use.

These three parts are followed by a series of appendices. Topics include map scale, remote sensing of the environment, projections, navigational aids, and useful mathematical tables. Each appendix is designed to complement material presented in the main body of the text.

Although a systematic development of subject matter is followed throughout this book, each section and chapter is autonomous from, and cross-referenced to, the rest of the material. Therefore, it isn't necessary to read the book in order from cover to cover. The strategy most appropriate for you depends on your background and interests. Generally, the book is organized to provide inexperienced readers with a logical development of concepts. There is a progressive building of skills from beginning to end. More experienced map users may wish to focus initially on sections or chapters of special interest and then refer to other parts to refresh their memories or clarify terms, concepts, and methods.

This book will have served its purpose if readers finish it with a greater appreciation of maps than when they began. In even the simplest map, there is much to respect. Cartographers have managed to shape the jumble of reality into compact, usable form. They have done a commendable job. Now it is up to us.

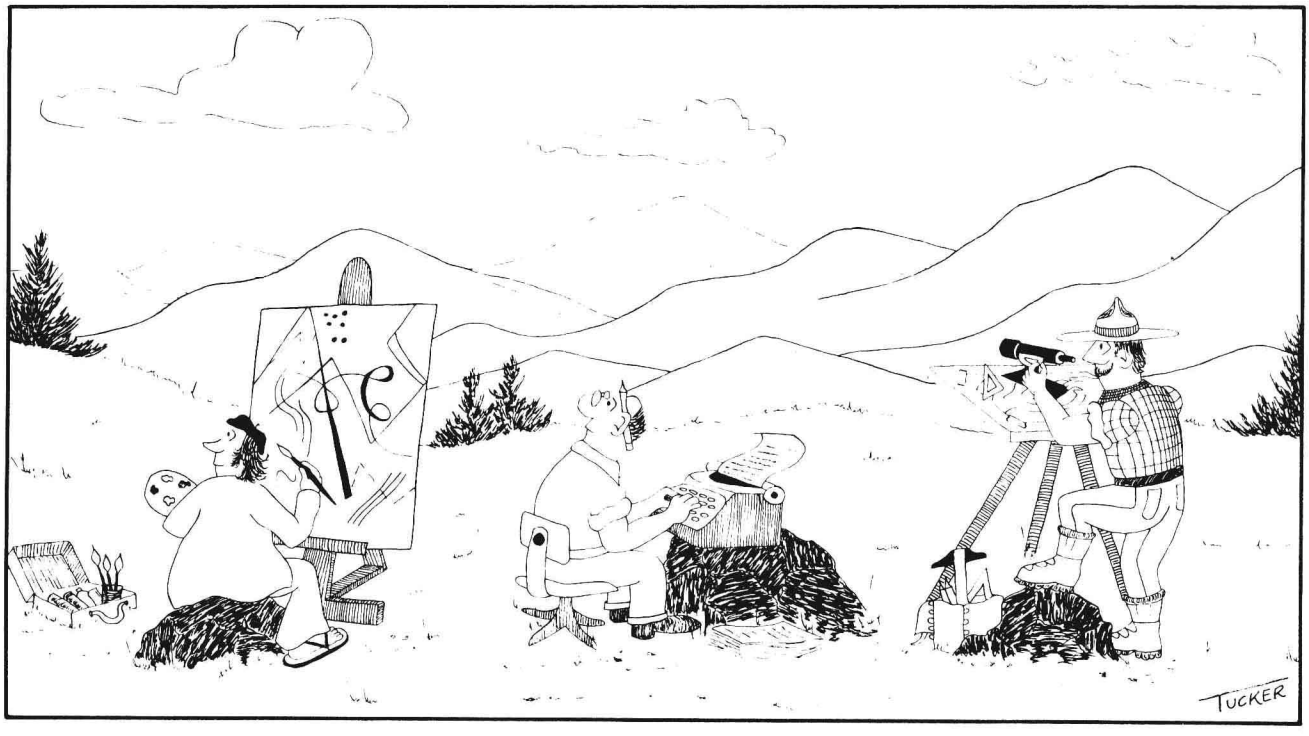
MAP

It tells the truth by lying, like a poem
With bold hyperbole of shape and line—
A masterpiece of false simplicity.
Its secret meanings must be mulled upon,
Yet all the world is open to a glance.
With colors to fire the mind, a song of names,
A painting that is not at home on walls
But crumpled on a station wagon floor,
Worn through at folds, tape patched and chocolate smudged
(What other work of art can lead you home?)
—A map was made to use.

—JULIANA O. MUEHRCKE

CONTENTS

INTRODUCTION



Map me no maps, sir, my head
is a map of the whole world.
—Henry Fielding

INTRODUCTION

It should be easier to read a map than to read this book. After all, we know that a picture is worth a thousand words. Everyone from poets to the Internal Revenue (with its pamphlet entitled "Road Map to Form 1040A") works from the assumption that nothing could be easier to understand than a map. The very term "map" is ingrained in our thinking pattern. We use it to suggest clarification, as in "Map out your plan" or "Do I have to draw you a map?" How ironical, then, to write a book using language that is, supposedly, more complicated than the thing we're trying to explain!

The problem is that maps aren't nearly as straightforward as they seem. Using a map to represent our detailed and complexly interrelated surroundings can be quite deceptive. This isn't to say that maps themselves are unclear. But it's the mapped world, not the map, that we're trying to understand.

Making maps simple doesn't change the world; it only lets us treat it, for certain purposes, as if it were less complicated. There are advantages in such a treatment, but there's also the danger that we'll end up with an unrealistic view of reality. All too often, in fact, such warped views of the environment are held by people who manage critical natural and human resources.

In this book, we'll define a map as a **spatial representation of the environment**. By "representation," we mean something that stands for the environment, that portrays it, and is both a likeness and a simplified model. With this definition, we can encompass such diverse maps as those on walls and those held solely in the mind's eye. To appreciate why it's important to think of maps in such an all-encompassing sense, let's take a closer look at how you come to know the environment around you.

KNOWING YOUR SURROUNDINGS

What you know about the environment is tied closely to the way you think and communicate. You don't gain environmental knowledge passively. It comes through an active process of information gathering, structuring, and association. You can better understand this process if you look at the stages involved, with emphasis on seeing.

Sensory Data

The most natural way you learn about your environment is through direct sensory data. You receive this information through your senses of sight, sound, smell, taste, and touch.

For instance, you see things when cells in your retinas pick up light energy reflected from different locations in your field of view (**Figure I.1**). Consider how different your conception of the environment might be if you could use X-ray, infrared, or microwave energy to see rather than depending exclusively on visible light.

Obviously, relying solely on direct sensory data limits the scope of what you experience. It also requires direct contact. You must experience everything first-hand.

Categorization

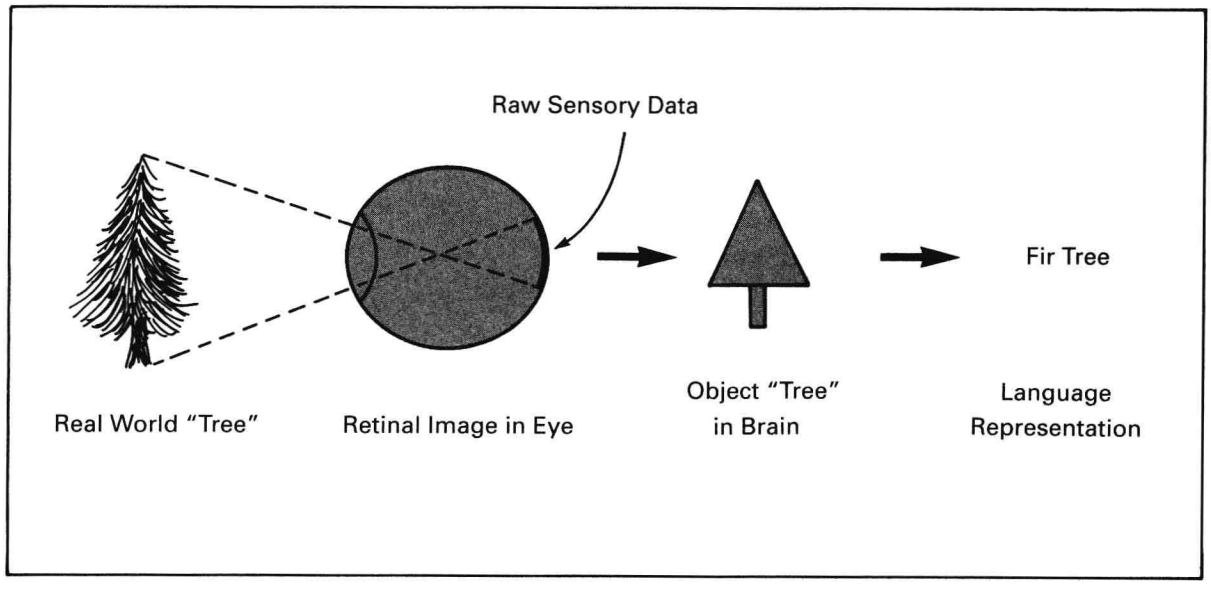
But you don't limit yourself to raw sensory data, of course. Seeing involves more than recording light energy on the sensory cells in your retinas. Your brain organizes this information into meaningful categories (**see Figure I.1**). You see features such as trees, not tiny spots of color as recorded by the individual retina cells. Such categories enormously simplify your view of the environment.

Representation

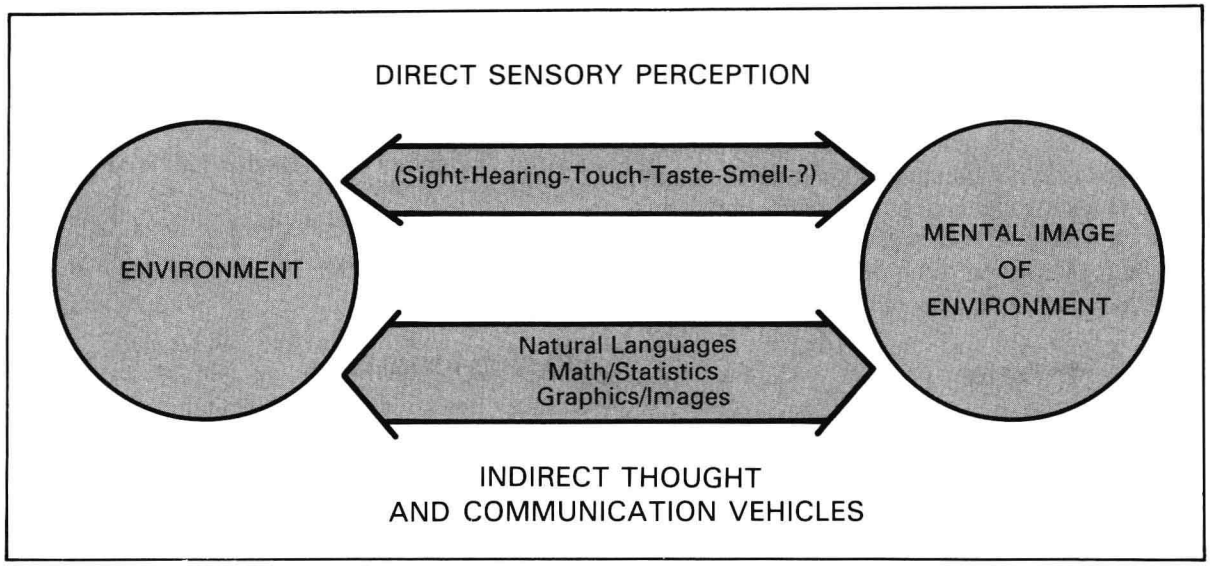
Categorization is just one component of thinking abstractly. Rather than pointing at actual features, we need something to stand for these features. For this purpose we invented symbols (see Figure I.1).

Symbols are the basis for indirect forms of communication (**Figure I.2**). These indirect communication vehicles include: (1) **natural languages** (such as English) (2) **artificial languages** (branches of mathematics), and (3) **pictures**, both graphics and images.

Each of these indirect means of environmental thought and communication is limited in scope and sensitivity. No single method best serves all purposes. In fact, words, numbers, and



I.1 The process of seeing begins with light rays reflected from environmental features falling on the retina in your eye and ends with the conception and representation of objects in your brain.



I.2 Humans are unique in learning to know their environment by supplementing raw sense data with indirect vehicles of thought and communication.

pictures occupy complementary positions along an abstraction gradient (**Figure I.3**).

You can use these abstractions in two ways when thinking about the environment: (1) You may see your surroundings in holistic, spatial terms, with everything occurring at once and in complete interrelation. This is the view of the visual arts and Eastern philosophy. Graphics serve this function well. (2) You may conceive of the environment in analytical terms, with the whole made up of parts which can be identified, isolated, and manipulated separately. This is the view of Western scientific thought. The formal logic of mathematics serves this function well.

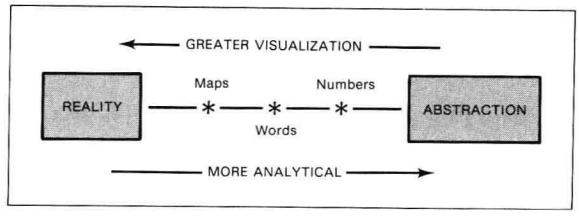
Many people prefer one or the other of these approaches to environmental understanding. In this book we'll stress a flexible use of both. Such a mix accentuates the strengths while minimizing the limitations of each alone. The ability to shift back and forth between these different strategies is a valuable skill to master.

ENVIRONMENTAL VISUALIZATION

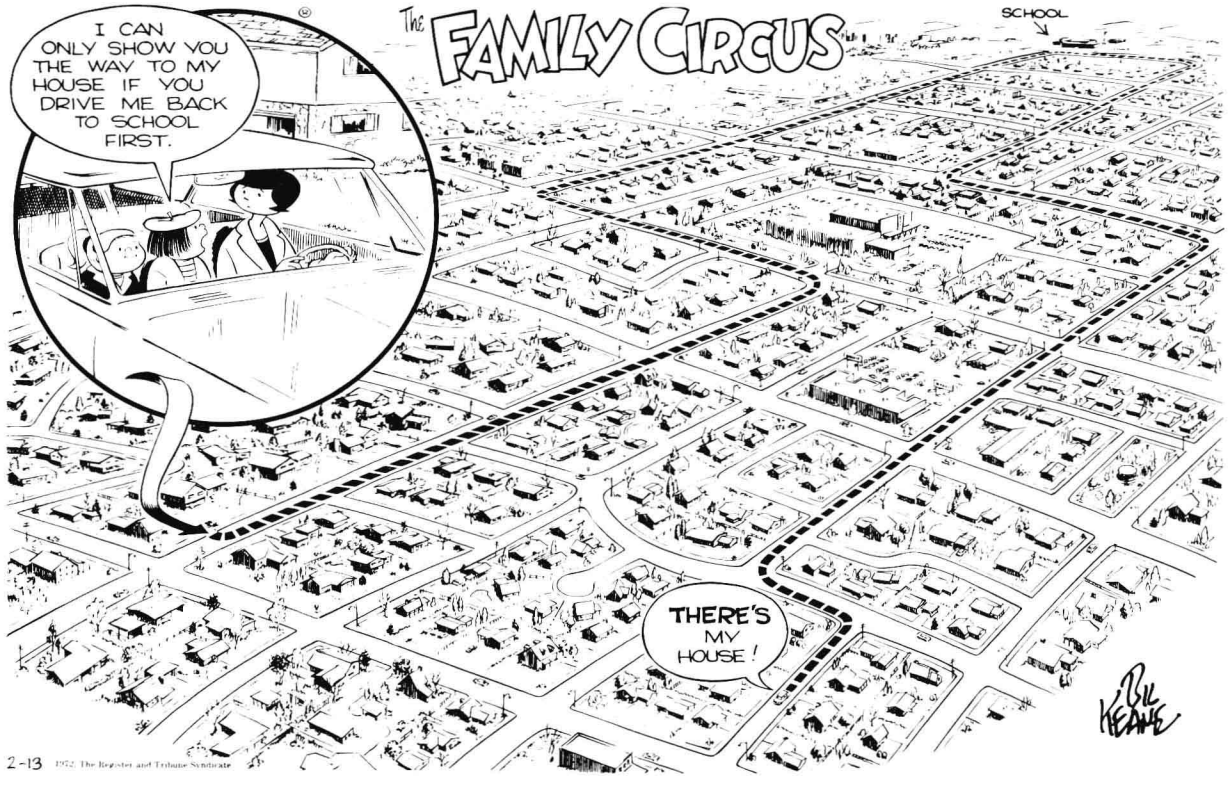
Your use of categorization and representation may take several forms. You may envision the environment by using physical maps, or you can use maps that are strictly in your mind.

The maps in your mind, known as **cognitive** or **mental maps**, are often slighted in map definitions. Yet they are really the ultimate maps, because they're the ones you use to make decisions about the environment.

Unfortunately, however, mental maps are restricted in scope and often fail. When this happens, it's helpful to rely on **cartographic maps**. Let's take a closer look at these two types of maps.



I.3 If we arrange graphics, words, and numbers along an abstraction gradient, we can see that the closer they fall toward reality the greater their visualization power, while greater abstraction better serves analytical purposes.



I.4 The geometry of a child's mental map is based on direct experience and connected pathways.

Mental Maps

As a child, your mental map was probably based on direct experience, connected paths, and egocentricism (in which you related everything to your own position). This view is summarized by the cartoon in **Figure I.4**. As an adult, you can appreciate this cartoon because you see how inefficient these primitive mental maps can be. But the truth is that you still resort to this way of structuring your environment when thrown into unfamiliar settings. If you go for a walk in a strange city, you will remember how to get back to your hotel by putting connective information together into a pathway. Your mental map will be narrow and striplike, resembling a ribbon with a few landmarks like beads strung along it.

Most of your mental maps are more complicated than this, however. For one thing, you take advantage of **indirect** as well as direct experience. You acquire information through TV, conversations, photographs, reading, and other secondary sources. You can transcend your physical limitations and conceptualize distant environments, even those at the other side of the planet. Your mental map becomes incredibly complex as it encompasses places you have never seen.

At the same time, your egocentricism is replaced by a **geocentric** point of view. Rather than relating everything to your own location, you learn to orient yourself with respect to the external environment. Thus, you can assume yourself to be at a distant position, even when you haven't moved physically. The feat might be called the geographical "What if....?"

Once you learn to separate yourself from your environment, you no longer need to structure your mental maps in terms of connected pathways. You can have a mental map of a scene without being part of it. You can visualize how to get from one place to another "as the crow flies"—the way you would go if you weren't restricted to roads. It's your ability to see the "big

picture," to have a comprehensive mental map, that makes the cartoon in Figure I.4 amusing.

Your geocentric viewpoint, with its freedom from the constraints of sequential pathways, is given a boost when you use a frame of spatial reference you can share with others. The system of **cardinal directions** (north, south, east, and west) provides just such a framework. Using this reference system, you can pinpoint something's location by stating its distance and direction from something else. You can say, for example, that a plane crashed about five kilometers northeast of here (**Figure I.5**). This conception of space is based on **Euclidean geometry**. You're familiar with Euclidean geometry, because it's the geometry taught in most schools. It's the same geometry which says that parallel lines never meet, that the shortest distance between two points is a straight line, that there are three dimensions, and so forth.

Your ability to view your surroundings in terms of these distance, direction, and dimensional relations is the essence of your geocentric perspective. It will serve you well when your surroundings are familiar, but it may fail you when you're thrown into a strange setting. In unfamiliar environments, most people revert to the more primitive pathway structuring. If they don't, they risk getting lost. Thus, while Euclidean geometry provides you with a conceptual framework, you probably don't adhere to it in all your mental maps.

Even when you view the world from a Euclidean perspective, your mental maps may not be Euclidean, because they must consider the routes you have to follow. Your environment is full of barriers which keep you from traveling along straight lines or taking what in Euclidean terms would be the shortest route. Planners who try to predict behavior often go wrong by assuming that people's mental maps are identical to maps based on Euclidean space.

If you think about your own mental map, you should now be able to pick out those parts of it which are based on direct experience and those which reflect indirect experience. But there will still be something—some images, some feelings about places—left unaccounted for, unexplained by either direct or indirect experience. This is because your mental maps are also influenced by **extrasensory perception**—information which originates in your mind rather than with external stimuli.

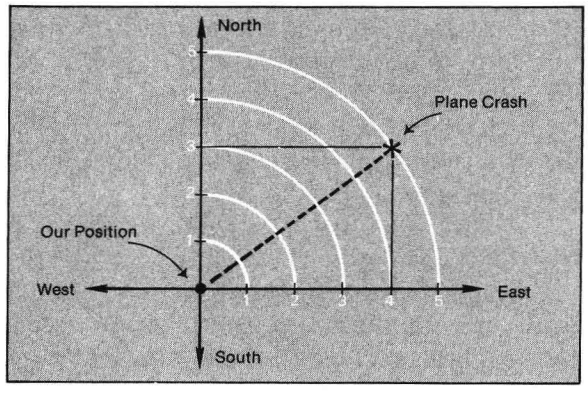
The major source of extrasensory information is thinking. You constantly ponder and modify the information you gather through experience. Much of what you *think* you know about your surroundings, therefore, is conjecture.

Extrasensory perception also encompasses information gained through your imagination, fantasies, dreams, and hallucinations. You have little control over these sources of information, and you're usually not conscious of the impact they have on your mental maps. Yet they shape your view of the world in the same way as do other information sources.

Although extrasensory input is the least reliable, there are problems with direct and indirect information, too. We like to believe that we take in environmental information in all the detail that our senses permit. In truth, however, perception is an active and highly selective process. You rarely see things as they are but, rather, as you expect or would like to see them. You bring much of yourself—past experience, biases, and limitations—to the perceptual process.

The problem is compounded when you rely on indirect experience, such as TV, books, or conversations. In this case, you are depending on the mental maps of other people, who have their own twisted notions of reality. In addition, their ability to communicate information, and your ability to decipher it, distort what you learn.

As an adult, then, your mental maps are a potpourri of fact and fiction, gleaned through a



I.5 An adult's conception of space is based primarily on the principles of Euclidean geometry.

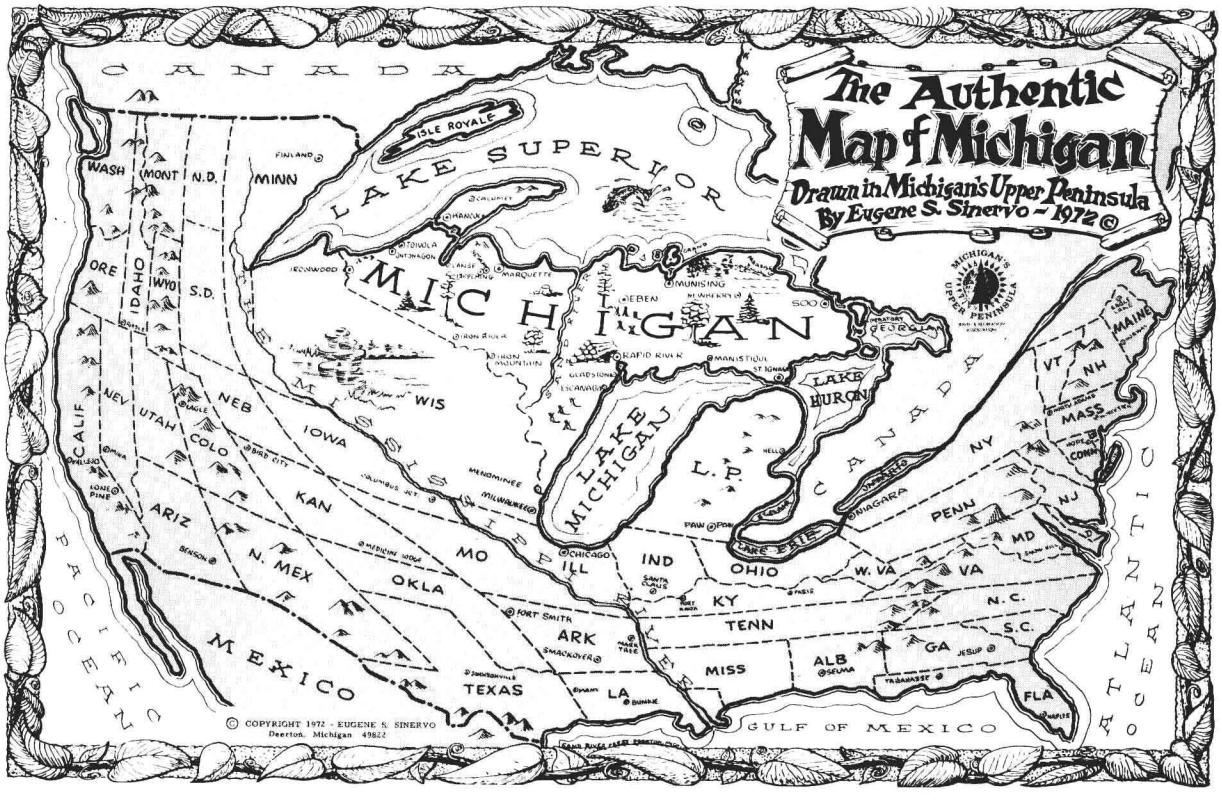
haphazard combination of direct, indirect, and extrasensory experience. Some parts of your mental maps are egocentric and based on connected paths, while others are geocentric and based on Euclidean distance-direction relations. You have forgotten some things and seen others incorrectly. Your fears and prejudices and longings all have biased your way of looking at the world. It is understandable that a combination of these factors may badly warp your image of the environment.

Try drawing, from memory, a map of the area in which you live. The resulting picture will tell you a great deal about your mental map.* Not only will you draw the places you know best with the greatest spatial detail and accuracy, but you will likely draw those things which are important in your life and leave off those you don't care about. Many of your attitudes will be reflected by the map you draw. Whether you show Joe's Bar or the corner church, the library or the football stadium, says something about your lifestyle and values.

Few people's mental maps correspond perfectly with cartographic maps. **Figure I.6** shows the distorted image which a person from Michigan's Upper Peninsula might have of the country. Tongue in cheek though this map may be, it captures the fact that people view their own region as far more important than the rest of the world. In the same way, your mental maps emphasize your own neighborhood, with distant environments assuming less significance.

The study of people's mental maps is a growing area for research and gives us many insights into the way we view the world. In one

**The accuracy of a drawn mental map is largely a reflection of a person's drawing skill. Those few with a flair for drawing may successfully convey on paper the true character of their mental maps. But for the vast majority of us lacking drawing ability, the resulting pictures on paper won't do justice to the maps held in our minds. Researchers have struggled unsuccessfully for decades to overcome this problem.*



I.6 The United States as seen through the eyes of a resident of Michigan's Upper Peninsula.