

SEEING IS DECEIVING: The Psychology of Visual Illusions

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SEEING IS DECEIVING:
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**This book is dedicated to
Leon Festinger and Julian Hochberg**

Preface

In the past century and a quarter over 1,000 articles have been published dealing with visual illusions. Despite this obvious evidence of interest, only three serious books have appeared dealing with these puzzling perceptual phenomena. The authors of these books include a lighting engineer, a physicist, and a psychologist, and their principle concern was with the presentation, or cataloging, of the basic visual distortions rather than with an integrated attempt at explanation. This book provides such an attempt. It brings together much of the known data and offers explorations and evaluations of the theoretical viewpoints that are exerting an influence on contemporary thought about visual illusions. We attempt to demonstrate that these illusory distortions do not represent a breakdown in the normal processes of perception but rather are the end product of many well-known perceptual mechanisms working in consort to produce a percept different from the physical reality.

The book opens with a treatment of how illusions have played an important part in the history of psychology. Few individuals are aware of the fact that Wundt used the existence of visual illusions as one major justification for his proposal that psychology should be a science separate from physiology and physics. Following the historical discussion, two chapters present a relatively complete catalog of visual geometric illusions. At least the prototype of each of the major distortions that can be elicited by lines drawn on paper is illustrated and described in these pages, as well as many of the important variants of the basic configurations.

Beginning with Chapter 4, three chapters provide a discussion of how the optical characteristics of the eye, the neural interactions that occur on the retina, and the analysis of input in the primary visual centers of the cortex play a role in the formation of many visual illusions. Beginning with Chapter 7, we consider a number of cognitive-judgmental or information-processing strategies that can lead to discrepancies between the conscious percept and the measured relationships in the environment. The eight chapters from Chapter 4 to Chapter 11 make it quite clear that illusions arise from many different sources and at many different levels in the perceptual process. In Chapter 12 these many divergent sources are brought together, and, at least at the demonstration level, it is shown how an illusory distortion may be dissected to show the contributions of various causal components. Chapter 13 takes this multicausal approach one step further and demonstrates how it might be used to establish a meaningful classification system for illusions. The last chapter attempts to reintegrate the study of illusions into the main body of psychological and perceptual theorizing and to demonstrate the usefulness of illusions as a tool for the investigation of visual processes.

Since this book occupied our attention for more than three years, many individuals have been involved with it at various stages. It would be virtually impossible to credit all those who have assisted in the preparation of the manuscript or who have interacted with us concerning the various ideas contained in it. It is certainly the case that three institutions played an invaluable role in providing us with assistance: The University of British Columbia, The City College of the City University of New York, and Princeton University. Their respective department heads, Dr. Peter Suedfeld, Drs. Donald Mintz and Louis Costa, and Dr. Sam Glucksberg, provided us with space and support during varying phases of the preparation of this manuscript. Much of the research was supported by grants from the National Research Council of Canada (A9783) and the National Science Foundation of the United States (74-18599). The mechanical aspects of manuscript preparation were handled by a number of people. Roberta M. L. Brustin helped with many of the figures. Lois Citron assisted in the preparation of the index, and James Walker found us a particularly elusive photograph. Thanks also go to the many people who assisted in the preparation of the bibliography, figures, duplicating, and other tasks too numerous and varied to mention but nonetheless vital. This group included Ann Daniels, Keith Humphrey, Jeannie Garbor, Richard Fraenkel, Rosalind Wu, Joe Porac, Lucille Spivak, and Richard Cropp. The typing and organizational tasks were well handled by Joyce Coninx-Wright, Susan Dixon, Sheryl Riley, Maureen Skuce, Melanie Wallace, Marilyn Santomauro, and Eileen Donohue. Two colleagues in particular, Clare Porac and Laurence M. Ward, read,

commented on, and disagreed with early drafts of the manuscript, thus providing much-needed stimulation and support. To all these individuals, as well as to all the members of our research teams working in our laboratories, we offer our appreciation. We further wish to thank all our colleagues in the field who have provided us with the data and theoretical viewpoints that form the foundation of this book.

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JOAN STERN GIRGUS

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1

A Brief History of Visual Illusions

In 1854 a rather unusual paper was published by J. J. Oppel. This paper was unusual because it devoted 10 pages of serious psychological analysis to an array of lines. These lines did not form a complex picture or graph but rather a simple figure shown in Figure 1.1. At first glance this figure appears to be nothing more than two horizontal extents. The upper extent is divided into a number of segments and appears to be slightly longer than the lower. Actually, it is this apparent difference in length that motivated Oppel's analysis since, as a ruler will quickly demonstrate, the two extents are physically equal. Oppel noted that there had been occasional mention of other instances where the relationships represented in consciousness are systematically different from what might be expected on the basis of direct physical measurement. For those instances that could be represented by lines drawn on paper, he coined the phrase *geometrisch-optische Täuschung* which we generally translate as *geometrical optical illusion*.

Oppel's paper was not to be an isolated treatment of such illusory phenomena. Soon the literature contained contributions by many of the most important researchers in physics, physiology, philosophy, and psychology, each attempting to explain the existence of such systematically fallacious percepts. The list included such notables as Baldwin, Brentano, Ebbinghaus, Helmholtz, Jastrow, Judd, Lipps, Muensterberg, Titchener, and Wundt. In addition to analysis, these luminaries presented many new configurations in which simple lines drawn on paper led to percepts at variance with reality. The interest aroused was quite intense. The 50 years after Oppel's treatise first appeared saw the publication of over 200 papers dealing with illusions, and the next 50 years saw this number rise to over 1,000. One might very well wonder why there has been so much fuss over the misperception of the size or shape of a few lines in a drawing.

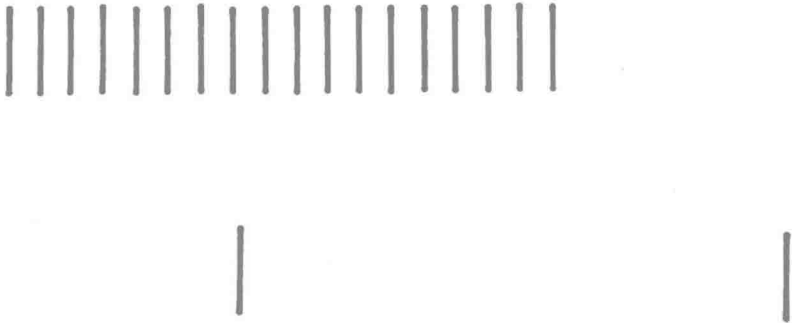


FIG. 1.1. An illusory distortion in which the divided space appears longer than the undivided space (after Oppel, 1855).

Perhaps this question is best answered by noting that the only contact we have with the world around us comes through our senses. We put total reliance on the correspondence between our conscious experience of the environment and its physical reality in order to perform such simple tasks as estimating how far we have to jump to get over a puddle without getting wet as well as for such complex life-and-death matters as estimating the distances between ourselves and other vehicles as we drive a car on a highway at mile-a-minute speeds. We have continual verification of the accuracy of our senses. When we reach for objects in view, they are always at the place where they appear to be. We use vision to keep ourselves from bumping into walls, falling over cliffs, or being run down by oncoming cars. Our experience has taught us that our sensory impressions are dependable and trustworthy. This confidence in the veracity of perception has become part of our cultural heritage and is expressed in such common phrases as "Seeing is believing" and "I didn't believe it until I saw it with my own two eyes." Thomas Reid clearly stated this position of faith in the senses in 1785 when he wrote:

By all the laws of all nations, in the most solemn judicial trials, wherein men's fortunes and lives are at stake, the sentence passes according to the testimony of eye or ear, witnesses of good credit. An upright judge will give a fair hearing to every objection that can be made to the integrity of a witness, and allow it to be possible that he may be corrupted; but no judge will ever suppose that witnesses may be imposed upon by trusting to their eyes and ears. And if a skeptical counsel should plead against the testimony of the witnesses, that they had no other evidence for what they declared than the testimony of their eyes and ears, and that we ought not to put so much faith in our senses as to deprive men of life or fortune upon their testimony, surely no upright judge would admit a plea of this kind. I believe no counsel, however skeptical, ever dared to offer such an argument; and, if it were offered, it would be rejected with disdain (Essay 2, Chapter 5).

It is because we have such faith in the ability of our senses to reproduce the external world accurately in consciousness that drawings such as Figure 1.1 are disturbing and excite our interest. The very root of the word used to describe such phenomena manifests this disturbance. The Latin root of the word *illusion* is *illudere*, which means "to mock." Thus these phenomena mock our trust in our senses.

Although it was simply the existence of a discrepancy between percept and reality that began the serious investigation of these phenomena, (as early researchers puzzled over the fact that a few lines drawn on paper could deceive the beautifully complex sensory and perceptual system that allows us to coordinate in the world), it was the theoretical implications that sustained the research. Such phenomena clearly demonstrate that the eye is not a simple camera passively recording stimuli. They provide evidence that perception is an active process that takes place in the brain and is not directly predictable from simple knowledge of the physical relationships. In this context it is not at all surprising that visual illusions comprised an important class of behaviors studied in the last quarter of the nineteenth century by the new science of mental phenomena named *psychology*.

THE BEGINNINGS

One can only speculate about which of the common everyday discrepancies among sense, impression, and reality was the first to be noticed. Perhaps it was an afterimage caused by glancing at the sun, which would appear phenomenally as a dark orb hovering in the field of view, always just out of reach. Perhaps it was a stick, half in and half out of a pool of water, which looked bent but felt straight. Surely phenomena of this kind must have presented a dilemma for primitive people whose knowledge about the world was almost completely limited to information gained through direct perception of the environment, without the benefit of any measuring instruments. We do know that by the time we reach the height of the Greek period, perceptual errors and illusions were being ascribed to some inner processing error. Thus Parmenides (ca. 500 B.C.) (Diogenes Laertius, 1925) explains the existence of perceptual illusions by saying, "The eyes and ears are bad witnesses when they are at the service of minds that do not understand their language."

The Greek writers and philosophers wrote about the problems of perception at great length. In general, they seemed to espouse one of two viewpoints:

1. Sensory inputs are variable and inaccurate, and one of the major functions of the mind is to correct these inaccuracies to provide an accurate representation of the external environment.

2. The senses are inherently accurate and thus responsible for our veridical picture of the environment, and it is the mind or judgmental capacities that are limited.

From the first point of view, perceptual errors arise when the senses are relied on more than the mind, whereas from the second point of view, perceptual errors arise when the mind interferes with the work of the senses. These two opposing viewpoints were both quite popular in ancient Greece and were to dominate thought about perception and cognition for more than 2,000 years. For example, Plato (ca. 300 B.C.) argued that we should talk of perceiving objects *through* the senses but *with* the mind, since the senses give only an imperfect copy of the world. Properties of objects, such as their identity, are taken to be the result of the action of the mind or intellect working on the sensory impression. Thus an error of perception could arise only through some mental miscalculation, perhaps due to inattention. The most succinct statement of this position comes from Epicharmus (ca. 450 B.C.) (Spearman, 1937) who says, "The mind sees and the mind hears. The rest is blind and deaf." An investigator with this orientation would study higher level information-processing strategies rather than the sense organs themselves in order to understand perceptual errors and illusions. The alternative doctrine, based on a total trust in the senses, can be exemplified by a statement from Protagoras (ca. 450 B.C.), who said, "Man is nothing but a bundle of sensations (Freeman, 1953)." In this view any errors or inaccuracies in perception must arise from distortions in the basic materials supplied to the receptors (i.e., the bending or tearing of visual rays).

Aristotle (384–322 B.C.) (Beare, 1931) seems to have adopted a compromise position, incorporating elements of both these viewpoints. He begins by arguing that there are some perceptual qualities that are immediately and accurately perceived by the senses: "Each sense has one kind of object which it discerns, and never errs in reporting that what is before it is color or sound (although it may err as to what it is that is colored or where it is, or what it is that is sounding or where it is)." There are, however, other qualities such as movement, number, figural qualities, and magnitude, that are not the exclusive property of any one sense but are common to all. These qualities, according to Aristotle, require intellectual mediation to assure accuracy of representation. As an example of how perception can be led astray, Aristotle describes an environmental version of the Oppel–Kundt illusion (which is the distortion we showed in Figure 1.1), noting that extents filled with many objects tend to appear greater than empty extents.

Greek architects of the classical era were also cognizant of the existence of visual illusions. Figure 1.2A shows a schematic diagram of the east face of the Parthenon. Although it looks quite square, this should not be the case. Consider the angle between the roof and the architrave, which forms the configuration schematically shown as Figure 1.2B. This array is actually a variant of the Jastrow–Lipps illusion, which we will describe more fully later. For the moment it will suffice if the reader notes that the horizontal line in the diagram appears to sag slightly away from the point of the angle. On the basis of this illusory distortion, we might expect that the building would look like Figure 1.2C, in

which we depict an exaggerated composite of what the percept should be. In fact, however, the building's proportions were altered to compensate for this distortion. A schematic version of the pattern of these alterations is shown in Figure 1.2D.

Such corrections were apparently made quite consciously. Vitruvius (ca. 30 B.C.) (Granger, 1931) specifically says, "The stylobate must be so levelled that it increases toward the middle with unequal risers; for if it is set out to a

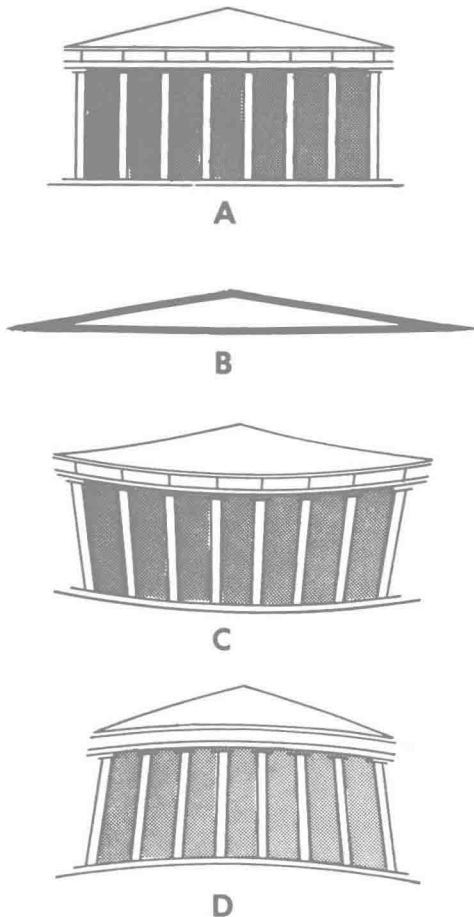


FIG. 1.2. Architectural illusions; (A) A schematic diagram of the east face of the Parthenon; (B) a simplified diagram of the Jastrow-Lipps illusion that is present between the roof and architrave; (C) a schematic representation of how the building should look, given the illusory distortion; (D) an exaggerated version of alterations made in the shape of the building in order to offset the illusion.