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Introduction:

PHILOSOPHY AND SCIENCE OF VISUAL PERCEPTION AND COGNITION

Consider your visual experience. In that experience, mind and world meet. The world is presented to you with its shapes, colors, and textures: a green expanse with moving blobs on it; or a whitish grey ribbon with shaped volumes of color moving at great speed. The mind responds by categorizing the objects and anticipating their behavior: here is a park with people playing volleyball, and someone is about to spike the ball; there is a busy highway as you navigate your vehicle at high speed, concerned that the car on the left is weaving a bit. Form, color, and meaning are all present at once in vision, and the objects of other senses usually are experienced as located within this visual world. The world we inhabit, the one in which we live, move, and breathe, is primarily a visual world.

For this reason, vision is the most thoroughly studied of the human senses. From antiquity, the disciplines of philosophy and psychology have both given special attention to vision. Indeed, the psychology of perception is the centerpiece of psychological science. Perusing a textbook such as psychologist Stephen Palmer's *Vision Science* reveals a broad range of topics, from sensory receptors and the retinal image, to the perception of color, spatial structures, motion, and events, and on to cognitive aspects of perception including object perception, conceptualization, attention, visual memory, imagery, and consciousness. These topic areas are treated experimentally and the phenomena are subject to explicit models framed within recognized theoretical traditions. Although philosophers sometimes have disparaged the notion of *psychological science*, in this case there can be no question of the just application of the honorific "science."

Sensory perception was the first topical area within psychology to which mathematics was applied, in ancient, medieval, and early modern optical

writings (Ch. 12), when the science of optics sought a complete theory of vision (Lindberg 1976). During the seventeenth century, this optical tradition was integrated into the natural philosophical tradition in psychology, which extended back to antiquity (Ch. 14). Self-consciously *experimental* psychology developed only in the latter part of the nineteenth century, primarily through the application of instruments and methods from physics and sensory physiology to the problem of describing and explaining sensory perception. These early studies included both the psychophysics of Fechner (1860/1960) and others (psychophysics correlates physical stimulus values such as intensity with experienced values) and the experimental testing of psychological theories of perception by Wundt, Helmholtz, Hering, and others. Following the consolidation of experimental psychology as a university discipline, the first edition of Robert Woodworth's *Experimental Psychology* (1938) devoted about a third of its pages to psychophysics and to sensory and perceptual psychology.

During the middle third of the twentieth century, when psychology was dominated by behaviorism, the study of perception preserved an interest in phenomenal experience and mentalistic concepts. Perception was a central player in the "cognitive revolution" that unfolded from the 1950s into the 1970s (Neisser 1967; Lindsay and Norman 1972). Other cognitive areas—which had maintained a more tenuous existence—also burgeoned, including attention, memory, problem solving, concepts, and reasoning. The subsequent development of *cognitive science*, with its early emphasis on language and computer models, introduced new explanatory styles to psychology, although these were not adopted wholesale. In physiological psychology, techniques for recording from individual neurons were applied to sensory perception from the 1940s onward. More recently, the explosion of studies using electrophysiological recording and neuroimaging offers a new source of data to experimental psychology in general.

Philosophers have studied perception since antiquity, offering *natural philosophical* explanations of how the senses work, *epistemological* analyses of the role of perception in knowledge, and *metaphysical* theories of the origin and status of sensory qualities. Early modern metaphysics and epistemology from Descartes to Kant examined the relation of sensory perception to intellectual cognition; sensory perception remained important in nineteenth-century philosophy (Hatfield 1990*b*, 1998; Yolton 1984).

Within analytic philosophy, perception was the single most prominent topic in the first half of the twentieth century. With some exceptions (e.g., Broad 1923; Hamlyn 1957), these discussions were divorced from the ongoing work in the psychology of perception and started instead from everyday examples of

(presumed) perceptual knowledge. Various analyses of perceptual experience and its role in knowledge were on offer, but the primary concept that is now remembered from this rich literature is the notion of *sense data*. The concept of sense data itself, and the related notion of momentary particulars, was invoked in several distinct analyses of the metaphysics and epistemology of perception, including neutral monism, naive realism, representative realism, and critical realism (Chs. 10–11, Hatfield forthcoming-*b*). In the middle decades of the century, sense data came under attack and there was a trend toward physicalism and mind–brain identity. In the latter part of the century, the theoretical options again opened up, partly through the development of several distinct analyses of color perception and color qualia. During this period, philosophers re-engaged the psychological literature on perception.

The studies herein draw on the philosophical and psychological study of visual perception in examining three things: visual perception itself; the science of psychology as exhibited in the study of visual perception; and philosophical accounts of perception and perceptual qualities. I am investigating both a subject matter and the scientific and philosophical study of that subject matter. Accordingly, philosophical considerations inform the investigation in three ways. First, I use philosophical concepts and methods, joined with scientific concepts and methods, to address questions about visual perception. Second, I bring philosophical analysis to bear on psychology as a science, in order to contribute to the philosophy of psychology, considered as a branch of the philosophy of science (on which, see Hatfield 1995*a*). Third, I address previous philosophical theories of perception at various points (esp. Chs. 3–4, 6–7, 9–12, and 16).

In this introductory chapter, I survey the basic features of the philosophy of visual perception and cognition that guides or emerges from the remaining chapters. In setting out this framework, I introduce particular conceptions from the philosophy of psychology that underlies or results from those chapters. More particularly, in succeeding sections, I first sketch my overall picture of visual perception and cognition, and I then describe the major phenomena in visual perception, the objects of explanation in perceptual psychology, the conceptions of functional analysis that I use, the notions of content and representation in play (with replies to some objections thereto), the explanatory resources in perceptual and cognitive psychology, the sorts of evidence brought to bear, and the role of philosophy in such investigations. These sections offer a unified presentation of positions and perspectives that must depend for their support primarily on the remaining essays, although in some cases I introduce arguments for points that are not directly sustained in those essays.

1. A Picture of Visual Perception and Cognition

The external senses function to put organisms in touch with their environments, in order to guide action and build knowledge. The visual system of primates, and more particularly of humans, serves to put the organism in contact with a distal environment. It does so by processing information from the optical array as received at the retinas, from bodily musculature, and from other internal sensory systems to yield representations of various visual properties, including colors (chromatic and achromatic) and spatial structure (size, shape, texture, distance, direction, motion), represented as belonging to bounded volumes that (usually) are distributed across a landscape, or, more recently, are in an architectural setting. Color, size, shape, and texture pertain in the first instance to the surfaces of those volumes and the surrounding landscape, whereas distance, direction, and motion pertain to their locations (whether viewer-relative or object- or scene-relative). The visual system also garners information about illumination (including shadows and brightness), which is of interest in its own right and as it informs the perception of the spatial and chromatic properties of objects.

Visual systems generate such representations by responding to the information available in stimulation. I take an ecological attitude toward information: stimulus information is always information for a type of organism in an environment (Ch. 2). The physical world contains conditional regularities that allow the perceptual system to glean information concerning the spatial and chromatic properties of distal objects from the stimulus values that its receptors transduce. Such regularities concern the structures in environments and the way light is reflected from those structures and received at the eyes by a stationary or moving organism. The information registered by the transducers is processed to yield perceptual representations of the surrounding spatial layout and color properties. (See also the Note on information, below.)

Some of these representations of sensible properties become available to consciousness as the phenomenal contents of visual experience, bringing the perceiver into immediate phenomenal contact with surfaces and objects at a distance. These representations directly present a world of colored surfaces and volumes, organized into figure/ground relations, and perhaps spatially grouped according to Gestalt principles (Ch. 7.7). The entire stream of representations (conscious and nonconscious) further allows the perceiver (or the perceptual system) to interpret the scene as containing objects, some of which are recognized as objects of a known kind (a dog, a table) or as known individuals (my dog, my table)—that is, to bring objects under specific concepts. Indeed,

merely to represent an object as an object is, in my view, already to bring it under a concept, viz., the concept of an object (Ch. 7). Such classifications or identifications of objects, together with any affective or emotional responses the objects invoke, may become phenomenologically present as part of the perceiver's conscious experience of the visual world. The perceiver (and/or the perceptual system) can direct attention to specific objects in or regions of the scene. Visual information (conscious and nonconscious) guides the perceiver's actions in interacting with this environment.

Many perceptual psychologists divide these phenomena of visual perception into two domains, which I describe as *sense perception* and *cognitive perception* (Chs. 2–3, 7). These names do not pertain to the character of the processes underlying perception (which are discussed below), but to types of products produced by those processes. *Sense*-perceptual products include the perception of basic features and properties of the scene: color and spatial properties. These properties are represented distally (i.e., as located in a three-dimensional world), in spatially determinate and chromatically specific ways, but without being brought under concepts. *Cognitive* perception depends on concepts, including especially object concepts, pertaining both to individually identified objects and to kinds of object. Although sense perception may guide action by representing the spatial layout, cognitive perception assigns functional significance and identities to objects. Attention can engage sense-perceptual products without presupposing their conceptualization, but it can also be sensitive to conceptualized content (Ch. 13).

I regard visual sense perception as imagistic in character. It presents determinate color qualities and spatial structures arrayed in three dimensions. Like David Marr's 2½-D sketch (1982, ch. 4), it presents surfaces at a distance in a spatially articulated manner. Going beyond Marr's sketch, these surfaces are organized into volumes that show figure/ground segregation and amodal completion. Thus, although sense perception is imagistic, it does not yield a simple copy of the environment; it represents the environment in species and subject-specific ways, which include organized spatial structures and phenomenal colors (Chs. 5–11). These statements describe the spatial and chromatic content of imagistic percepts; they make no commitments regarding the processes that yield such percepts (e.g., whether these processes are symbolic or nonsymbolic, and cognitive-conceptual or noncognitive-nonconceptual). In describing our imagistic experience as presenting three-dimensional spatial structures, I am speaking of the normal case. By adopting a special attitude, we can experience something close to a two-dimensional perspective image (the "visual field" of Gibson 1950). I return to the spatial structure of our imagistic experience in Section 4.

In describing percepts as imagistic, I do not posit "images in the head" that might be seen by a neurosurgeon who has sectioned the occipital cortex. As far as I can tell, the contents of phenomenal experience have an intentional status, in Brentano's (1874/1995, 88) original sense: such contents are not physical images or pictures (even if some visual brain processes are organized retinotopically); they are phenomenal contents (further discussed in Secs. 4–8) that exist "in the mind," without literally imparting to the relevant mental state the spatial and color properties that they make present, phenomenally (Chs. 5.4, 11.6). I reject substance dualism and maintain that these intentional states are correlated with (perhaps emergent from) neurophysiological processes. The spatial characteristics possessed by these neural processes might be relevant in explaining the spatial structure of visual experience, but they are not necessarily so; whether and how they are relevant depends on one's psychoneural linking hypotheses (Ch. 4.2.3).

Further, I do not suppose that we experience the world as a sequence of static snapshots. That description goes wrong in three ways. First, as many philosophers now attest, our everyday experience is phenomenally "of the world," and not "of something experienced as an image of the world." I agree with this phenomenological report, but I do not conclude from it that we don't have imagistic experience that mediates our perception of the visual world (and I deny that the report by itself can sustain this conclusion; see Chs. 6.6, 11.2, and 16). Second, the snapshot view supposes that our experience typically is constructed from static elements. Our experience comes closest to this when we observe a still scene without moving (in such cases the eyes and body always move slightly, but the perceived scene remains stable). Often when we see, we are moving about and our perceptual systems use the flow of optical stimulation in perceiving the stable structures in the visual world; also, we typically perceive moving objects within a larger, stable environment. Third, in many cases we are actively looking and are seeking visual information; we are not merely passive receivers (though of course we do receive information that we aren't looking for). Finally, my description of visual sense perception as imagistic initially applies to conscious experience. I also allow for pre- or nonconscious imagistic representations, but the postulation of these representations belongs with the discussion of perceptual processes (below).

The conscious experience of an adult perceiver does not present bare unconceptualized images. Overall, phenomenologically, we experience a world populated by individual objects arrayed within a scene; many of these objects are experienced as being of a certain kind (a cup, a pencil, a tree, a person). Cognitive perception pervades sense perception. The type-identities and (some) individual identities are directly present to us phenomenologically: we

aren't aware, in the typical case, of "working out" what we are seeing (even if nonconscious processes in fact work to identify what's there). Further, although objects may attract our attention involuntarily, we can also choose to direct our attention here and there, making some objects perceptually and cognitively more salient than others. We may focus on some objects that we intend to approach or to act on in some manner (e.g., by grasping them).

Suppose for the moment that this distinction between types of visual perceptual products (sense perception vs. cognitive perception) can be maintained. A further question is to investigate the processes by which they are produced. Theorists have proposed various types of processes, including symbolic computational processes that already involve some (at least proto-) conceptualization; inferential processes that take a primitive description of sensory stimulation as input and yield conceptualized images as output; various types of nonsymbolic processes of information-combination (or computation); in Gestalt psychology, holistically conceived configural brain processes (Chs. 4.2.3, 5.3); with James J. Gibson, neurophysiological mechanisms that simply "resonate" (to use his metaphor) to optical information specifying distal structures (1966, chs. 12–13; 1979, 239–50).

My own view is that noncognitive (nonconceptual) processes underlie sense perception, and that cognitive (conceptual) processes are required for cognitive perception. I thus reject unconscious inference as the basic cause of sense perception, but I maintain that the processes of sense perception permit a psychologically interesting decomposition into subprocesses of information-flow and information combination or computation. To this extent, I view perceptual processes as *constructive*: they produce perceptual representations by processing information. Under normal conditions of viewing, a great deal of information is available in stimulation to guide these noncognitive processes of construction.

Perhaps because I have not cognitivized the fundamental processes underlying sense perception (by viewing them as inferences, judgments, or descriptions), I find no need to posit an underlying symbol system to carry out the processes of information combination. Subsymbolic or connectionist mechanisms suffice. (I return in Sec. 6 to the character of these processes.) Although the processes of sense perception occur in relative independence of cognitive perceptual representations, they are not totally independent. Some top-down effects occur. (These are especially manifest in the perception of ambiguous figures or in cases of impoverished stimulation, but also in other cases, as in priming effects.) In accounting for the cognitive perception of objects, I eschew both causal and descriptive theories of reference. In their stead, I posit the sense-perceptual tracking of bounded, three-dimensional volumes that are

subsequently subsumed under object concepts; in cases of visual reference, such objects are the targets of cognitive acts of referring intent (Ch. 7).

Although I treat conscious phenomenal content as an object of explanation in itself and also as a factor in visually mediated behavior, I do not hold that all of the visual representations that affect behavior need be conscious or even available to consciousness. Many models of perceptual processing rightly posit nonconscious representations to account for the combination of discrete sources of stimulus information to yield conscious perception, or in order to explain behaviorally manifest discriminations that occur in the absence of reportable consciousness (as in blind sight). In my view, the study of visual perception is not only about conscious vision, it is about visual processes and capacities taken generally as they mediate action and support the acquisition of conscious or nonconscious, momentary or lasting representations of the distal environment, including beliefs and perceptual or cognitive maps.

This picture of visual perception has arisen from reflection on extant psychological and philosophical theories of perception, and it is guided by the notion that human visual capacities have evolved through natural selection and are subject to biofunctional analysis. Indeed, my take on the most basic forms of information-flow and representational content is that their ascription is mediated by a decomposition of the processes of the visual system into components that are to be "functionally described" in two senses: as components in a complex system with a division of processing labor (so, as elements in Cummins-style functional decompositions, as described in Cummins 1975); and as states in a system that is ascribed an overall function in the biological sense (Wright 1973), and whose subcomponents are to be seen as contributing to that function. Thus, if a primary function of primate (including human) visual sense perception is the representation of surfaces in space with distinctive features such as color, then the subprocesses of vision can be assigned subfunctions—and indeed can be ascribed content-bearing informational states—that serve that larger function. I thus attribute informational content to sense-perceptual processes by working downward from a functional decomposition of those processes, in relation to a biofunctional description of perceptual systems. Accordingly, representations are not individuated by their causal roles alone, but always in relation to their contribution to the (bio)function of a system.

Finally, in describing perceptual experience, I distinguish between phenomenally determinate features of visual experience and other features of that experience that are part of an overall phenomenological description. As explained in Chapter 6, in perceptual psychology a phenomenological description is one that seeks to describe experience without, as far as is possible,

introducing the perspective of any particular theoretical account of perception. Anything we find present in our experience can be subject to phenomenological description. Some aspects of our experience, and especially imagistic spatial structures and specific shades of color, are more or less phenomenally determinate (or at least appear to be so). I restrict the adjective *phenomenal*, and related forms, to such phenomenally determinate features. Other aspects of experience, such as the immediate experience of something as being a dog, or as being a drawing produced by a friend of ours, have *phenomenological* presence as part of our overall experience but do not possess the determinate *phenomenality* of spatial structures and experienced color qualities. Thus, *phenomenology* is an umbrella term for a descriptive attitude toward experience and the resulting descriptions. As it relates to vision, it includes the description of phenomenally definite as well as other, conceptual aspects of experience. By contrast, the term *phenomenal* applies to determinate spatial and chromatic structures (and other determinate features of visual experience, if such there be).

So much by way of sketching my picture of perception. Figure 1.1 provides a summary overview. The subsequent sections take up aspects of this sketch, broach additional questions in the philosophy of visual perception, and address some points that are not directly taken up in subsequent chapters.

2. The Objects of Explanation in Visual Perception and Cognition

Although the study of visual perception is among the oldest fields of scientific psychology, there is no agreed-upon answer to the question of what exactly constitutes visual perception, or of what the object of explanation should be in vision science. But the available answers cluster. In considering various answers, I will focus on what Marr (1982) termed *early vision* and what I have termed sense perception, since that area receives the most extended treatment by perceptual psychologists and vision scientists.

Many investigators accept Koffka's (1935, 75) question, "Why do things look as they do?" as the central question for the psychology of visual perception. Koffka's question focuses theoretical attention on visual experience or the appearances of things. In this tradition, Irvin Rock (1975, 3) places "visual appearances" at the center of perceptual theory. Whether such appearances are "veridical" (i.e., "truthfully" reflect "the objective state of affairs") is secondary; he assigns equal evidential weight to veridical and illusory perceptions (ibid.). Nonetheless, he pursues the mechanisms underlying *perceptual constancy* as

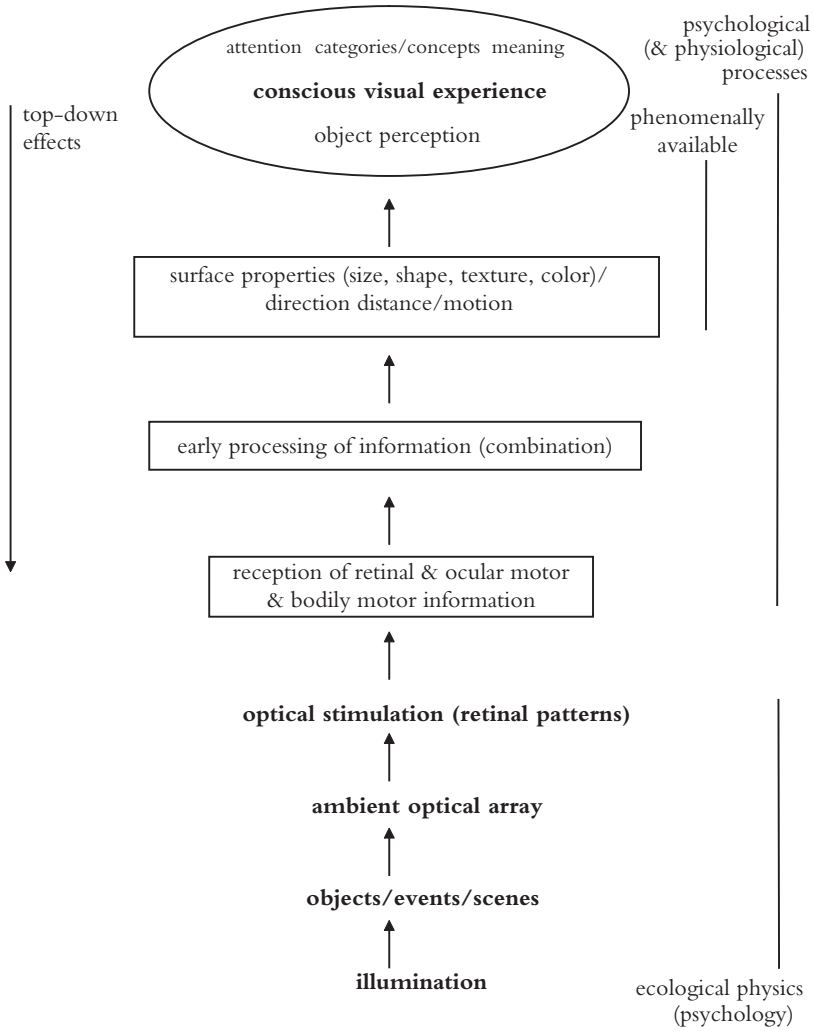

Figure 1.1. Perception: from objects to phenomenology. A chart of major causal factors, processing stages, and informational factors in the conscious perception of surfaces and objects. The diagram represents the phenomenological observation that object classification, attention, and meaning are part of our overall visual experience. See Fig. 1.2 for major response categories interacting with conscious perception.

he conceives it: the tendency of perceptual representations to remain stable (and perhaps to represent the actual sizes, shapes, and colors of objects) despite variations in the retinal image (the *proximal stimulus*). Richard Gregory (1997, ch. 1) shares Rock's focus on perceptual appearances. Each author

also favors a neo-Helmholtzian explanation of perception as a process of unconscious inference and hypothesis formation. Rock (1975, 1983) is the most prominent recent theorist to contend that such inferences start from a representation of the two-dimensional retinal image (Pt. III, Intro.).

Other theorists include visual experience as part of what is to be explained, but emphasize the functional role of vision in supporting action and the acquisition of knowledge. Marr (1982) and Palmer (1999) share this general position. According to Marr (1982, 3–6), vision is the "process" of forming "representations" (both conscious and unconscious) of *what* is in the world and *where* those things are. Palmer (1999, 5) offers a formal definition of visual perception as "the process of acquiring knowledge about environmental objects and events by extracting information from the light they emit or reflect." As Palmer makes clear, the knowledge acquired may often serve in the guidance of action and behavior; it may or may not become available to consciousness as visual experience (see also Milner and Goodale 2006, and Ch. 15.2.3). Marr and Palmer both favor an information-processing approach to perceptual processes, and they each characterize these processes as inferential (Marr 1982, 44; Palmer 1999, 80).

Another group of theorists discounts the importance of visual experience as an object of explanation and focuses on perceptual mechanisms for guiding behavior and acquiring knowledge. Brian Wandell (1995, 387) regards vision, or seeing, as "a collection of inferences about the world." These inferences concern pattern, color, motion, and depth, and they are ultimately integrated into descriptions of objects and surfaces. He does not directly discount the importance of visual experience, but he largely leaves it out of his analysis of the processes of vision. His analysis concerns receptor encoding, retinal and cortical representation, and inferential processes that interpret such representations to yield the perception of color, motion, and depth. Lloyd Kaufmann (1974) sees visual perception as a constructive process, and considers the ultimate explanatory vocabulary to be physiological rather than cognitive. According to him, reports of visual experience are simply descriptive constructs of an organism who is put in a "reporting" situation (1974, 16). John Heil (1983) maintains that visual experience is inessential to visual perception, which he regards as essentially a matter of forming beliefs based on information gleaned from light. Zenon Pylyshyn (2003, 3, 133; 2007, ch. 4) discounts the importance of visual appearances as an object of explanation because he believes that the imagistic character of perception is a kind of illusion, constructed out of perceptual information that guides action and yields knowledge.

All of the authors thus far mentioned in this section distinguish the processes of sense perception from ordinary reasoning and conscious inference. In

Rock's (1983, 20) terminology, sense-perceptual processes are "insulated" from conscious conceptual knowledge. The inability of general knowledge to influence perception has long been recognized (Rock 1975, 511, 560; Ch. 4.2.1). Pylyshyn (1980) proposed that insulated perceptual systems are "cognitively impenetrable." He reasoned that if perceptual processes are cognitively penetrable (i.e., can be influenced by beliefs and goals), then the processes of perception are themselves inherently cognitive (symbolic, inferential, and conceptual). Originally, he extended such penetration quite deeply (1980, 131). Fodor (1983) countered that perceptual systems are informationally encapsulated modules within which symbol-mediated inferences occur in isolation from central cognitive systems. Theorists characterize the insulated processes differently: Rock, Marr, Gregory, and Wandell describe them as cognitive (inferential), whereas Kaufman does not. Pylyshyn (2003, ch. 2; 2007, ch. 1) now argues that early vision is largely impenetrable and so noncognitive.

Gibson (1950) took visual experience to be an important object of explanation in perceptual theory, within a theoretical context that viewed perception as guiding action and supporting the acquisition of knowledge. He rejected the traditional characterization of optical stimulation as impoverished and observed that for a moving observer there is rich information in the optical array concerning the spatial structure of the distal environment. Subsequently, he focused on the senses as mechanisms for detecting this rich stimulus information (1966, 1–2) so that an organism "can take account of its environment and cope with objective facts" (1966, 6). In his final book, he came back to questions about visual experience and approvingly paraphrased Koffka's question (Gibson 1979, 1). Throughout his writings, he is concerned with the role of visual perception in allowing organisms to navigate their environments. This involves not only detecting what is where, but also detecting change (what's happening?) and the perceiver's own motion (where am I going?). Gibson (1966, 1979) emphasizes the study of vision in ecologically valid (or normal) environments; he treats illusions as special cases that are not especially revealing of the normal processes of perception, but must be explained by deficiencies in stimulation or in physiological mechanisms (1966, ch. 14).

Gibson's emphasis on the role of perception in guiding action has been incorporated into the mainstream of perceptual theorizing (e.g., Palmer 1999). The importance of perception for guiding action has also been a theme in comparative physiological psychology of vision, in the study of the visual capacities of fish, amphibians, reptiles, and various mammals, including primates (Ingle 1967; Schneider 1967; Trevarthen 1968). This comparative work led to the postulation of "two visual systems," meaning physiologically and functionally distinct pathways of visual processing in the brain (Ungerleider

and Mishkin 1982; Milner and Goodale 2006). I consider this hypothesis in Chapter 15.2.3.

Gibson (1966, 2; 1979, 251) viewed the processes underlying both the sensory and cognitive aspects of perception as noncognitive (see Ch. 2). For describing the mechanisms that "pick up" the information in stimulation, he adopted a physiological vocabulary and used the physical analogy of mechanisms that "resonate" to such information. Kaufman (1974) agrees with Gibson that *sense* perception is noncognitive; but he disagrees with Gibson's (1950, vii; 1966, ch. 13) hints that the underlying processes are unsuited to psychological study and belong instead to physiology. (Kaufman sees physiological reduction as a long-term goal, not as a prescription to avoid psychological descriptions now.) Other authors who are sympathetic to Gibson's position about the richness of optical stimulation nonetheless favor cognitively characterized processing mechanisms to pick up the information (Neisser 1976, ch. 2; Haber and Hershenson 1980, chs. 9–10).

I hold that the objects of explanation in visual perception are the visual capacities that serve to guide behavior and for the acquisition of information and knowledge about the environment. It is well established that not all of these visual capacities rely on or result in conscious visual experience. Nonetheless, consciously available visual experience is a central object of explanation in visual perception and a central explanatory factor for visually guided behavior (see also Wallhagen 2007). Koffka's question remains important for vision science, although it does not exhaustively specify its subject matter.

Explanations of the visual capacities are multifaceted. They involve explanations of visually guided behavior and of the acquisition by vision of knowledge and information. They also involve the decomposition of the visual capacities, including those that yield visual experience, into subcapacities that explain those visual capacities. The further explanation of such subcapacities may take any of several forms: physiological (as in receptor characteristics), evolutionary, cognitive-architectural (invoking connectionist or symbolist explanatory primitives), or psychological (invoking psychological explanatory primitives, such as primitive capacities for information combination). Individual investigators may choose to stop with any one type of explanation even if other types are in principle available. Some theorists hold that physiological explanations are more basic than psychological explanations, but I challenge that intuition (Ch. 15).

Although sense-perceptual capacities provide the initial focus for the psychology of vision, conceptual capacities also enter in. Gibson (1979, ch. 8) explained such capacities through his noncognitive theory of "affordances," which holds that the visual system directly detects functional properties of

objects, such as "affording cutting" in the case of a knife. Most other theorists disagree, maintaining that conceptual representations must come into play when we visually recognize and identify objects. The relevant conceptual capacities are recognitional: they move from perceptual characteristics to the recognition of objects, object-kinds, and known individuals. I discuss such cognitive abilities in Chapters 2–4 and 7.

3. Functional Analysis

Functionalism entered into modern psychology in two distinct periods. At the turn of the twentieth century, the American functionalist school of psychology followed Darwin (1859, ch. 7; 1872) in viewing the mind, or the various psychological capacities, as adaptations that mediate the adjustment of an organism to its environment (O'Neil 1982, ch. 6). William James (1890) made this form of analysis prominent. The biological outlook was taken up into American behaviorism (Hatfield 2003*a*). Although evolutionary thinking fell under suspicion in mid twentieth-century psychology, Gibson (1966, 1979) was noteworthy for applying such thinking in perceptual psychology, and evolutionary considerations were strongly represented in comparative sensory physiology and psychology (Autrum 1979; Jacobs 1981; Trevarthen 1968).

At about the time that this sort of Darwinian functionalism in psychology was at its nadir, the philosophers Hilary Putnam (1967) and Jerry Fodor (1975) introduced a new notion of functionalism, which defined psychological states by their computational roles in mediating between inputs and outputs (stimulus and response). By focusing on the relation between input and output, this new functionalism resembled behaviorist learning theory (Ch. 3); but it differed from behaviorism in allowing mentalistic intervening variables between stimulus and response (many philosophers thought of these variables as beliefs and desires). With its focus on computational relations among internal psychological states, this new philosophical functionalism was consonant with new modes of analysis in cognitive psychology (Neisser 1967; Lindsay and Norman 1972), which decomposed perceptual and cognitive capacities into subcapacities, often represented by boxes linked together with arrows to indicate the direction of causal influence and information-flow. An analogy with computer programs was not far from the surface, and Fodor (1975) maintained that it was no analogy: he held that the routines and subroutines described in his functional analyses are literally carried out in an internal symbol

system, the most basic version of which has the same fundamental status as the machine language in a standard digital computer. Psychologists themselves had mixed reactions to this particular Fodorean commitment (Ch. 14.4).

This new brand of functionalism was soon ensconced in Robert Cummins' (1975) notion of "functional analysis," which he applied to both biological and psychological systems. In a Cummins-style analysis, the ability of some entity to exhibit a capacity of theoretical interest is to be explained through a division of labor: the overarching capacity is analyzed into subcapacities that are so organized as to bring about the to-be-explained results. John Haugeland (1978) labeled the resulting explanatory style a "systematic explanation," and he observed that such explanations are typical in cognitive psychology. In this brand of functionalism as applied to psychology, representations are identified by their causal and computational roles in a system. These roles were typically described in syntactic (non-intentional) terms (e.g., Fodor 1975; 1980), although Haugeland (1978) allowed for systematic explanations involving intentionally characterized interactions that might or might not be subject to non-intentional reduction via physical instantiation.

Cummins-style analysis captured the flavor of many explanations in perceptual and cognitive psychology, which tended to chart information-flow, information-combination, and in general to decompose larger tasks into smaller ones. But it had a problem: how do we decide what the larger tasks are? Pragmatically and locally, this problem might not seem pressing: the psychologists provide the functionally characterized tasks to be analyzed, such as depth perception, color perception, object recognition, problem solving, and so on. But theoretically and philosophically, there was a problem (Hatfield 1993): how are we to understand our function-ascriptions to organic systems? Do such ascriptions simply represent our theoretical interests, or are these functions psychologically and biologically real? If some functions are real, how do we tell which ones?

Near the time that Putnam–Fodor functionalism was being incorporated into what came to be called cognitive science, philosophers of science were working on the notion of biological function (Hempel 1963; Nagel 1979; Wright 1973). This work brought the Darwinian connection between function and natural selection back onto the philosophical scene. Wright (1973) offered an intriguing answer to the question of which functions are true biological (and psychological) functions: they are the functions performed by structures and mechanisms that have been culled by natural selection because they do X. In this context, the thing that does X is in the system *in order to do X*; this description is teleological, but the teleology is cashed out by natural selection. Doing X is the function of a given structure because its doing X is responsible

for its fixation in a population of organisms (or type of organism); or, in a needed adjustment to the theory, because doing X currently contributes to the fitness of the organism (Walsh 1996; Schwartz 2002).

The function of the heart is to pump blood because that is the characteristic of the heart structure that is responsible for its presence in populations or types of organisms, through the agency of natural selection. The function of the visual system is to bring animals into perceptual contact with distal objects; the function of trichromatic color vision is to make objects more discriminable by their color (let us suppose). Dysfunction (error) occurs when a system fails to perform what is properly its function. (Systems that are functioning normally can also yield nonveridical percepts: Matthen 1988.) As in Marr's (1982, ch. 1.2) "computational level"—which is actually a functional analysis in the biofunctional (teleological) sense (Ch. 3.4)—describing the tasks performed by the visual system and its subsystems is the first step in investigating those systems. The importance of an explicit *task analysis* is now widely recognized in perceptual psychology.

These two forms of functional analysis fit together nicely. The Wrightian analysis could provide an answer—or could assure the theoretician that an answer was possible—to questions about what psychological functions there are. The Cummins-style analysis indicated how the relevant capacity might be explained (through a division of labor). But there was a problem for the Wrightian (or "aetiological," meaning explanation through causal origin) type of analysis: the evolutionary process by which many biological and psychological functions have come into existence is unknown. Moreover, psychologists surely are not in the position of having to speculate about or to determine the past course of evolution in order to specify the psychological tasks that they wish to investigate and explain (Proffitt 1993). Surely they can rely on theoretical tradition, or current intuition, in deciding what the tasks or functions of the visual system and its components are.

In fact, psychological theorists often are guided by prior theory or current intuition in performing a task analysis (functional description) of the visual system and its components (Hatfield 1993; Ch. 3). But an evolutionarily guided ecological perspective is nonetheless desirable for that (Shapiro 1998). As Gibson (1966, 1979) has shown, asking questions about the conditions under which a system evolved can be heuristic in considering how the system performs its functions; for example, considering stable properties of the environment–eye relation can yield fresh insights into the sorts of stimulus variables (including texture gradients and motion flow) to which visual systems are sensitive. Ecological and evolutionary considerations are frequently invoked in the study of color vision, and genetic techniques provide new information

for constraining evolutionary scenarios (Chs. 8, 9, 11, 15). And in any case, theorists can appeal to the contribution that a perceptual mechanism currently makes to fitness when describing the mechanism's biofunction (Walsh 1996). Accordingly, in invoking biofunction, theorists needn't be privy to the history of selection; they need only have a reasonable conception of how a mechanism currently contributes to the functioning of the visual system.

As set out in Chapters 2–3, 5–6, 8–11, I place heavy weight on the notion of task analysis and function-ascription in formulating descriptions of what perceptual systems do (what their functions are), and I then follow the widespread strategy of seeking to explain such capacities by positing subcapacities. There is nothing vacuous in this, if the subcapacities perform progressively less ambitious functions, until they can be discharged as functional primitives or through appeal to another mode of explanation (say, biochemical, as in the case of the visual receptors). It is through task analysis and functional decomposition that I support ascriptions of representational content to the subsystems of the visual system.

4. Content and Representations

Although the notion of *representation* did not wholly disappear from psychology during the behaviorist era (Ch. 14.3), that notion subsequently became ever more widespread in perceptual and cognitive psychology (Neisser 1967, 20, 287; Lindsay and Norman 1972, 1, 19; Haber and Hershenson 1973, 35, 159; Rock 1975, 5, 24; 1983; Palmer 1999, ch. 2.3.4). Some theorists have supposed that representations must be symbolic in nature (Fodor 1975), while others have not shared that assumption (Dretske 1981). The related notion of *content* is something of a philosopher's term of art. Recent usage of the latter term has often assumed that content is propositional in nature (e.g., Dretske 1981, 65; Heil 1983, 45; Rey 1997, 4, 19). I do not follow such usage and instead invoke the notion of nonconceptual *phenomenal content* in discussing visual representational content (see also Crane 1992*b*; Peacocke 1992).

As the following essays make clear, I think it is a mistake to equate representations with symbols. There surely are symbolic representations (in natural language, if nowhere else), but I doubt that all of the internal representations that are reasonably posited in perceptual and cognitive psychology are symbolic (Chs. 2–3). Further, in my version of functional analysis, representations are not defined by their causal or computational role in mediating between inputs and outputs (as in Putnam–Fodor functionalism); rather, they are assigned

their content by considering what they have the function of representing. Such representations may play causal and computational roles, and those facts may be relevant to their function; but such roles alone do not yield a representation. Finally, the fact that a representational state is caused by a certain physical stimulus also does not fix its content (as in causal theories of content).

Some accounts of perceptual content first distinguish between a *representational vehicle*—a neural state, or a subject-dependent qualitative state—and its attendant representational content and then argue that the properties of the vehicle are irrelevant to the content (e.g., Dretske 1995*b*, 35–7; Tye 1991, 118). Not accidentally, such accounts deny qualia and hold that perceptual representations do nothing more than provide information about the physical properties of distal objects; on this view, there is no phenomenal content to be aware of except the distal property.

I adopt a different stance, at least for conscious contents. With nonconscious perceptual processes of information-flow, representational content can be characterized independently of vehicle, by functional contribution. In contrast, visual content that is carried in qualitative imagistic form cannot be characterized independently of the vehicle insofar as the vehicle has Brentanian intentional status (as phenomenal content); but it can be characterized independently of its neurophysiological realization. (This doesn't make the neural vehicle irrelevant; it simply says that the connection between phenomenal vehicle and neural vehicle is not a necessary one, so far as we know.) For imagistic percepts, the spatial structure of the vehicle itself (i.e., the spatial structure found in the phenomenal content of spatial perception) matters: the vehicle provides the spatial content. Similarly for consciously experienced colors: the subject's color qualia are vehicles that purvey content (normally, they purvey the colors of things). I conceive imagistic percepts as nonconceptual presenters of the spatial structures and chromatic qualities of the world—a position that rejects naive realism but is, I argue, consistent with critical direct realism (Secs. 7–8). (On introspective awareness of phenomenal content, see Chs. 5.4, 16.)

For sense perception, my ascriptions of content depend on a functional analysis of the various sense-perceptual tasks. For example, consider the (nonconscious) information provided by the outputs of the three cone types in color vision. We perceive one or another color when the visual system compares the activation of the three types of cones. The output from each cone represents, or carries informational content about, the activity of that cone (at the least). Whether such outputs also carry information about the presence of light that falls with a range of wavelengths (the range of sensitivity of that cone type)—or, better, information described by a mathematical function relating

wavelength and intensity within that range—is another matter. I'm skeptical about ascribing such physically described content to the outputs of the various cones (Chs. 4, 8). In my view, such outputs may be attributed informational content because they enter into processes that have the function of producing a representation of the distal surface (Pt. II). Those processes may use cone activation to represent the presence or absence of light. Spatial mechanisms use such bottom-up information to produce representations of the spatial structure of distal surfaces, and the color system phenomenally clothes the represented surface in a specific hue. This hue represents the surface in a distinctive manner, as an illuminated surface with a color quality.

In the case of spatial perception, outputs from various small regions of the retina might represent (retinocentric) visual direction. Binocular neurons may detect disparity between like features (light–dark borders, or other features) in nearly corresponding positions on the two retinas. However, as with the cone types, I resist assigning representational or informational content to retinal mechanisms simply on the basis of a physical description of the stimuli to which they respond. Binocular neurons do not count as "disparity detectors" simply because they physically respond to disparities. Such neurons conceivably could serve other functions, such as tuning the alignment between the two eyes so as to preserve single vision (Crawford *et al.* 1993). If some disparity-responsive neurons were specialized for this function, then variation in the disparities to which they respond might simply be noise, or might serve to capture information at various grains of precision, so as to allow fine-tuning of the alignment. In all such cases, the specific content to be assigned depends on an analysis of the system that the detector mechanism serves.

Reflecting on visual perception and theories thereof leads me to maintain that, as regards sense perception (early vision), the primary representational content is spatial and chromatic. As explained in Chapter 5, I hold that the perceptual system creates a visual space. This space is not congruent with physical space but is contracted with respect to it, in such a way that visual direction is preserved (i.e., visual direction typically is congruent with physical direction) while spatial structures are represented at less than their true physical distance (in accordance with a 3-D to 3-D projective relation). Visual space contains phenomenal structures. These structures represent the physical spatial structures of objects and scenes by means of a resemblance relation. In many contexts, phenomenally present visual line segments represent physically present line segments. Sometimes, a phenomenally present trapezoid represents a physically present rectangle (Chs. 5–6), and in this case the resemblance is attenuated. If the representing structure is normally contracted for the circumstances, I count the percept as veridical.

I do not hold that these resembling structures represent the corresponding physical structures simply in virtue of resemblance. Their status as representations is set by functional analysis (as explained in Sec. 3). The fact that they resemble is a feature of their representational character; they carry information about spatial structure *by* resembling it, which can explain how visual perception is able to guide locomotion successfully. (Such resemblance is not a *necessary* feature of representation in my view, as the case of phenomenal color shows.) Further, although circular phenomenal structures do not represent a circular surface simply because they are caused by it or resemble it, visual representational types such as circles presumably have been selected during evolution or learning to represent physical circles because they resemble them (and so I favor "wide" content: Ch. 2.4). Both causation and resemblance may affect evolution and learning, but neither by itself establishes a representational or referential relation (Chs. 7, 11). Insofar as the representational characteristics of physiological structures affect their selection, then such structures are selected because of their psychological (representational) properties. Finally, I not only deny that resembling structures represent distal surfaces simply because they are caused by light reflected from those surfaces; I also deny that *sense perceptual* representations possess content that is itself of or about *individual* surfaces and objects at all. Rather, I hold that imagistic percepts represent spatial (and chromatic) properties abstractly but determinately (Ch. 7); that is, as a determinate spatial structure of a certain type, for example, a circle of certain size and viewer-relative location.

Phenomenal color qualities do not resemble the surfaces of objects, nor do they (in my view) represent the underlying physical causes of color experiences. Rather, they function to represent object surfaces (in the basic case) in a qualitatively distinctive manner. Although there are systematic relations between physically described surface-properties (spectral reflectance distributions, or SRDs) and color experience (as also mediated by contextual factors, including illumination), I do not consider the color experience to represent the SRDs—except perhaps to a well-informed theorist, and in that case the representing is mediated by theoretical knowledge. As is apparent, I endorse a version of the distinction between primary and secondary qualities (Chs. 9, 11).

In my descriptions of what visual sense experience represents, I have invoked nonpropositional and nonconceptual content. Phenomenal colors nonconceptually represent surface characteristics. A phenomenal line segment (usually) nonconceptually represents a physical line segment. It is an imagistic content. The spatial structure of the line segment as phenomenally present may guide our action, and it may also allow us to recognize the presence of

a line segment through the appropriate concept. I of course also recognize conceptual and propositional content, as discussed in Chapters 2–4 and 7.

I have suggested (just now and in Sec. 2) that there are recognitional concepts. Fodor (1998) denies them. His arguments assume that a recognitional concept such as *red* not only must serve the cognitive-perceptual function of detecting instances of red, but also must explain all other cognitive abilities involving the concept *red*, including the productivity and compositionality of belief content. This objection loses force if our conceptual capacities are hierarchically layered. A recognitional concept may serve to gather instances of red in the visual world. That recognitional concept might yield the further tokening of an abstract representation of red that is not tied to present instances and that is related to other features of redness (that it is a color, that it pertains to vision). The abstract representation might itself yield the tokening of a mental word (or an English word) that enters into further computations that exhibit productivity and compositionality. As I discuss in Section 6, Fodor's argument is an instance of a widespread strategy of supporting or opposing a single-type account for all perceptual and cognitive operations, rather than allowing diversity of representational format and function.

5. Attacks on Biofunctional and Evolutionary Accounts of Representational Content

There have been some prominent objections to invoking biofunction and evolution to underwrite representational content in psychology. Fodor (2000, ch. 5) contains several, but they are easily disposed of (e.g., Ariew 2003, on Fodor's main point; Sec. 3 above on function and teleology). Lewontin (1998) offers what his editors describe as an "unremitting attack" (1998, 129) on study of the evolution of cognition. Lewontin points to problems in reconstructing the past; in using chimpanzees as a window into the last "common ancestor" between the apes and the lineage resulting in Homo; and to alleged difficulties in determining what counts as "cognition" in nonhuman species. As examples of what he is opposing, he cites two works: a sociobiological book by Charles J. Lumsden and E. O. Wilson (1981) containing identical twin studies in support of innateness, and a paper by cognitive scientists Steven Pinker and Paul Bloom (1990) on the evolution of language. Otherwise, his is entirely a "just can't" argument, which doesn't engage the specialist literature of those who think you can, including work by physiological psychologists (Donald 1991), paleoarchaeologists and paleoanthropologists (Gamble 1991; Mellars 1989;

Mithen 1990), evolutionary biologists/anthropologists (Boyd and Richerson 1985), and anthropological psychologists (resulting in Tomasello 1999), or the synthetic works in which these results are summarized (e.g., Mithen 1996). (On more recent literature, see Hatfield forthcoming-*a*.)

As regards visual perception, Fodor (unpublished, 1990) has posed an interesting objection to using evolutionary considerations in studying perception and cognition: how does an appeal to function or evolution allow us to decide which specific content should be assigned to a given structure or process? This question has famously been asked about the frog's alleged fly detector. The frog visual system and brain is such that when a fly comes in range, the frog shoots out its tongue and ingests it. The frog will also (let us say) snap up bee-bees, or paper dots, that move appropriately. So what is the detector's content: *fly*; the more generic *food*; *small black dot*; or the disjunctive *fly or bee-bee or paper dot or*…?

Several answers have been given. Before considering some of them, let's step back and ask how we should determine an answer. On my account, we first seek to specify the function of the frog's visual mechanism that represents the small black (or dark) dot and to learn how that representation is related to the snapping response. If the frog's visual system were such that it initially formed representations of moving items at different locations independently of a recognition and response system, then we might suppose that the content reduces to shape, color, and motion. It would still be intentional in Fodor's sense (i.e., representational): it would represent a particular shape, darkness, and motion, and be subject to misrepresentation such as misrepresenting the direction to a target, getting the size wrong, and so on. Suppose also that a subsequent ("recognitional") mechanism induces the frog to snap only at things of a specified size and direction that exhibit a characteristic motion pattern. We can now seek the function of this further mechanism that triggers snapping. Is it to detect food? To detect small black dots that move at a certain speed?

Fodor is skeptical that biofunctional and evolutionary considerations can yield any answer concerning the representational content of the frog's detector mechanism. In his view, the whole system can be treated as a causal mechanism that has been selected because it serves *to procure* flies in the usual frog environment, but not because it *represents* flies (or anything else). As Fodor (1990, 72–3) puts it (with characteristic pith): "Darwin doesn't care how you describe the intentional object of frog snaps. All that matters is how many flies the frog manages to ingest in consequence of its snapping."

There have been several responses to this sort of point. Dretske attempts to explain how the content gets into perceptual states such as the frog's by

combining his notion of semantic information (Dretske 1981, ch. 3) with the idea of a biofunctionally characterized representational system (1988, 1995*b*). Suppose that a frog's eyes respond to characteristic motions that only flies make in the frog's normal environment. On Dretske's account of information, the semantic information that a fly is over there is present at the frog's eye if there is a stimulus variable that naturally indicates the fly's presence. Any physical structure that is present only if a fly is present possesses the "indicator content" that a fly is present (independently of whether any organisms do or can use this information). If a structure in the frog's visual system responds only if that stimulus variable is present, then it shares that indicator content. Thus far, we don't have a representation of a fly. For that, Dretske (1988, ch. 3) requires that the system has the function of using indicator content to guide behavior. If the tongue-snapping trigger has the function of inducing a snap when and only when the visual system's fly indicator fires, then the system *represents* flies; and, when it misfires, it misrepresents flies.

I don't accept Dretske's analysis because I am skeptical of his proposal that physical information directly yields semantic information which in turn furnishes the content for psychological representations (as if by osmosis). It's not that I deny that conditional relations might exist between motion-patterns and the presence of flies (physical information). It's rather that I don't see a way to ascribe semantic content of any kind to the motion-path stimulus variable short of finding a mechanism that is sensitive to that sort of motion *because* it indicates the presence of flies, or because it serves to increase the chance (on the frog's part) of eating, or serves some other function. By contrast with Dretske, I don't believe in semantic information without a system that creates it in response to physical information. For that reason, I must rely on the notion of a *function to represent* in ascribing content, without deriving the content from Dretskean indicator content. (See the Note on information.)

Shapiro (1992) provides another approach to this problem. Like Dretske, Shapiro appeals to evolutionary considerations to fix content. He argues, contrary to Fodor as quoted, that the phrase "was selected for representing things as F" is *not* transparent to coreferring expressions. Suppose that in the frog's environment, *moving black dot* and *food* are co-extensive. Shapiro holds that "selecting for" provides an intensional context that is opaque to substitution, on the grounds that only by putting "food" into the context do we capture the relevant generalizations from the ecological and ethological sciences that explain why the frog has the detector it has (such as the generalization that frogs that catch more food fare better).

I agree with Shapiro that "was selected for representing things as F" is an intensional context (on the intension/intention contrast, see Ch. 7.4). But I

think it is doubly so, and that only one of the intensions gets us to food (or flies) as *representational content*. The "selecting for" part is intensional over the properties relevant to lawful (or otherwise explanatorily generalized) regularities concerning frogs and their food. Such generalities might pertain to the rate at which one or another version of the frog's detector mechanism snaps up food in a given environment. Although the intensionality of lawful or explanatory contexts is a controversial matter (see Dretske 1981, 75–7), I'm willing to live with the notion that objects fall under explanatory generalizations only under certain descriptions (e.g., "frog food," and not "my grandmother's least favorite insect"). But these descriptions apply to the behavior of the frog's detector as described from the outside: a behaviorist could use such descriptions. This instance of intensional opacity doesn't get us to the frog's representations.

To a limited extent, I agree with Fodor (1990) that selection is not content-specifying: the mere establishment through natural selection of a mechanism that successfully induces fly-snaps does not tell us what representational content to ascribe to the mechanism. In describing behavioral success, Darwin needn't determine the specific representational content. To account for the frog's snapping mechanism as it is relevant to selection, *food*, *moving black dot*, and *flies* all work (assuming they are ecologically co-extensive). But that's because a mechanism that had the function of representing any of those three would work equally well in the frog's environment (we are supposing). Presumably, a mechanism that had the frog snap at any movement at all wouldn't work, nor would one that had the frog snap an inch behind the fly's present position. As Shapiro (1992, 472) observes, Fodor never denies that the visual mechanism governing snapping is a *detector*. For Fodor (1990), the issue is whether selection assumes a specification of whether the detector distinguishes between *fly* and *food* (etc.). I answer: no, it doesn't, if the mechanism that is selected is in fact able to detect food in an adequate manner.

But just because behaviorism works for some purposes is no reason to stop there. There may still be a fact of the matter about what the frog is detecting, and *how* it "represents things as F" (our second intensional context). Evolutionary explanations start from the extant variability in a population and selection then accounts for the fixation of a trait in subsequent populations. If a certain frog in fact possessed a representation of *fly* and not *moving black dot*, and that representation triggered its snapping mechanisms with more successful outcomes than other detectors in the population and therefore was selected, then we have the functional specification of the detector's content as *fly*. I consider it unlikely that frogs have the conceptual resources for such a specific content. If, as seems plausible, the system can function with the

minimal content *moving black dot here now*, I would rest content with that. But that does not mean that there is no intentionality or misrepresentation. Because we treat the visuomotor system as having the function of representing items so that they can be targeted and ingested, we have a basis for assigning representational content and for allocating misrepresentation. Further, if the states that account for the frog's success at fly-catching do so because they are representations, then, on the aetiological account, the function of those states is to represent.

A reader of a naturalistic bent might balk here. Dretske (1988, 1995*b*) attempts to reduce representational intentionality to the allegedly physical notion of semantic information, plus the notion of biological function. I do not attempt to reduce it to either. I treat representation and aboutness as features that arise in organisms and become subject to selection, but I don't explain how they arise. Perhaps they evolve through mutation from simpler mechanisms that causally co-vary with environmental states (see Lloyd 1989, ch. 3). Or perhaps they arise from the mutation of physically self-organizing aspects of organisms that in some way come to be directed beyond themselves (Walsh 2002). I offer no account of their emergence. I posit that it occurs, on these grounds: presumably, before life evolved there were no representational states (nor states with semantic content, since I don't allow semantic information without a user, or using mechanism), and now there are such. I treat representing states as emergent features that then undergo selection. This position is consistent with an *inclusive naturalism*, which includes unreduced intentionality in the natural world, perhaps as an emergent feature (see Ch. 10.5, and Hatfield 1990*b*, ch. 7.2; Shapiro 1997).

6. Explanatory Resources

The theorists discussed in Section 2 invoke a variety of explanatory notions for sense perception and cognitive perception. Most of those theorists see sense perception as resulting from cognitive operations that combine information via unconscious inferences. One prominent strand of such theory, inspired by the computer analogy (Fodor 1975) or by an analogy with logical reasoning (Rock 1983), regards these inferential processes as symbolic in nature. When such processes combine information that is described logically or numerically, they are called *computational* or *algorithmic* processes. A cognitive theory need not posit internal computations but might instead describe perception using the language of belief-formation (Heil 1983, ch. 7). Conversely, one can posit

computations and algorithms without supposing that they are mediated by cognitive or symbolic processes (Chs. 2–3).

Theorists who view perception as resulting from an active process of information processing are typically called *constructivists*; they may further be specified as *information processing* theorists, because they hold that perceptual processes combine local information to yield global perceptual outcomes. Although a cognitive and symbolic conception of constructivist information processing is the most common, it is not required. In my picture of visual perception and cognition, the processes underlying visual sense perception are noncognitive and nonconceptual. I also hold that they are nonsymbolic. To the extent that processes of information-combination are quantitatively specifiable, they may be deemed algorithmic computations. Further, I hold that nonsymbolic processes can underlie conceptual and cognitive representations, although of course as cognitive operations break into language, symbols are needed—however, such symbols need not be primitively specified by the computational architecture, but may be derived and constructed entities (Ch. 3).

For sense perception, I derive representational content by working downward from a task analysis (Chs. 2–3, 8). A task analysis can tell us what is being represented, but it doesn't by itself reveal which subprocesses in fact carry out the task (Marr's algorithmic level). For that, we need to determine the structure of processing. For many tasks in visual sense perception, the relevant models postulate the registration of stimulus information (cone activations, microfeature detection, and registration of larger-pattern variables such as projective shape, or of higher-order stimulus variables that specify distal shape). The various sources of registered information (including ocular and bodily orientation) are then processed and combined in algorithmic processes, as in Figure 1.2. Registration already synthesizes across physiological receptors and is to that extent "constructive," as are the processes that combine and transform registered information to yield spatial and chromatic visual structures. Although sense-perceptual processes are in this way synthetic, constructive, and computational (algorithmic), they need not be regarded as inferential, cognitive, or symbolic (Chs. 2–5). Sense-perceptual processes yield representations (nonconscious and conscious) that subsequently engage the cognitive perceptual capacities and may invoke other responses. There can be top-down influence (from cognitive perception to sense perception), but in my view the sense-perceptual processes operate largely independently of cognition. As discussed in Section 2 (and Ch. 15.2.3), some registered information may be passed on to visually guided motor-control systems without entering consciousness (Fig. 1.2).

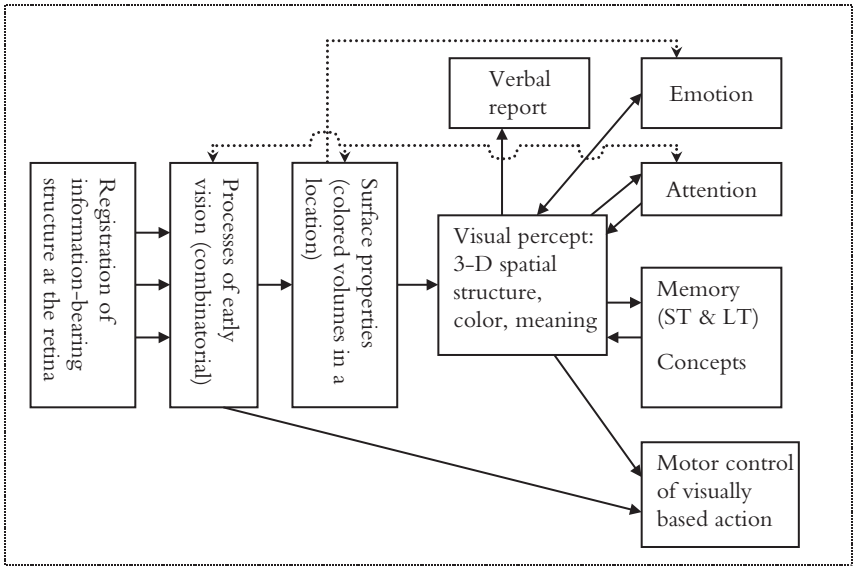

Figure 1.2. Perceptual processing stages and response categories. Response categories including concepts, attention, and emotion feed into the phenomenological content of the percept. Bodily actions such as grasping targeted objects with the hands are guided by both conscious and nonconscious visual representations (Sec. 2, and Ch. 15.2.3). Verbal reports are shown as a separate motor response to conscious visual experience. Solid lines indicate primary causal and functional relations; dotted lines indicate secondary causal and functional connections.

Different sorts of explanatory resources can be applied in explaining the processes of sense perception. In a discussion of the spatial constancies, Epstein (1973, 1977*b*) posits processes for registering, transforming, and algorithmically combining stimulus information. He does not describe the combinatorial processes as inferential or cognitive, and I take his descriptions to be compatible with my noncognitive (nonconceptual, nonsymbolic) functional algorithms (Ch. 2). Epstein (1973) treats such notions as registration, transformation, and combination as explanatory primitives. There is nothing wrong with this attitude; the viability of such primitives is tested by the empirical success of the theoretical models that employ them. But some theorists may wish to explain the basis of these capacities. Such theorists might introduce a further functional decomposition (say, of the transformational or combinatorial mechanisms), or might look to hardware (receptors) to explain stimulus registration.

More generally, a theorist might posit one or another underlying computational architecture to explain processing and combination of perceptual information. I prefer to think of sense-perceptual computations (transformations,

combinations) as performed by connectionist nets (Chs. 2–3). Other theorists posit symbolic architectures, and they tend to treat the underlying processes as inferential (Fodor 1983; Marr 1982). But a symbolist need not adopt an inferential conception of sense-perceptual processes. A symbolist might hold that Epsteinian processes of stimulus registration, transformation, and combination occur in a symbol system that uses syntactically structured entities to convey nonconceptual information and to combine such information according to specified algorithms that serve as symbolically realized processing rules (see Ch. 3). I find it superfluous to use symbols in this way, for the reasons developed in Chapters 2–3.

In the literature of cognitive science there has been a great debate between symbolists and connectionists. I hope that the essays in Part I provide some antisymbolist ammunition (see also Kosslyn and Hatfield 1984; Hatfield and Epstein 1985; Epstein and Hatfield 1994). Here I would like to indicate a way in which the rhetoric employed in contemporary debates is misleading.

Sometimes authors write as if the choice between connectionism and symbolism is that between a general associationist account of the mind and a view that posits internal states with precisely specified representational contents. On this view, connectionism treats the mind as one large connectionist network, thereby eschewing any psychological division of labor among processing mechanisms. Fodor (1998, 153) puts the point this way:

> What's your favorite metaphor for minds? If you're an empiricist, or an associationist, or a connectionist, you probably favor webs, networks, switchboards, or the sort of urban grid where the streets are equidistant and meet at right angles: New York's Midtown, rather than its Greenwich Village. Such images suggest a kind of mind every part of which is a lot like every other.

The mind is one big homogeneous net.

This way of characterizing the debate gives rhetorical favor to the symbolist, for it treats the division as if it were between associationists and representationalists, which can be decoded as a debate between behaviorist learning theorists and the newer information-processing psychology. Of course, associationism-connectionism (whisper: behaviorism) is supposed to lose.

Carruthers (2006, ch. 1.6) characterizes the debate in such terms, citing Gallistel (1990) in support. In fact, Gallistel contrasts general associative learning models with models that postulate internal representations, but he leaves open whether these representations are direct isomorphisms or are symbolically encoded (1990, 28–9). (On isomorphism, see Ch. 5.3.) He treats the representations in the brain as continuously varying vectors that are realized in the spatial structure of neural activity (Gallistel 1990, ch. 14). Such a

system of representation is consistent with connectionism (broadly conceived). Subsequently, Gallistel and Gibbon (2002) claim to support "symbolic" models of cognition: but again the choice is between associationism and representationalism. They don't define the notion of symbol and barely mention symbols, save in their book title and preface. Their book shows that empirically successful models of conditioning attribute representations of magnitudes (including rates and statistical relations) to organisms. The only way to read Gallistel and Gibbon (2002) as providing support for symbolism is to make the unjustified slide from computation and representation to an allegedly necessary symbolic realization of computations and representations (as in Gallistel 1998). Connectionist models are of interest in part just because they offer nonsymbolic realizations of computations, representations, and rules (Chs. 2–3). They do so with an architecture of connections, activation states, activatory or inhibitory gain, modifiable thresholds of activation, and the like. Considered in the abstract, these are closer in flavor to neural properties than are symbols. However, although some connectionist models are neural wiring diagrams, most thus far are not, and so should be considered simply as connectionist computational models, whose comparative advantages must rest on other grounds than a direct match with neural reality. If, as connectionists maintain, their architectural primitives can also realize operations that are essentially symbolic (in functional or task-level description), then the need to build a primitive symbolic computational architecture into organisms is obviated. Connectionism wins on parsimony, since it can handle symbols but needn't import them where they're not needed.

I use connectionist notions as a proposed implementation for psychological models that posit as fine-grained a functional decomposition of perceptual processes as you like. In the domain of sense perception, there needn't be much associationism in such models. Many basic computational routines (for color perception, spatial direction, accommodation and convergence, and stereopsis) could turn out to be innate (hard-wired), subject only to minor environmental tuning (which might be associationist). The processing rules for such routines need not be realized symbolically; they can instead be *instantiated* connectionistically (Ch. 3.7). In the domain of cognitive perception, it seems clear that many recognitional concepts are learned. Some of this learning may be statistical and locally associationist, some may involve more structured representations (which nonetheless receive a connectionist implementation). In no case would one posit a single, large connectionist net, even to account for only the visual recognitional concepts. There is presumably a division of labor that is modeled by functional decomposition, and that ultimately must be realized in the appropriate hardware.

Finally, I treat neurophysiological structures as explanatorily relevant for psychology, but not as the ultimate bedrock of explanation. Perceptual psychology and neurophysiology exhibit an interplay, in which psychological models usually lead the way. Neurophysiological data can serve to confirm psychological models and can suggest the need for new psychological models. The basic point is that neurophysiology can be relevant for psychology without our needing to suppose that psychology can be reduced to neurophysiology (which I doubt).

7. Sources of Evidence: Visual Phenomena, Behavior, Neurophysiological Data

The sources of evidence in vision science include introspective and phenomenological reports of visual experience, whether illusory or veridical; behavioral measures in response to visual stimuli; and neurophysiological data, including invasive recording from nonhuman animals and neuroimaging of both human and nonhuman animals.

I have mentioned neurophysiological mechanisms in previous sections and I discuss neurophysiological data in Chapter 15. Behavioral data are collected in experiments in which subjects respond to various visual stimuli, sometimes of brief exposure. In analyzing such data, experimenters may consider: the stimulus variables they have manipulated, including their ecological validity; the task they set for their subjects; the theoretical models of perceptual processing they intend to test; subjects' response options (pressing a button, verbal response, selecting a matching stimulus, making a drawing); and the conditions under which subjects make a response (e.g., under instruction to respond as rapidly as possible, or only once they are sure of what they have seen). On the basis of the interactions among such factors, the experimenter qua theorist may conclude that one or another theoretical model of perceptual processing is confirmed or disconfirmed. Often, these models include the postulation of unconscious processes. Chapters 5–7 and 13–16 describe examples of data used to test or confirm theories, and Palmer (1999) describes many perceptual experiments. I want to consider more closely the status of phenomenological observations.

Psychologists of visual perception only sometimes discuss the role of phenomenological reports, which often target spatial or chromatic phenomenal qualities. Nakayama *et al.* (1995, sec. 1.1) endorse the role of phenomenological reports in vision science, as do Rock (1975, 21) and Palmer (1999, 349–50).

As mentioned in Section 2, others discount the role of phenomenological evidence and also doubt that phenomenal experience is an important object of explanation in perceptual psychology.

From the point of view of psychological science, it is important to determine to what extent phenomenological descriptions describe real features of perceptual experience. It is not that there would be nothing to study about phenomenal experience if it were discovered to be "illusory," because one could still study the reported content of the illusion. But phenomenological reports take on greater salience if there is reason to believe that they tap into genuine features of visual experience.

A notorious challenge to the reality of phenomenal experience comes from Daniel Dennett (1988, 1991). In his view, spatially articulated (imagistic) qualitative experience of spatial and chromatic features is not real. What is real are various descriptions, largely of features of the world, that exist as "multiple drafts" for perceptual judgments (1991). Our apparently coherent phenomenal experience is a fictional construct of these internal descriptions, as if we are talking to ourselves about what we see (1978). Dennett does not, to my mind, adequately address why our descriptions have the coherent fictional phenomenology they do, but he does insist that description is all we have.

Dennett's position is complex and I'll give just one example of the type of argument he sometimes offers (or once did in a talk at Penn). Visual psychologists studied *change blindness* during the 1990s. If an image is significantly altered during a saccadic eye-movement, or even if it is appropriately modified while the subject is looking at it, the subject typically does not notice the change (Palmer 1999, 538–9). The change can be large (the removal of bushes from a region of an image), but it cannot be at the unbroken point of fixation. Dennettians conclude from such data that perceivers don't really have an imagistic percept that includes the bushes (or whatever), and that they suffer from an illusion that their experience is both detailed and spatially articulated like an image (or, as I hold, like a three-dimensional imagistic structure).

This type of argument against rich, detailed phenomenal experience, although it became widespread (e.g., Blackmore *et al.* 1995), is inconclusive. The argument confounds whether the subject can report a phenomenal change with whether there was one. But theories of perception regularly distinguish what is phenomenally present from the response mechanisms that mediate an overt response. There are many contexts in which this distinction is made, but the most salient is research in attention (Ch. 13). Theorists regularly posit that there is more available in a percept than subjects can categorize and notice. The fact that a bank of bushes goes missing may alter the percept but not be noticed. Indeed, the change-blindness scenario is artificial: usually, a

bank of bushes doesn't disappear all at once, but must be removed bit by bit, with each bit tracing a continuous motion trajectory as it is cut and removed. My observation that the change-blindness argument confounds perception with perceptual reporting does not decisively show that perceptual experience is spatially and chromatically detailed in an imagistic manner, but it does stay the bite of that argument.

A related issue concerns the spatial definiteness and extent of our imagistic percepts. Subjects are often surprised to find that, within a momentary fixation, the central region is clear and detailed but that the portion of the field beyond about 30° from the center is considerably less clear. This has led some theorists to suppose that, while we may have rich detailed spatial structure near the center of the visual field, we are deluded in believing that (say) a whole wall of books across the room in our study is visually present to us.

Alva Noë (2004) has responded to these concerns by noting, first, that the central portion of the visual field in fact is rich and detailed, and, second, that the books (in my example) to the left and right are "virtually present": we can move our eyes to see them, and it is part of our visuomotor skill set to know that we can attain detailed experience of them. Noë's emphasis on visuomotor skill is partly inspired by Gibson (1979). I prefer a different Gibson-inspired answer. Gibson (1979, 195) describes the momentary scene as a three-dimensional perception of the environment as seen-at-this-moment-from-this-point. Such a view is clear and detailed in the middle and fades off. But our ongoing visual experience is not a series of momentary (3-D) snapshots that we piece together; rather, as our eyes move we integrate the optical flow pattern into an awareness of a visual world that surrounds us and that, within the specious present, extends beyond the momentary vista. The surrounding books are present to our ongoing visual awareness, and not simply (as with Noë) implicit in visuomotor knowledge.

Noë (2004) and Gibson (1966, 1979) are both *physical direct realists*, so they interpret the content of this phenomenology (however described) as consisting in the books and shelves themselves, unmediated by a perceptual representation. I am a *critical direct realist*, so I interpret this phenomenology as presenting me with visual experiences as of shelves in a room with ceiling and walls, all in some sense visually present as I move my gaze about. Noë (2004, 72) points to "transparency" in favor of his view; as mentioned in Section 1, I doubt that this argument can establish his points about the metaphysics of (non) representation (see also Crane 2000).

Where does this leave us concerning the reliability of our phenomenological descriptions of a spatially and chromatically rich visual experience? In the absence of compelling reasons not to, I take such descriptions at face value.

Phenomenally, we are presented with a stable visual world that surrounds us and is immediately available for a closer look. That's phenomenology. The metaphysics of visual experience (what the real underlying basis is for such experience) is another matter.

8. Role of Philosophy

In the history and continuing development of theories of visual perception, philosophy plays several roles. In the guise of natural philosophy, it has been a source of theories and analyses. These include: the distinction between primary and secondary qualities as developed by Robert Boyle and John Locke (with foreshadowing from Descartes, as discussed in Hatfield 1986*b*); the notion of unconscious inference in perception, as developed by Ibn al-Haytham and subsequent theorists; an associationist theory of size and distance perception, deriving from George Berkeley (Ch. 12); and the concept of sense data from the early twentieth century. Philosophy also has been a source of methodology, in the guise of introspection and phenomenology. Philosophical analysis has examined the explanatory structures and metaphysical commitments of the various theories of vision, and philosophers currently participate in a dialogue with visual scientists concerning such structures and commitments. Philosophy examines questions that some visual scientists also propose to answer, such as "what is color?" Philosophers also venture into topics that visual scientists usually skirt, such as the status of phenomenal experience (Chs. 10–11), the mind–body problem (Chs. 10, 15), or the manner in which sense perception justifies knowledge.

Discussions of the role of perception in knowledge recently have focused on whether nonconceptual perceptual content could be epistemically relevant. John McDowell (1996) believes that nonconceptual content cannot provide a basis for epistemic justification. He reasons that if the sense perceptual states that I've described were to be assigned correctness conditions (as they certainly may be, since they present the world as being spatially and chromatically a certain way), any appeal to those conditions in epistemology would commit the "naturalistic fallacy" (1996, xiv). Like Fodor and Carruthers above, McDowell foists onto his opponents a putative one-step account of how perception supports knowledge. But as Chapter 7 describes, sense perception may initiate epistemic contact with objects, by making them salient perceptually. As we move into an epistemic context, sense-perceptual representations must be brought under concepts; the application of concepts and the assertion of

conceptual content may be as epistemically norm-governed as you like, despite its engagement with nonconceptual, naturally produced phenomenal content (see also Hatfield forthcoming-*c*).

The status of phenomenal experience is widely discussed of late. The current trend is to try to reduce phenomenal experience to something else: it is nothing but pure informational or representational content (Dretske 1995*b*; Tye 1995); or it is nothing more than an unmediated awareness of the physical world itself (the new naive realism). I oppose this trend, which is partly driven by distaste for sense data or other perceptual intermediaries. As originally conceived, sense data are supposed literally to possess the qualities they appear to have: bulgy and red, for tomato-y sense data. In some versions, this claim about sense data was motivated by a type of direct realism; one which led, in one stream of thought, to neutral monism (Ch. 10), thereby reducing the material world to qualitatively characterized (e.g., bulgy, red) elements. However, neutral monism won't work if one believes, as do I, that physical things are made of atoms and molecules.

The ongoing objections to perceptual intermediaries are phenomenological and theoretical. First, on the face of it, perception doesn't *seem* to be mediated. We seem to face the world directly; we are not ordinarily aware of any need to move from mediating appearances to things in themselves. Second, there is the problem of how to fit qualitative phenomenal experiences, as states of the perceiver, into a naturalistic framework. I offer answers to these problems in Chapters 5.4, 10–11, and 16. As previously mentioned (Secs. 1, 7), I agree with the phenomenological point about phenomenally direct perception but deny that it can sustain a metaphysical conclusion about whether our perception of the world is mediated by qualitative experiences. If perception is so mediated, it is not those qualitative experiences that we *see*; rather, by means of having them, we see the world. In this regard, I am a critical direct realist, that is, a direct realist who acknowledges the need for subjectively conditioned representations and qualia. As to fitting phenomenal experience into nature, I don't believe that this is such a problem: it's already there. Some philosophers are reluctant to accept the reality of the phenomenal prior to achieving a theoretical understanding of what it is. As I see it, phenomenal experience is real, no matter what it really is.

In the best of its engagements with perceptual psychology and vision science, philosophy is neither underlaborer nor imperious judge. Rather, philosophers engage with the living inquiries of perceptual psychologists and vision scientists in addressing current issues. In so doing, philosophers may bring a perspective informed by the broader philosophical concerns of epistemology, metaphysics, and philosophy of science. They may also join perceptual psychologists in

conducting empirical work and proposing phenomenological descriptions. In all of these endeavors, my own view is that philosophers should seek to participate in a discussion, rather than to criticize from the sidelines or simply to describe in clear terms what the sciences are saying (see also Hatfield 2001). Just as, on the scientific side, when theories are undergoing development there is no such thing as "just doing science" without also producing philosophy, so too, for philosophers, there is no such thing as talking in a substantive way about visual perception without engaging the science of vision, whether wittingly or not.

As philosophical and scientific discussions of visual perception continue, I believe that each party will gain from engaging the work of the other. Philosophers can contribute by raising new questions and challenging old answers. One thing is for sure. There is no danger that the mysteries of seeing will be completely solved in the near future. There isn't much that is as puzzling as is seeing itself.

Note on the Concept of Information in Perception

The notion of information was widely invoked in psychology during the 1960s and 1970s, and it is now firmly entrenched in discussions of perception and cognition in psychology, cognitive science, and philosophy. Descriptions of perception point to information in the light reflected from objects, information transduced by receptors, information processed by perceptual systems, and information contained in perceptual representations and stored and retrieved from memory. Although the word "information" is common to all these discussions, the notion of information has undergone development, and more than one concept is now in play. Thus, some sorting out is needed in order to make clear which notions of information I favor, which not, and why.

The concept of information that initially was prominent in psychological discussion of the 1950s and 1960s derived from Claude Shannon and Norbert Wiener (see Shannon 1948). Fred Attneave (1954) was among those who brought this new concept into the study of perception. Shannon and Wiener developed a mathematical theory of information as a means for measuring information transmission in communication devices. Their concept of information had nothing to do with content; it concerned only the amount of information transmitted. Technically, they defined information as negative entropy, or as the reduction of uncertainty. Their measures were widely used in perceptual investigations in the 1950s and 1960s, but this use subsequently waned because such measures did not correlate well with stimulus characteristics that perceptual psychologists found to be empirically important.

We needn't explore the technical definition of information, or chart its passing from the psychological literature (see Corcoran 1971, ch. 2; Haber and Hershenson 1973, 160), in order to understand the core idea that was ultimately retained from this notion. The Shannon–Wiener notion effectively proposes that information transmission involves the existence of conditional probabilities between two distinct entities or sets of events (Dretske 1981, chs. 1–2). Information is transmitted between A and B if the states of B exhibit a conditional relation to A. Smoke bears information that there is fire because, usually, where there is smoke there is fire. The lengths of shadows bear information concerning the time of day because they are conditionally related to the height of the sun in the sky, and the height of the sun measures time of day (relative to season). The structure of light reaching the eyes bears sufficient information to specify the layout of the distal environment if, given a certain structure at the eyes, the distal environment must have a specific spatial configuration. (This relation of specification exists only given certain assumptions, such as that the environmental

structures tend to keep their shape, so that when an observer moves his eyes the changes in stimulation result from that motion and not from a simultaneous deformation of the environment.)

A second impetus toward talk of information in psychology stems from Gibson. His notion of information pertains, in the primary case, to relations of structure. There is information "in the light" because the structure of the light specifies the structure of the layout from which it was reflected (subject to some background conditions). Gibson himself at first endorsed a relation between his concept of information and the notion of conditional structural relations as derived from information theory (1966, 245), but he subsequently came to doubt that his notion of information was consistent with information theory (1979, 242–3). I agree with Neisser (1976, 60) that Gibson's notion of information is consistent with the core idea of information as conveyed by structural dependencies between objects and the stimulus array. But Gibson's specific concept differs from the generic notion derived from information theory. Gibson's notion is ecological: the structure in the light is information for an organism in an environment. Ground texture is information for distance only if the texture is comparatively homogeneous at a scale appropriate to the height of the organism that samples the optical texture generated by that ground texture (Gibson 1979, fig. 5.1).

In my view, the idea of physical or optical information available in the light should be accepted without difficulty. Theoretical questions arise in considering what is needed for a perceptual and cognitive system to respond to, register, and represent that information. These questions are raised by the tendency to view the flow of information from the world to sensory systems, or to the organism more generally, as a process of absorption. The perceptual system simply "picks up" the needed information, and the perceiver then directly perceives the distal layout. As mentioned in Sections 1–2, Gibson himself believes that there are mechanisms involved, which he describes as "resonating" to the information in stimulation, making it seem as if the information is simply absorbed. But it strikes me that there is no reception and transformation of information without mechanisms—including receptors and subsequent processing mechanisms—that register and transform the information. No information can get into or be used by the system unless the system has receptors that can register the structure of light, and no registered structures can yield the perception of a distal environment unless there are mechanisms for producing representations of the distal environment using stimulus information.

In this connection, I agree with Ralph Haber and Maurice Hershenson (1973, 159):

> Since the retinal projection of the light itself cannot get "into" the organism, a representation of it, which we call information, is the content that we will describe in our theories. When this information is stored, we will want to know its relation to the information in the retinal projection of the stimulus. Is it in the same form or has it been transformed? Is it coded in some way?

Information in stimulation is one thing. Information as registered by the visual system and subsequently processed and transformed is another.

The processes that register information in the light begin at the retinas. The most basic units for human daylight vision, the cones, respond to the intensity of light within a range of wavelengths (depending on cone type). Information about the retinocentric direction of the light is associated with the cone's position in the retina and presumably is preserved in the retinotopic projection of stimulus information into the visual cortex. The retina and cortex also contain various mechanisms that compare the activation of adjacent or nearby cones. These detector mechanisms may respond to features in the light, such as light–dark boundaries, and may detect the presence of motion in a direction.

The registration of a Gibsonian higher-order stimulus variable, such as an optic flow pattern, clearly depends on comparing and integrating the outputs of such detector mechanisms across the retina. For example, Gibsonian theorists are interested in a pattern of optical expansion described by a mathematical function known as *tau* (Proffitt and Kaiser 1995). There are several applications of tau to describe flow patterns that might specify the observer's motion or the motion of objects toward the observer, including *global tau* (a global expansion of optical texture around a point specifying the observer's heading) and *local tau* (the expansion of a local area within the optic array, such as would be produced by an approaching object, e.g., a baseball). Presumably, the visual system has mechanisms to detect a local tau-pattern and mediate the perception of approaching objects. But notice that it is no good simply to have a tau-detector that tells the system that a tau-pattern is on the retina. In order to help explain how we experience approaching objects, this information must be incorporated into a perceptual representation of a solid volume approaching from a direction. Tau-detection in itself is not helpful unless the distal significance of tau enters the process (even if only in the structure of a reflex response).

As I see things, the representational significance of external physical information cannot simply be absorbed at the retina but must be generated by the receptors and subsequent processing mechanisms according to their functions to represent. Cones (or their activations) do not represent the presence of light simply because light causes them to respond; rather, because they respond to light, they have been wired into the system as light-detectors. The mechanisms that use local tau to generate representations of solid volumes approaching from a direction do not get their content by simply absorbing the information in the optic array; rather, because the structure of the array offers information about distal events, these mechanisms have been wired up to respond to that information by generating a representation of the distal motions. We must look to the properties of the visual system to understand what representation-generating mechanisms it has. I assume that the basic mechanisms have been selected in evolution because they respond to stimulus structures by generating representations that are reasonably accurate portrayals of the distal situations that produce those structures (Sec. 5). Consequently, I don't build my concept of representation from the concept of information, but I treat representational content as arising *sui generis* as the perceptual system evolves.

I thus distinguish information in the light from information registered by the system. The former exists independently of being transduced or registered, even if,

in accordance with ecological optics, the classification of structural information in the light proceeds in a species or genus-specific manner. Information in the system is always, for me as for Haber and Hershenson (1973), represented information. And I see its content as contributed by the system—although presumably the system produces a specific content because, for receptor mechanisms, such content accurately represents a light-structure present at the retina, or, for subsequent mechanisms, because by integrating registered information it produces representations of the distal scene.

In this regard, my notions of information in stimulation and information in the perceptual system differs from Dretske's concept of information. Dretske's *Knowledge and the Flow of Information* includes an exposition of the mathematical theory of information, which brings out the core idea of conditional dependency (1981, chs. 1–2). Thus far, this concept of information is similar to the core idea from information theory that is shared by Gibson and myself: conditional dependence. Dretske then adds to this concept the idea of *semantic information*. He says in effect that when B bears information about A, this information exists in semantic form in B without being detected or represented by a system. He inserts semantic content into the physical state. Semantic information is what is distinctive to the Dretskean concept of information.

Dretske's extension of traditional information theory by adding semantic information is not uncontroversial (e.g., Sturdee 1997; Lombardi 2005). It is what allows him to "naturalize" representational content in his sense. He does so by supposing that a mechanism (B) in an organism that fires only when A is present would thereby instantiate the semantic information *that A* (1981, 65). This semantic information then becomes the basis (in ways described in Dretske 1981, chs. 6–7; 1988, ch. 3; and 1995*b*, ch. 1) for the representational content that accrues to the representations that incorporate it. In this way, semantic content (allegedly) is absorbed into representations from the information in the world.

I do not accept Dretske's postulated semantic information. Accordingly, optical structure may bear information, but that information can be extracted and rendered into semantic form only by mechanisms that bring their own representational content with them. There is no semantic content without representations and concepts. In this sense, information doesn't perform any psychological work unless there are mechanisms for registering, detecting, and processing it. Information yields representational content, but it does not do so by being absorbed. It does so when information-bearing structure is registered and transformed by mechanisms having the function to represent (Chs. 3, 11).

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