One of the perhaps most striking phenomenological facts about the human perceptual experience of the world is that it seems to be divided into modes. Our perceptions of the world are delivered to us in distinct classes, those of the separate sensory modalities, such as vision, hearing, and touch. When confronted with, say, a horse after a ride on a hot summer’s day, we experience vivid impressions of the animal in the form of how it looks (large and brown), how it sounds (loud, heavy breathing), how it feels to the touch (hot and slick with sweat), and so on. That these different modes of experience are, well, different seems beyond question. The existence of separate sensory modalities would seem to be a brute fact about perception, if ever there were one.

The apparent “bruteness” of this fact of human experience might explain why, throughout history, philosophers and perceptual scientists have had relatively little to say about the nature of this difference. Yet the apparent fact of this difference lay at the very foundation of philosophical and scientific questions about the senses. Its very cen-
trality is what makes it simultaneously both a difficult and a crucial question: Exactly what is it that distinguishes the senses from one another?

I. INTRODUCTION

My goal here is two-fold. First, I want to bring attention to this underexplored topic—to bring together much of what little has already been written on it and, in doing so, to encourage others to take up the challenge it represents. Second, I want to propose an answer to the question. The answer is based on the criteria used in neuroethology, one of the sciences that daily confronts issues related to distinguishing, comparing, and contrasting sensory modalities. Distinguishing the senses in a way useful to those sciences which study perception requires knowledge of several factors, including the categories of physics, as well as the neurobiology, evolutionary biology, and behavior of the organism whose senses are to be distinguished.

On my account, to possess a genuine sensory modality is to possess an appropriately wired-up sense organ that is historically dedicated to facilitating behavior with respect to an identifiable physical class of energy. Perhaps the correct way to think about modality is best suggested by a definition of the term in Webster’s Ninth New Collegiate Dictionary: “One of the main avenues of sensation (as vision).” Modality is an “avenue into” an organism. Question: What travels on an avenue? Answer: information about the physical state of the world exterior to the central nervous system (CNS). What constitutes an “avenue”? An evolutionary dedicated sense organ that converts energy into nerve impulses and conveys those impulses to the CNS. This captures the original sense of the term: the different senses are different “modes” of perceptual interaction with the world.

I shall leave further discussion of my proposed answer to sections II (where I discuss how to set up the problem of distinguishing the senses) and III (where I present my proposal in detail). Perhaps surprisingly, I shall argue that the distinct experiential qualities of perception—the qualia—so central to the common-sense understanding of perception are simply nonstarters for a scientific understanding. I draw a similar conclusion about the most venerable theory of the senses: Aristotle’s account of the senses in terms of the “proper objects of sensation.” In section IV, I shall turn my attention to these prima facie plausible proposals in order to show how they fail to provide a firm foundation for an empirically adequate account of sensory differentiation.

Both the Aristotelian and the qualia-based approaches are best thought of as representing common-sense accounts of the senses.
Although they may well be adequate for this purpose, this is not my goal. To the contrary, I offer what might be termed a “thoroughly naturalized” approach to distinguishing the senses—one that proposes to make sense of the problem as it presents itself to the perceptual sciences. Therefore, one way of looking at what I do here is to provide an eliminative materialist theory of the sensory differentiation as an alternative to common-sense theories.

Before proceeding to the answers, however, I need to explain a little more fully what the philosophical question is here. What is it about the question of how we ought to differentiate the senses from one another which should draw the interest of philosophers? Further, what is the philosophical payoff?

Let us get the somewhat facetious answer out of the way first. If one defines philosophical problems as those questions which actual philosophers find important enough to grapple with, then the issue of distinguishing the senses would seem to qualify as sufficiently philosophical. Although, as I note above, the topic has received relatively little philosophical interest, it has nonetheless drawn the interest of philosophers as varied as Aristotle, H. P. Grice, David M. Armstrong, and Nelson Goodman. Introducing his take on the issue, John Heil1 observes: “Regrettably, philosophers have had little to say about what distinguishes the senses from one another” (ibid., p. 3). That situation may be changing, however, as evidenced by a number of recent papers.2

Surely, we can say more about the source of this interest. Turning again to Heil: “An explication of the senses, a determination of what constitutes a sensory mode must, it seems, occupy a position of central importance in any theory of perception” (op. cit., p. 3). Perceptual psychology, sensory biology, neuroethology, and numerous other sciences make foundational use of the notion of separate senses without much discussion of the details. Such sciences typically just assume the existence of different senses. One sees this reflected in the textbooks used in undergraduate psychology and neuroscience curricula. These textbooks are often divided into chapters covering the various separate senses, but it is rare to see an explanation for what makes the separate senses separate. (Not that this is a feature

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1 Perception and Cognition (Berkeley: California UP, 1983).
unique to scientific theorizing. Philosophical theories of perception likewise tend to start from an unexplained foundation of differentiated senses. Those which do explicate such a foundation typically do so in terms of the approaches I shall criticize in section IV.

I agree with Norton Nelkin: the question of differentiating the senses “asks how we should define the senses so as to make them scientifically useful concepts. More metaphysically, it asks what is the real nature of the senses” (op. cit., p. 149). That is, the issue engages philosophy of psychology in both of its emphases. To the extent that philosophy of psychology is a branch of philosophy of science, the notion of the senses as differentiated from one another is a core notion in perceptual sciences; a scientific assumption requiring philosophical justification. Philosophy of psychology also has a foot in philosophy of mind, and Nelkin’s “more metaphysical” aspect of the issue invokes that connection. Part of what is required in spelling out this fundamental aspect of perception involves explicating exactly what sort of metaphysical entity a sensory modality is.

In discussing this topic with colleagues, I have discovered a surprising amount of unrecognized disagreement among individuals. Some believe that the problem is intimately tied up with qualitative experience, to the extent that a “nonconscious sensory modality” is seen as an oxymoron. To have a sense is to have a unique set of experiences—qualia—associated with that sense. But others see the issue as much more related to the sorts of things in the world which can affect behavior, regardless of whether we are ever consciously aware of such influence. For example, they feel that we would be right to posit a human magnetic sense if people could be shown to respond behaviorally to magnetic stimuli in a systematic fashion regardless of whether we experience “magnetic qualia.” Still others insist that the senses are strictly related to sense organs; for example, refusing to accept the existence of a genuine “vestibular sense” until informed of the existence of the semicircular canals and associated cranial nerves. “No organ, no sense” seems to be their rule.

These differing intuitions agree on Aristotle’s five senses, so people tend not to notice their different intuitions. Such apparently widespread agreement reinforces the strength with which these intuitions are held. After echoing the sentiment that the differentiation of the senses have “seldom been directly discussed,” J. W. Roxbee Cox3 goes on to diagnosis this curious condition by supposing that it may be “due to the fact that certain answers have seemed to different people

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so obvious that they did not need to be supported by argument" (ibid., p. 530). The disagreement among individuals begins to become clear once we start considering potential senses in addition to Aristotle’s five, examples of which I shall be discussing below. What makes the problem of discriminating the senses philosophically interesting is that the intuitions here are fundamental, firm, and generally unrecognized by the people who hold them. When one finds a disagreement with these three qualities, it is a clarion call for philosophical inquiry.

That I shall argue that qualia are not central to differentiating the senses indicates one important philosophical payoff from the topic under discussion here. The legitimacy of the concept of qualia in our scientific understanding of the mind is a matter of ongoing controversy. One line of argument might run thus:

P1: Qualia are essential to the project of differentiating the senses; one cannot make sense of different modalities except by reference to the qualitative character of perceptual experience.

P2: Differentiating the senses is an essential component of any science of perception, such as perceptual psychology or sensory biology.

\[ \therefore \ C: \text{Qualia are an essential component of any science of perception.} \]

I fully accept P2. In offering my “qualia-free” account of sense differentiation, however, I will be attacking P1—an attack that, if successful, can only undermine one of the primary purposes for which qualia could be useful. But if the account I defend here is wrong, and qualia are essential to differentiating the senses, then this would represent a powerful, new argument for the scientific legitimacy, nay the scientific necessity, of qualia.

For these reasons, I suggest that it is clear that the problem of how to differentiate the sensory modalities is an interesting and important philosophical topic. I shall return to the topic of philosophical implications in the final section. That said, assuming I have adequately justified the legitimacy of the topic, I shall consider in the next section how to address the question and consider what form the answer should take.

II. HOW TO THINK OF THE QUESTION AND THE FORM OF ITS ANSWER

Aristotle famously counted five human sensory modalities: vision, hearing, taste, smell, and touch. Since then, his list has been expanded to include such potentially novel modalities as proprioception (our sense of the relative location of our limbs) and the vestibular sense (the sense of one’s orientation with respect to gravity). So, Aristotle undercounted, but by how many? Reviewing the
human sensory literature, Robert Rivlin and Karen Gravelle\textsuperscript{4} opine: “Five \textsuperscript{1} is obviously just not enough to account for the huge range of sensory possibilities of which the human species is capable; \textbf{seventeen} senses is probably a more accurate count\textsuperscript{2} (ibid., p. 17; my emphasis).

Lurking behind the empirical seeming question of the number of modalities, we find a philosophical question of how we ought to count them. By what criterion (or set of criteria) should we count individual senses? I believe it is wise to recognize two different versions of this problem. The first version I call Aristotle’s problem: How many modalities do humans have and how ought we decide the issue? This version of the problem is rather hoary, and I do not believe I need to introduce it further.

The same problem arises again, in a slightly different guise, in animal sensory biology. Aristotle not only counted a total of five \textit{human} senses, he thought that was the number found in the entire animal kingdom. We also have good reason to believe, however, that he underestimated the sensory skills of other species. The animal kingdom is full of all sorts of wonderful ways of detecting the world. Certain snakes and boas use special pits below their eyes to sense infrared.\textsuperscript{5} It has been proposed that certain fish, such as shad, can hear in the ultrasonic frequency range,\textsuperscript{6} as can bats.\textsuperscript{7}

While all these examples are interesting, one might argue that they are not genuinely different from human sensory capacities. If our ears or eyes, say, were built just a little differently, then we too could hear in the ultrasonic range or see in the infrared. Nonetheless, there are animals with sensory capacities that are extremely alien with respect to human capacities. Sharks are apparently capable of sensing


magnetic fields.\(^8\) There are also animals, including several species of fish, capable of perceiving electric potential.\(^9\)

Consider, for a moment, the star-nosed mole. Perhaps the most striking thing about this animal is the structure that gives the animal its name: a fleshy, tendrilized nose. Casual observation quickly reveals that its star-shaped nose is most likely a sense organ. The mole constantly jabs it against the ground when exploring the environment. For the sensory biologist, a question arises: given that the nose is a sense organ, what modality is involved? Is the nose a tactile receptor, a chemoreceptor, or perhaps even an electroreceptor? These questions have been a topic of recent debate in biology. In 1993, scientists\(^10\) at the Smithsonian Institution published experiments suggesting that the star-nosed mole uses its nose for electroreception. Others\(^11\) dispute this claim, and the recent work of Kenneth C. Catania and Jon H. Kaas\(^12\) argues that the nose’s modality is most likely tactile in nature.

What I shall call the star-nosed mole problem is the general philosophical problem raised by this type of scientific controversy. On what philosophical grounds should we decide which organisms possess which modalities? When scientists claim to have discovered a new sensory modality, what is the theoretical content of this claim? If philosophers have paid relatively little attention to Aristotle’s problem, they have almost completely ignored this related problem.

The above discussion gives some feel for what I take the question to be. But before continuing, I shall say a little more about my assumptions concerning the appropriate form of the answer. I introduced the topic by proposing that we should think of the sensory modalities as “avenues” into the organism for information about the physical state of the external world. Further, I draw the boundary at the edge of the CNS. At this point, three questions arise.


First, why draw a boundary at all? Central to the concept of perception is that there is a duality: a perceiver and a perceived. Senses do not exist *en vacua*; they are possessed by “sensers” and, at the most basic level of analysis, they act as some kind of informational connection between the world and the psychological entity that possesses them. A theory of perception must posit such a boundary between perceiver and perceived. The concept of modality would then refer to the different ways in which information about the world crosses that boundary.

Second, if we must draw such a boundary, is it not necessarily arbitrary? Why draw the boundary at one place versus another? My answer is that drawing the boundary at the CNS is not arbitrary if we keep in mind my initial starting point: I am here presenting a concept of sensory modality which is useful to sciences that deal with human and animal perception. Given an environment and some kind of psychological system under investigation—two things I am assuming here—a sensory modality is a potential mode by which information in the environment can pass through some boundary and enter into the psychological system. If we are materialists and believe that the central nervous system is somehow the locus of the mind, then it is not arbitrary to draw the boundary between the environment and the psychological system at the “world/CNS” junction.

Finally, I claim that the appropriate boundary surrounds the CNS and not the body in general. I do not have space to go into an example here, but I wish to leave open the possibility of “internal modalities”—for example, proprioception or our sense of thirst (mediated by hypothalamic blood osmotic pressure receptors). The point in these examples is that information about the world external to the CNS (in this case, the body) is passing across the conceptual boundary surrounding the CNS along a particular pathway that represents a mode of interaction different from other pathways.

### III. FOUR PROPOSED CRITERIA FOR INDIVIDUATING THE SENSES

So much for preamble. Now, I shall survey the four criteria that I believe, taken together, constitute the best account of modality differentiation. These criteria are, I propose, individually necessary and jointly sufficient. I shall discuss why each is a necessary component of a correct account, as well as what is insufficient about each taken on its own.

1. **Physics**: the external physical conditions upon which the senses depend. That is, we might distinguish the senses by reference to the physical qualities of their respective stimuli: vision is the detection of differences in electromagnetic stimuli; olfaction is the detection of differences in concentrations of chemical stimuli.
Sensory systems operate by physiologically responding to different forms of energy in the environment. Independent of any psychological and biological concerns, physics provides us with an ontology of energy forms. According to our best physics, electromagnetic phenomena are just different from mechanical energy, both of which are different from chemical gradients. This ontology provides a foundation for a nonarbitrary sensory differentiation.

In providing an ontology of forms of energy, what physics provides is the space of possible modalities. Whether any animal on earth makes use of a magnetic modality or not, the fact that physics identifies magnetism as a type of energy raises the possibility of a magnetic modality. Although necessary, physics is not a sufficient criterion. By itself, physics tells us nothing about which modalities actually exist. Physics can give us magnetism as a form of energy, but in order for there to be a magnetic modality, there must be organisms capable of sensing this physical class of stimuli.

(2) Neurobiology: the character of the putative sense organs and their modes of connection with the brain. For example, vision is what we do with our eyes; audition is what we do with our cochlea and associated auditory brain areas.

This would seem to be the additional “contribution of the organism” required by the discussion of (1). It also matches well with some of our naive notions of modality individuation; that is, we individuate our modalities in part on the basis of our sense organs. As Armstrong points out, however, individuating sense organs is itself no mean problem. Following a suggestion by Anthony Kenny, Armstrong proposes (ibid., pp. 211-13) that sense organs are bodily structures that we actively use to gain information about the world, as when we open and move our eyes to see or cock our head to hear. But he continues, this runs up against the problem that we do not actively move organs in all the putative cases of sense. For example, we do not do anything to gain vestibular information. It seems to be ever present (which might explain why Aristotle did not remark upon it). The use of an organ in active perception does not seem to be of help here.

My suggestion is to follow sensory neurobiology and look for physiological, anatomical, and morphological characteristics to indi-

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viduate sense organs. A legitimate sense organ, I suggest, has three characteristics:

First, it has to be an organ that physiologically responds to a naturally occurring degree of physical stimulation. If the organ in question is a genuinely magnetoreceptive organ, then it needs to respond to the presentation of appropriate amounts of magnetic stimulation.

Second, a sense organ needs to be innervated by neurons; in other words, something cannot be a sense organ unless it is “wired up” properly to the CNS. (Hence, the neurobiology criterion explicitly helps rule out vestigial sense organs.)

Third, we need to be able to identify an “end organ” of some type; the neurons leading to the CNS from the putative sense organ need to start there. This is to discount as sense organs the second, third, fourth, and so on neurons in the chain leading from the sensory periphery. A sense organ must contain cells that respond to energy in the environment, not another nerve cell. Most legitimate sense organs feature morphologically distinct end organs (for example, the rods and cones of the eye) that are physically so constituted as to transduce some class of energy (say, photons) into the electrochemical energy of neurons. But some senses seem to make use of so-called “free nerve endings” without any identifiable end organ. In these cases, however, the putative sensory cells still lie at the beginning of a chain of neurons leading to the CNS. In its usage here, the stress is on end rather than organ.

There is, of course, more to be said here, but suffice it to say, I think it is possible to deal with the issue of individuating sense organs. I said above that this criterion “helps” deal with the problem of vestigial organs. It does not completely rule them out, however, which indicates the insufficiency of this criterion. It is possible to conceive of an end organ which is wired up to the CNS, but which passes on information of which the animal never makes any use. To have a genuine modality, it is not enough to have an organ of a particular type wired up to the CNS; that organ has to allow you to do the right sorts of things. Hence, the next criterion:

(3) Behavior: the ability to discriminate behaviorally between stimuli that differ only in terms of a particular physical energy type.

15 It must to respond to a naturally occurring degree of physical stimulation. The reason for this additional lemma will be discussed under criterion (4), dedication, below.
Part of what it means to have a modality is to be able to make behavioral discriminations within that modality. Once again, the suggestion of this individuating criterion generates further individuation requirements. To wit, how ought we individuate “behaviors?” For example, it seems odd to identify tanning as a behavior. My plan here is simply to follow Fred Dretske16 on this issue: “behavior is endogenously produced movement, movement that has its causal origins within the system whose parts are moving” (ibid., p. 2). Tanning is something that happens to a person, not something one does. On the other hand, pressing a button or vocalizing are paradigmatic behaviors.

The science that is arguably most invested in the study of the relationship between behavior and the senses is the science of psychophysics. In his Sensory Qualities, Austen Clark17 wields the impressive conceptual and empirical framework of psychophysics to ground an account of qualitative appearances which is materialist in spirit and which answers a variety of philosophical questions concerning the nature of appearances. Furthermore, he proposes that psychophysics alone has the resources to individuate the sensory modalities. For this reason, I shall now go into that proposal in some detail to show why the behavior criterion taken alone is insufficient to differentiate the senses.

Central to Clark’s account is the psychophysical concept of “matching” (taken originally from Goodman18). “Matching” is the relation between two stimuli that differ physically but are nonetheless in principle indiscriminable from one another. For example, two color patches might reflect slightly different wavelengths of light, but differ so minutely that any human subject would report that the two patches are perceptually identical. Perhaps surprisingly, it turns out that the matching relation is nontransitive: stimulus A may match stimulus B, and stimulus B match stimulus C, but stimulus A need not match stimulus C. Using this relationship, one can construct “matching spans” of stimuli in which each stimulus matches its immediate neighbors, but the ends of the spans are easily discriminable.19 For example, we can construct such matching spans for color, creating a series of stimuli that vary infinitesimally by wavelength from red to green, say. A given observer, when presented with any two adjacent elements from this series, will be unable in principle to discriminate

19 Clark, pp. 79-84.
them, even though she can clearly distinguish red from green (the ends of the matching span).

This is only a tiny fraction of the story Clark tells, but it is all we need to understand his proposal for individuating modalities (also taken from Goodman):

Facts about matching can individuate modalities. Sensations in a given modality are connected by the matching relation. From any sensation in the given modality, it is possible to reach any other by a sufficiently long series of matching steps. Distinct modalities are not so connected. One can get from red to green by a long series of intermediaries, each matching its neighbors; but no such route links red to C-sharp (op. cit., pp. 140-41).

There are two problems with Clark’s proposal. First, on this account of modality individuation, we get many more modalities than we might have otherwise thought. Clark’s account would entail breaking up the modalities into many submodalities, for not only can you not get from red to C-sharp (thus demarcating vision from audition), you also cannot get from red to “moving left to right across the visual field” (or however motion sensations ought to be described), nor from C-sharp to “darn that’s as loud as a 747 engine from ten feet away” (or however auditory intensity sensations ought to be described). Lacking the appropriate matching relationships, there is no reason to class the “color” and “motion” submodalities of vision as both being submodalities of vision. We are left with an account that makes “color” and “motion” as distinct from one another as each is distinct from “pitch.” Such an account fails to provide the resources for grouping together as “the same modality” sensory qualities that we would intuitively group together. All Clark has shown us is how to individuate submodalities.

Second, Clark’s account attributes the wrong modalities to the wrong organisms. For example, using (3) alone, humans would have an electrical modality! Consider the following: humans are easily capable of discriminating fully charged nine-volt batteries from “dead” ones, simply by sticking them to the tongue. Nine volts is more than enough electricity to stimulate the sensory cells of the tongue. You could do all sorts of interesting psychophysical studies of human electrical discrimination. Yet it seems absurd to claim that humans have an electrical modality, at least not in the same sense as electric fish are thought to. Something more is needed than simply a capacity to discriminate behaviorally stimuli of a certain physical type. We need some acknowledgement of the function of the alleged sensory modality in the species under consideration.
(4) **Dedication**: the evolutionary or developmental importance of the putative sense to an organism. For example, we ought not attribute an electrical modality to an individual unless electrical properties of the world are part of the normal environment of that individual and to which the organism is attuned.

Dedication, a concept taken from the science of neuroethology, is an attempt to make relevant what is biologically important to an organism. Just because a particular individual can behaviorally respond to a particular class of stimuli does not give us warrant to propose a modality for sensing that class of stimuli. In the example above, the reason why it is absurd to attribute an electrical modality to humans is that, as a species, we do not go around using this electrical capacity of our tongues to sense the electrical properties of the world. Electric fish, on the other hand, detect the electrical properties of their world all of the time. It allows them to navigate the nearly opaque environment of the tropical waterways in which they live. It allows them to carry out a nocturnal lifestyle, which in turn gives them a fitness advantage over nonelectroreceptive fish.

Neuroethologists, neurobiologists who study the evolution and neural basis of animal behavior, make a distinction that is useful here. The suffix *-detection* is applied to any organism that is capable of responding, by any means, to the presence of a particular type of stimulation in the environment. The suffix *-reception* is reserved for those organisms which carry out such sensory discriminations through the use of a dedicated anatomical system of structures. So, they would say that whereas electric fish are capable of electroreception—they can behaviorally respond to electrical stimulation using structures that have evolved specifically to process electrical information about the world—at best, humans are capable of electrodetection—humans detect electrical potential using the pain, taste, and tactile receptors on the tongue. By considering both the developmental history of an individual and the evolutionary history of its species, we can determine to what forms of energy in the world a putative sense organ has become dedicated.

To consider a concrete example, there are at least three different things that can stimulate a vertebrate eye: (1) photons, (2) mechanical distortion (as when you press the eyeball with a finger), and (3) a properly inserted stimulating electrode (as in a neurophysiological

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21 See my “Fixing Content and Function in Neurobiological Systems: The Neuroethology of Electroreception.”
experiment). These are quite clearly three different forms of energy (electromagnetic, mechanical, and electrical, respectively) to which the eye qua sense organ is physiologically responsive (satisfying criteria (1) and (2)). All three types of stimulation can elicit behavior as required by criterion (3). What makes the eye part of a visual system, but not part of a mechanosensory or stimulating-electrode-receptive system, is the evolutionary history of those vertebrates which have eyes. It is this history which determines to what sense a putative sense organ is dedicated. Dedication, in turn, allows us to distinguish those animals which genuinely possess a given sensory modality from those which have figured out a way of using some other sense to make occasional inferences about the world.

At this point, I can finally address an account that has likely bothered some readers by its absence in this discussion: ecological psychology. In *The Senses Considered as Perceptual Systems*, J. J. Gibson offers a characterization of the senses at odds with many other accounts in psychology. As Heil points out (op. cit., pp. 10-11), Gibson does not directly address Aristotle’s and the star-nosed mole problems, but such an account seems implicit in his work (and I shall rely on Heil’s explication here). According to Heil, “Gibson’s fundamental notion is that perceiving is the picking up of information about the world made available to the perceiver by various sorts of physical stimulation” (op. cit., p. 10). The notion of “information” is critical to the Gibsonian account, and it is at the crux of why I part company with them. Gibsonians hold that it makes sense to attribute a sensory modality to any organism that can act on structured stimuli of a particular physical type regardless of how that information is obtained by the organism. Take the case of a blind person equipped with a video camera and mechanism that converts the visual image into an isomorphic pattern of vibrating pins placed against the skin, as in the 1970s experiments with “tactile visual substitution systems” (TVSS) made famous by the work of P. Bach-y-Rita. On the ecological psychology account, therefore, it makes sense to say that TVSS-equipped persons can see (albeit poorly)—that they have a visual modality.

Given what I just said about the distinction between detection and reception, however, it should be clear why I disagree here. A TVSS-equipped, but otherwise blind, individual is capable of visual detec-

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tion, not visual reception. Such persons should no more be said to have a visual modality than all of us should be said to have an electrical modality just because we can detect electricity with our tongues. It is true that they are getting visual information about the world, but they are getting that information via their tactile modality. Giving a blind person a TVSS system does not give them a modality they did not have before. Rather, it allows them to make better use of the modalities they already have. To the extent that ecological psychology fails to draw this distinction, it does not give us an adequate account of the senses.

The distinction at play here is that between the content of the senses and the mode of perceptual interaction between the organism and the world. Sensory modality is not simply an issue of what things in the external world can become the content of an individual's psychological states, but rather the mode by which that content comes into the organism. It may well be the case that a blind person can come to have every propositional attitude a sighted person has. But such an individual is still blind; he lacks the modality of vision. He has one less modality than typical members of his species. He has just cleverly jury rigged a sensory system dedicated to the reception of mechanical distortion (his skin) into one capable of providing him with generally reliable information about the electromagnetic spectrum. But his perceptual mode of interaction with the "visual world" is tactile.

What this example shows is that there is more that we may wish to learn about perception than simply what modalities are at play. But an understanding of modalities will help us recognize an important way in which a TVSS-equipped blind person and others differ perceptually: one (the blind person) lacks a sensory system dedicated to the perception of electromagnetic stimuli which another person (a sighted one) has. One lacks a modality that the other one has, just as electric fish possess a modality (electroreception) that humans lack, although, thanks to our ingenuity, we can sometimes obtain information about the electrical world.

IV. TWO CRITERIA TO BE REJECTED

In the preceding section, I argued for the four criteria that I believe are necessary to differentiate the senses. Other criteria have been proposed. On my account, however, they are misapplied to Aristotle's and the star-nosed mole problems. Nonetheless, they are worth considering in some detail, if only because they have a great deal of intuitive plausibility.
In perhaps the twentieth century’s most cited discussion of Aristotle’s problem, Grice (op. cit.) discusses a set of four criteria for distinguishing the senses: proper objects, sensation, neurobiology, and physics. The bulk of Grice’s paper, however, is not spent arguing for the adequacy of these four criteria, but rather discussing the relationship between the first two:

(5) **The proper objects of sensation** is the special features detectable by the operation of the senses; that is, “the differing features that we become aware of by means of [the senses]” (op. cit., p. 250). For example, through vision, we become aware of colors; through audition, degrees of loudness.

(6) **Sensation**: “It might be suggested that two senses, for example seeing and smelling, are to be distinguished by the special introspectible character of the experiences of seeing and smelling; that is, disregarding the differences between the characteristics we learn about by sight and smell, we are entitled to say that seeing is itself different in character from smelling” (op. cit., p. 250).

Grice’s first criterion (our (5)) is perhaps the most venerable approach to the issues at hand. This is the account to be found in Aristotle’s *De Anima*, Book ii.\(^{24}\) He points out that there are qualities, such as color, that are perceived only by a single sense. These are the “proper objects” of these senses, “the things to which the very being of each sense is naturally related” (ibid., p. 56). Aristotle goes on to contrast the proper objects with the “common sensibles”—number, shape, magnitude, motion, rest, and so on—which are qualities that are sensible by multiple modalities. Therefore, on this account, one first identifies the formal objects that are proper to only one sense, and based on that list we can derive a classification of the senses related to those objects.

In a sense, Aristotle's criterion can be seen as a primitive version of the physics criterion (1) in that a proper object account draws a strong connection between the categories of physics and those of our phenomenology. The categories of Aristotelian physics are the categories of common-sense physics. Of course, it is always open to us to reinterpret Aristotle’s account in light of contemporary physics and argue, for instance, that “wavelength of electromagnetic energy” and not “color” is the true proper object of vision. But such a reinterpretation represents such a significant change to

the common-sense nature of Aristotle’s original proposal that it seems appropriate to identify it as a different proposal.25

Grice’s26 second criterion (our (6)) proposes to individuate modalities by reference to the “special introspectible character,” or what might be more commonly referred to as the distinct sensations or qualia associated with each given sensory modality. Since each sense has its own unique experiential quality, we can use these qualities to differentiate the senses. The second criterion would have us catalogue the different experiences we have, sorting them in terms of similarity and difference, and end up with several sets of related experiences that are the different modalities: the visual experiences, the olfactory experiences, and so on.

While these two criteria seem independent of one another, one of the central goals of Grice’s article is to argue that they are not: any attempt to make suggestion (5) work leads to difficulties which seem soluble only if we bring in suggestion (6); yet suggestion (6) in turn involves difficulties which seem soluble only by adopting suggestion (5) (op. cit., p. 259). I do not wish to regurgitate Grice’s clear, and to my mind correct, arguments for the interdependence of these criteria. But to motivate my critique of the sensation criterion below, let me present half of it—the dependence of proper objects on sensations.

25 At this point, I should mention two relatively recent approaches that are suggested improvements on Aristotle’s “proper object” account. Both are attempts to spell out an account of the senses based on the content of perception; spelled out in terms of either “key features” (Roxbee Cox, op. cit.) or “primary objects” of perception (David H. Sanford, “The Primary Objects of Perception,” Mind, lxxxv (1976): 189-208). In addition, Lopes (op. cit.) has recently endorsed a sensation-based account. He does not actively argue for it, however. Instead, he concentrates his attention on showing the inadequacies of Dretske’s position (Naturalizing the Mind (Cambridge: MIT, 1995)) that we can make sense of the senses using an appropriate theory of content. At best, Lopes seems to ignore the possibility of unconscious sensory modalities. At worst, he rules them out by stipulation: “what it is like to perceive in one sense modality is different from what it is like to perceive in others—each has a unique ‘phenomenal character’—and this is a fact which any theory of perception must take account” (op. cit., p. 439). My disagreement with this claim should be clear from the discussion of criterion (6) below. (Cf. Dretske, “Reply to Lopes,” Philosophy and Phenomenological Research, lx (2000): 455-59. See also Nelkin (op. cit.), and Ross (op. cit.) for related content-based approaches to the senses that regrettably I do not have space here to engage.)

26 Grice does not use the terms ‘proper objects of sensation’ or ‘sensation’ or ‘qualia’ in his discussion of the senses. But what he says about each position seems to line up well with the common uses of these terms, so for pedagogical reasons, and to place Grice’s discussion in a broader context, I shall use these terms to identify his criteria.
Grice begins by following the suggestion of the proper objects criterion. He identifies a series of perceptual features of the world that are independent of the agent—for example, color, pitch, and temperature. This then allows us to individuate the senses using this list, without any reference to the way such features are experienced by a perceiver. At this point, a problem arises: “According to [the proper object criterion], certain properties are listed as visual properties, certain others as tactual properties, and so forth; and to say that color is a visual property would seem to amount to no more than saying that color is a member of a group of properties the others of which are...[sic]. This leaves membership of the group as an apparently arbitrary matter” (op. cit., p. 255). That is to say, relying on the proper objects of sense does not tell us by virtue of what these properties are the proper objects of vision, whereas those properties are the proper objects of touch. Of course, the obvious thing that classes these properties together is that we see the visual ones, and tactualy feel the tactile ones. But to invoke this feature is to revert to the sensation criterion.

A second problem with the proper objects criterion is that it breaks down once you try to put it into practice. That color is a proper object of vision seems uncontroversial. But is warmth a proper object of the tactile sense? This seems correct until we realize that one can occasionally see the temperature of objects, as when the blacksmith sees that the red glowing metal bar next to the furnace is hot. The clear response to this worry is to draw a distinction between directly sensing temperature (as the tactile sense does) and inferring temperature (as we sometimes do with our visual senses). The proper objects of a sense are those which it directly senses. Grice demonstrates over several pages, however, that we cannot make sense of this suggested distinction without cashing out the notion of “directness” in terms of having a particular qualitative experience; for example, directly sensing warmth is to experience a sensation of warmth, something you get through the tactile sense and never through the visual sense (op. cit., pp. 251-55). Once again, criterion (5) only makes sense by invoking criterion (6).

Given the above arguments, the cogency of criterion (5) rests on the foundation provided by criterion (6). How firm is this foundation? Grice argues that any account of the senses in terms of experiential character of sensation rests, in turn, on an account in terms of proper objects. I want to take a different tack. I accept that a proper object account rests on an account of sensation, but argue that we cannot use the experiential character of sensation to differentiate the senses. Both proper objects
What is wrong with using the experiential character of sensation as a criterion for individuating the senses? There are two problems with this approach. First, while potentially useful for solving Aristotle’s problem, it is less clear what use it is in solving the star-nosed mole problem. Do we have to believe in the existence of electrical qualia, say, before we can sensibly talk of an electrical modality in electric fish or decide whether the star-nosed mole has an electrical modality? It seems to require that we be able to answer Thomas Nagel type questions concerning what it is like to be an electric fish or star-nosed mole. This point echoes one made by Coady: “Further difficulties will arise for a Gricean view from the fact that we commonly attribute sight, touch, hearing, etc. to dumb animals and here we not only make no use of [the sensation criterion] but there seems to be no way in which we could” (op. cit., p. 111).

Of course, there is never a guarantee that philosophical analysis will make science easy (or even possible), and we might just have to accept that science cannot answer the star-nosed mole problem until it has overcome the worries raised by Nagel. I think, however, that there are other reasons for rejecting criterion (6) which render Nagel mute on the issue at hand. Grice’s proposal runs into problems even with humans, because there is reason to believe that there are legitimate sensory modalities that lack a special introspectible character altogether.

Consider the case of the vomeronasal system. Admittedly, there is still controversy as to whether humans possess this modality, but over the past decade evidence in its favor has begun to mount. Furthermore, if we in fact possess this system, two things about it are striking: first, it plays a significant role in human behavior; and, second, we experience no sensations associated with this modality—there is no “special introspectible character” here, hence no basis to individuate this modality from any other. It would appear to be a modality without sensory experiences.

In almost all vertebrates investigated, airborne chemicals are detected by multiple anatomical systems. One is the well-known system

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27 In addition to Grice, Mark Leon—“Characterising the Senses,” Mind and Language, III (1988): 243-70—also argues for a sensation-based approach to differentiating the senses. But he is mainly concerned to counter the criticisms of Grice and to distinguish his account from belief-based approaches. He does not address the issues I raise here. Lopes (op. cit.) also endorses criterion (6), but see footnote 25 above.

involving the olfactory epithelium within the nasal cavity containing chemosensory cells that project to the olfactory bulb. In humans, this is the system responsible for smell and taste experiences. In most animals, this system is primarily responsible for the detection and evaluation of food.

There is a second system, however, that is primarily social in function. The vomeronasal organ is located in a pair of pits on either side of the nasal septum. The vomeronasal system is primarily responsible for detecting pheromones, which in turn have been shown to play a central role in reproductive behavior. For example, animals with lesioned vomeronasal organs typically exhibit greatly reduced sexual behavior. Similarly, artificially stimulating this organ and the nuclei to which it projects generally produces sexual behaviors in the animal so manipulated, even in the absence of appropriate conspecifics.

Do humans have a vomeronasal system? The textbook answer has traditionally been that while this system is present in human fetuses, it disappears during normal development. In recent years, however, this received wisdom has been called into question. In terms of anatomy—contrary to the textbooks—vomeronasal pits are present in most adult humans. Furthermore, the pits are innervated by sensory neurons.

Behaviorally, there is a growing list of findings in humans that closely resemble behaviors carried out by the vomeronasal system in other species. This, combined with the fact that these behaviors seem to have no conscious correlates, suggests the presence of a nonconscious modality in humans. First, it has been reported that individuals can detect the gender of another based on smelling the breath alone. Some women are reportedly able to identify the gender of a breather with an accuracy of ninety-five percent! Second, clinicians have

34 Rivlin and Gravelle, p. 154.
observed that damage to the nerves in the nasal region is often, but not always, associated with a loss of interest in sex. (Because medical students have typically been taught that humans do not have a vomeronasal organ, however, nobody has pursued a study of naturally occurring lesions to the vomeronasal versus olfactory epithelial systems in humans. Therefore, to my knowledge, no attempt has been made to try to tease apart the functions of these two systems, as has been done in nonhuman animals.)

While the science is admittedly controversial here, the possibility of a human vomeronasal system stands as a potentially interesting case of a modality without a special introspectible experiential character. Women who can guess the gender of breath do not report that they experience “male” versus “female” qualia associated with the breaths. Indeed, subjects are generally surprised to be informed that they are so good at distinguishing the smells. Gender detection via the putative vomeronasal sense seems akin to an olfactory version of blindsight. And if it is a modality that lacks qualia, then criterion (6) cannot even begin to distinguish this modality from others.

Many will no doubt be surprised by the above arguments that the differentiation of the senses is independent of any appeal to the experiences associated with the senses. A commentator on an early version of this article put it this way: “Much of the bad press over qualia is well-deserved; but if there is one place experiential qualities have a safe home, I would’ve thought it would be with the sense modalities.” In response, I would say that experiential qualities do have a safe home in the modalities. Much of what we experience, we experience through the senses. My argument here is not that there is no such thing as sensory experience, but rather that we should not use those experiences to differentiate the senses. Experience is often associated with the senses, but its nature does not define the difference between the individual senses.

36 Tom Polger made this comment at the 1999 Society for Philosophy and Psychology meeting in Palo Alto, California.
37 For reasons of space, one issue I have not discussed here is the assumption that the senses are “fairly discrete systems,” as Leon puts it (*op. cit.*, p. 245, footnote 1). It is common to assume that the different senses are significantly separate and independent of one another. Indeed, this assumption motivates the questions discussed here. To my knowledge, this ubiquitous assumption has received even less attention in the philosophical literature than the star-nosed mole and Aristotle problems; a curious observation given the existence of empirical phenomena that raise questions about it. I am thinking here of synesthesia: Richard E. Cytowic, *Synesthesia: A Union of the Senses* (New York: Springer, 1989), *The Man Who Tasted
V. IMPLICATIONS: WHAT SENSES DO HUMANS AND OTHERS HAVE?
The proof, they say, is in the pudding, and I conclude by showing how my account deals with some actual cases by spelling out its philosophical implications. First, let us consider Aristotle’s problem. On my account, vision, hearing, touch, smell, and taste come out as different senses. Each involves sense organs dedicated to the detection of a different class of physical stimulation. If future science pans out as I have described it above, humans should be said to have a vomeronasal modality as well. We also have a vestibular sense (based in the semicircular canals in our heads) as well as a proprioceptive system (based in the stretch receptors in our skeletal muscles).

At the same time, on my account, humans should not be said to have an electric sense because we have as yet discovered no organ that is dedicated to the processing of electrical information in our environment. As noted above, we can access electrical information through our tongues, but only by electrically stimulating sensory systems that are normally responsive to other physical properties—physical properties that are part of the normal human sensory environment. On the other hand, electric fish should be said to have an electrical sensory modality because these organisms have organs that have evolved specifically to process biologically meaningful electrical stimuli in their environments.

What about the star-nosed mole? On my account here, the nose of a star-nosed mole would seem to be best thought of as mediating a tactile sense. Although it is true that sensory cells in the nose of this animal can be stimulated by the presentation of electricity, as with the case of the human tongue, I realize that this fact does not settle the issue. All sensory cells, when blasted with enough electricity, can be made to respond. The question is whether there is any reason to believe that the amount of electricity required to stimulate the nose of a star-nosed mole is within the range that would make it likely that their noses had evolved this capacity. Is the detection of electricity a dedicated function of star-nosed mole noses? To date, such evidence

Shapes: A Bizarre Medical Mystery Offers Revolutionary Insights into Emotions, Reasoning and Consciousness (New York: Putnam, 1993), and the McGurk effect—H. McGurk and J. MacDonald, “Hearing Lips and Seeing Voices,” Nature, CCLXIV (1976): 747-48. In the neurological-condition synesthesia, the proper objects of one sense result in experiences in more than one modality—for example, “colored-hearing.” In the McGurk effect, normal humans will literally hear the same auditory speech stimulus differently, depending on what they see (lip movements of one sort versus another). It is not clear what effect such interaction between senses has on the story I am telling here. Unfortunately, to explore the issue fully would require another article.
has not been forthcoming. On the other hand, the work of Catania (op. cit.) indicates that these same sensory cells are responsive to tactile stimulation and, furthermore, that the range of mechanical stimulation required falls within an ecologically plausible range. With such a nose, a star-nosed mole is able to make all sorts of useful sensory discriminations of the texture, motion, and shape of objects that it places its nose upon. What is more, Catania has done careful comparative studies indicating that the sensory end organs on the nose of the star-nosed mole are likely modified versions of the tactile-sensing end organs found in related species of moles, which in turn are modified versions of the basic tactile-sensing end organs found in most mammals, including humans. All of these discoveries point to the conclusion that the nose of a star-nosed mole is properly thought of as a tactile-sensor.

The sort of story told about the star-nosed mole can be used as a template in the cases of all putative sensory modalities in nonhuman animals. If, for example, one wishes to argue for the presence of a magnetic sense in migratory birds or an electrical sense in the platypus, then the same set of evidence needs to be collected. One must characterize the target of the sense in physical terms (What range of magnetic stimulation? Exactly what electrical properties?). One must demonstrate via the organisms' behavior that the organisms in question can make use of the alleged sense. One must find a sense organ that can transduce this information from the environment to the CNS of the organism. Finally, one must demonstrate that this organ has the evolutionary or developmental function to carry out such sensory transductions. Only if you do all four of these things can you properly talk of the animal as having the sense in question.

Those are the scientific implications of my account. What of the philosophical ones? If the account that I have presented here is plausible, then it represents a strong, naturalized alternative to the more common-sense approaches to the issues typically favored by philosophers. For the purposes of the perceptual sciences, at least, distinguishing the senses from one another is not a matter of such folk-scientific entities as the proper objects of sensation or some specific qualitative feel of conscious perceptual experience. Strictly speaking, this is not to say that qualia do not exist, but rather that they do not have a role to play in this particular scientific story, however useful they may be to our folk understanding of ourselves. Defenders of qualia need to look elsewhere for scientific legitimacy.

If you are unconvinced with the positive story I have told here, I hope to have at least persuaded you that there are interesting philosophical and scientific questions yet to be answered concerning the
differentiation of the senses in humans and other animals. At the same time, I believe I have shown that some of the more intuitive criteria for partitioning our senses run into problems, particularly when it comes to such potentially novel senses as proprioception and the vomeronasal sense, not to mention those of such exotic animals as star-nosed moles and electric fish. The principled extension of common-sense concepts into novel domains is a long-standing project in philosophy. I hope that this discussion has shown that there is still interesting contemporary work to be done on ancient problems.

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