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# Individuating the Senses

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The senses, or sensory modalities, constitute the different ways we have of perceiving the world, such as seeing, hearing, touching, tasting, and smelling. But what makes the senses different? How many senses are there? How many could there be? What interaction takes place between the senses? This introduction is a guide to thinking about these questions.

One reason that these questions are important is that we are receiving a huge influx of new information from the sciences that challenges some traditional philosophical views about the senses. This information needs to be incorporated into our view of the senses and perception. Can we do this while retaining our preexisting concepts of the senses and of perception, or do we need to revise our concepts? If they need to be revised, then in what way should that be done? Research in diverse areas such as the nature of human perception, varieties of nonhuman animal perception, the interaction between different sensory modalities, perceptual disorders, and possible treatments for them calls into question the platitude that there are five senses, as well as the presupposition that we know what we are counting when we count them as five (or more). In the following sections I provide an overview of the main issues. In addition to explicating existing views of how to individuate the senses, I advance my own view about how one should do so by providing a framework within which we can situate our existing notions of the senses and other actual and possible ones. Finally, I provide an overview of the classic works and the new work commissioned for this volume.

It is an exciting time to be interested in the senses. One reason, mentioned earlier, is that scientists are now uncovering lots of interesting facts about the way in which nonhuman animals sense the world. The apparently wide and varied nature of senses in the animal kingdom provides lots of new empirical data to consider. For example, scientists claim that some animals can perceive the world by means of magnetic fields (e.g., pigeons), electric fields (e.g., many fish), infrared (e.g., pit vipers and some beetles), and echolocation (e.g., bats and dolphins).

Another reason is that scientists are discovering a great deal about the human senses on three fronts. First, they are discovering ways in which our senses and ways of perceiving the world can break down—ways that previously might not have been thought possible. For example, in blindsight, people claim to have either no visual experience or none in one portion of their visual field, typically half of their visual field. With respect to that portion, they claim to be blind and, for the most part, interact with the world the way blind people do.[1] The brain damage that they have suffered to their visual cortex backs up their claim that their vision is damaged. Yet, with respect to the blind portion of their visual field, these people can make accurate guesses (up to 99 percent accurate) about what is before them in the world in a forced-choice paradigm (that is, when asked to select between certain options presented to them). For example, if a vertical line were presented in the blind portion of a subject's visual field, the subject would not spontaneously be able to say what was there. However, if the subject were asked to guess whether a line that was there was vertical or

horizontal, the subject would be able to guess correctly. Weiskrantz reports that subjects with blindsight:

> are able, in their blindfield hemifields, to detect the presence of stimuli, to locate them in space, to discriminate direction of movement, to discriminate orientation of lines, to be able to judge whether stimuli in the blindfield match or mismatch those in the intact hemifield, and to discriminate between different wavelengths of light, that is, to tell colours apart. (1997, 23)

This illustrates that information about the world is still being processed by the subjects' visual systems and can, to a limited degree, affect the subjects' behavior.

Another example comes from people suffering from a form of visual agnosia. Due to their condition they cannot identify common objects by sight—objects that we know they are familiar with and can identify using their other senses—despite the fact that they can draw the objects on the basis of their current visual experience of them.[2] A third example is that some people with damage to the visual cortex appear to be able to detect certain properties that we can detect with our eyes, but not all. For example, they may be able to detect movement but not shape or color. Thus, their visual experiences must be very degraded compared to those of normal subjects.

These types of cases are interesting as they demonstrate the existence of forms of experience or perception that are very different from our own and which theories of the sensory modalities ought to be able to account for. For example, some people think that the blindsight case provides a challenge to

traditional accounts of perception that analyze perception in terms of having appropriate kinds of perceptual experiences because it is an example of perception in the absence of perceptual experience. The other cases provide examples of apparently degraded experience which challenges traditional accounts of the differences between the senses that appeal to characteristic kinds of experience associated with each sense. Can such accounts be preserved? Can we provide better ones? Or should such cases make us think that there can be amodal perception?

The second front on which science is making progress concerning human perception is in creating forms of prosthetic vision. There are now devices that allow the output from a camera placed on a subject's forehead to directly stimulate the subject's retina or visual cortex, apparently creating some crude form of visual experience that subjects can use to navigate obstacles. There are also sensory substitution devices that take output from a camera mounted on the subject's head and convert it to aural or haptic (tactile) signals that are then given to a subject. For example, a camera might drive a series of vibrating pins on a subject's back corresponding to the levels of light and dark that the camera detects. These devices allow the subject to detect three-dimensional objects at a distance from the subject's body and on the basis of this information navigate through space.[3] Again, a theory of the sensory modalities should be able to account for such novel means of apparently perceiving the world and be able to classify them. These cases of prosthetic perception will create particular difficulties for theories that try to categorize the senses by virtue of the sensory mechanisms or physical processes that partly constitute them.

The third front on which scientists are discovering facts about human perception concerns the mechanisms underlying ordinary human perception. For example, more is being learned about the mechanisms underlying our sense of touch. It turns out that there are very different and fairly discrete mechanisms for detecting properties associated with the sense of touch such as pressure, temperature, and pain. In addition, scientists are studying other types of receptors in the body that detect and process information: the semicircular canals, which deliver information about position with respect to gravity; the stretch receptors in the muscles, which deliver information about the position and movement of parts of the body; receptors for detecting pheromones in the Jacobson's organ in the nose. These facts have suggested to some that humans may have more ways of perceiving the world than has been traditionally thought.[4]

All these scientific advances provide a rich seam of empirical facts for philosophers of the senses to troll and mine in developing theories of the nature and individuation of the senses.

## 1. How Many Senses: The *Token* Question

Of any creature we can ask:

(1) How many token senses does it have?

(2) What types are those senses?

Types are general kinds of thing, and tokens are instances of types. For example, in the word "proclivities," there are ten types of letter but twelve letter tokens. This is because there are three tokens of the same type: "i."

Questions 1 and 2 are very different questions, and it is important to keep them separate. This is not always as easy as it may seem, however, and failure to do so can lead to confused thinking.

To illustrate what we would be asking if we asked question 1, imagine that we came across a creature very much like a human but for the fact that it had four eyes—one pair above another. Call the creature "Four-Eyes." Four-Eyes might have one sense of vision, as we do, with all four eyes contributing to it, as our two eyes contribute to ours. Or Four-Eyes might have two distinct senses of vision, with each set of eyes contributing to its two different visual senses. If the latter were the case, and if Four-Eyes had no other senses, then it would have only one *type* of sensory modality, but it would have two *tokens* of that type. (Of course, for all I have said, Four-Eyes might indeed have three or four tokens of the visual sensory modality type, corresponding to its many eyes, and, if it is in other respects like a normal human, it will have other types of sensory modality such as hearing and touch. Moreover, for all I have said, depending on how we further specify the case, there may even be some reason to think that not all of the senses associated with Four-Eyes' eyes are senses of vision. [5])

To answer question 1, one might begin by thinking about the following questions:

(3) Which processes are perceptual processes?

(4) Which processes constitute the totality of processes associated with a modality, and which constitute just parts of the processes associated with a modality?

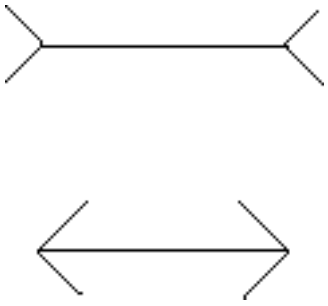
Not all bodily processes are perceptual ones. Digestion, for example, is a process that few would take to constitute a perceptual process.[6] How does one tell which bodily processes are the perceptual ones or part of perceptual ones? One might think that perceptual processes are those that allow a subject to gain information about the world. So perhaps all and only these are perceptual ones.

However, this definition requires further elucidation if it is to be helpful. To make progress, let us consider some familiar facts. In a typical case of perception, say vision, light—which consists of electromagnetic waves—is reflected off objects and enters our eyes. Light-sensitive cells in our retinas detect this light, and then an incredibly complex chain of brain processing begins. The cells in the retina send signals to other cells in the eye, and these send signals to cells that make up the optic nerve—a chain of neurons leading from the eye into the brain. Although signals from the eyes get sent to many areas of the brain, we know that there is an important pathway along which information from the eyes gets sent. This pathway leads to the visual cortex, an area of the brain at the back of the head in which most of the visual processing goes on. This area seems to be crucial for vision. If it is destroyed, for example by a stroke, then blindness ensues even if the eyes are not damaged.[7]

In a typical case of perception, in addition to mere brain activation, we also have a visual experience. That is to say, we go into a conscious state in which we are aware of the world around us. We know that states of one's visual cortex and states of visual consciousness are closely related. There appear to be correlations between the two. The evidence suggests that having one's visual cortex in a certain state is necessary in order to have a certain visual experience (and damage to one's visual cortex can impair one's visual experience). However, the relationship between visual experiences and states of the brain is highly disputed both among scientists and philosophers. Philosophers identify many different relationships that could obtain between the brain and conscious perceptual experiences that would be consistent with the facts that we know. For example, identity theorists think that particular brain states are to be identified with perceptual experiences. Many functionalists think that perceptual experiences are to be identified with any state of the brain that fulfils a certain causal role or with a higher-order state, such as the state of being in a state in which some physical state plays the causal role in question. Some dualists think that brain states may cause mental states to come into existence, but mental states are not physical states of the brain; indeed, they think that they are not physical states at all.[8]

Visual experiences are states that have phenomenal character—which is to say that there is "something that it is like" for one to be in such a state.[9] Most philosophers also think that visual experiences represent the world to be a certain way.[10] When one perceives the world, the world seems a certain way to one, and the way it seems is the way that the experience represents the world as

being. When one specifies what one's experience represents, one specifies the content of the experience. One's experience may be veridical (that is, represent accurately), or it may be inaccurate (either partially or completely). An example of partial inaccuracy would occur when one suffers from some illusion: One sees the world but misperceives it in a certain way. For example, when one looks at the Müller-Lyer illusion, one perceives the two lines but misperceives the lines to have unequal length. One's experience represents one line as longer than the other when they are in fact the same length. An example of complete inaccuracy would be if one suffered a hallucination in which what one seemed to see bore no relation to what was really in front of one. (However, hallucinations need not, by their very nature, be inaccurate; one might have a veridical hallucination, for example, a hallucination of a dagger, and by chance there might be a dagger of the sort that one seems to see in the position in which one seems to see it.)



The Müller-Lyer Illusion

Ascribing content to a subject's visual experiences is a good way to make sense of the subject's behavior. For example, why a subject did something may be explained by how the subject's experience represented the world to be to the

subject, and that way may be accurate or inaccurate. Providing a good explanation of behavior and explaining the accuracies and inaccuracies that we think experiences can have are two reasons to think experiences have content.

(Beliefs and desires are the paradigms of states that have content. These form part of the class of propositional attitudes distinguished by being states in which a subject forms an attitude toward some proposition. For example, when believing, one forms the attitude of holding some proposition to be true, say, that that there are seashells on the beach. When desiring, one desires some proposition to be true, say, that there are seashells on the beach. The proposition in question specifies the content of the belief or desire. The content specifies a way the world could be, and the world may or may not be that way.)

When one perceives an object or a property, what one perceives is called the *distal stimulus*. If one sees a seashell, then the seashell would be the distal stimulus. We can also identify what is called the *proximal stimulus*, that is, whatever it is that directly stimulates the sensory organ. In the example of seeing the seashell, the proximal stimulus would be the light hitting our eyes. In the case of touch, the proximal stimulus might be pressure; in the case of hearing, pressure waves in some medium like air or water, and so on.

So now that we have gone over the simple facts about what happens in a typical case of perception, can we be more specific about what a perceptual process is, as opposed to some nonperceptual process, beyond saying that perceptual process are the ones that allow a subject to gather information about the world?

First, a number of further questions would have to be settled to determine the conditions that are *necessary* for perception. For example, what is it for a subject to obtain information? Must the subject come to form relevant beliefs? Or is that not necessary, as some people have thought, because animals and young children can perceive without believing since they are not cognitively sophisticated enough creatures? Moreover, if the formation of relevant beliefs is not required, then what, exactly, is? Must the subject use that information or be in a position to use it to guide action? Or is that not required because it seems reasonable to think that a completely paralyzed person could perceive while having no possibility of acting? Must the subject have a conscious experience with relevant content in order to perceive? Or is unconscious perception possible? (On the one hand, cases like blindsight, discussed earlier, might make one think unconscious perception is possible, but, on the other hand, it is not obvious that the very limited abilities that blindsight subjects possess, such as guessing from among options presented to them, really amounts to the ability to perceive the world.)

Second, it will not be easy to determine the *sufficient* conditions for a process to be perceptual. For example, one can imagine a subject coming to consciously believe things about the world—perhaps even true, justified things—in a way that seems to involve nonperceptual processes. For instance, verrucas are caused by the human papilloma virus. If one had a verruca, one might thereby come to believe, truly and justifiably, that one was infected with the human papilloma virus. However, plausibly, having a verruca is not a perceptual process or even a part of one. The seeing of the verruca is surely the

perceptual process involved in the belief acquisition, but the having of the verruca is not. We need to think of some way to distinguish processes that are (or are part of) perceptual processes and those that are not.

Question 4 (which processes constitute the totality of processes associated with a modality, and which constitute just parts of the processes associated with a modality?) is a difficult question, too. Recall the creature, Four-Eyes, described earlier. How would one determine whether Four-Eyes had one sense of vision or two, three, or four?

One might think that the creature's physiology would settle the matter. For example, one might think that each sense consists in discrete and completely independent ways of processing information about the world. One might think that the processing of signals from the eyes is completely separate from the processing of signals from the ears. In short, one might think that there are physically isolable systems in the brain corresponding to each sense. Thus, one might think that the number of physiologically discrete perceptual mechanisms Four-Eyes has inside it relating to its eyes will determine how many senses it has. However, when you look at human physiological mechanisms pertaining to our different senses, we find that they are not completely discrete. Two examples illustrate different kinds of lack of discreteness.

One is the McGurk effect.[11] This phenomenon illustrates that there is interaction between what are almost always taken to be two separate sensory modalities in humans: vision and audition. When subjects listen to the sound of a spoken speech phoneme, such as a /ba/, in normal conditions with no visual input, or when looking at the lips of someone who is making a /ba/ sound, they

will report that sound. However, if they listen to that sound in normal conditions except for the fact that they are looking at a video in which a person is making the lip movements suitable for producing a /ga/ sound, subjects report that they hear a different sound, in this case a /da/. Such interaction shows that the mechanisms in humans associated with different modalities are not completely distinct. There must be connections between the mechanisms that explain these and other, cross-modal interactions.[12]

The second example arises from the fact that the deliverances of our senses feed into our one cognitive system (the system comprising and governing beliefs, desires, thoughts, and other propositional attitudes). So, for example, if I hear a scream and I see a dagger, then I can come to have one belief about what I have seen and heard—I can come to have the one belief that there are both a scream *and* a dagger in my environment. This suggests that, although the sensory mechanisms may initially be rather distinct at the point of information reception, there is a convergence of these mechanisms in the cognitive system, which explains how we can have thoughts and beliefs as a result of the deliverances of multiple senses. Thus, one might think that many sensory mechanisms are linked at least at some high level, and therefore it will not be easy to determine just how separate physiological mechanisms must be in order for two or more sensory modalities to be present as opposed to one.

One might resist this thought by holding, as many people do, that sensory mechanisms end as they interface with the cognitive system, so that even if the deliverances of the senses feed into the one cognitive system, this does not undermine the distinctness of the senses. However, plausible as this idea seems,

it can be resisted. One might think that perception and hence the sensory modalities are "cognitively penetrable"—that is to say that one's perceptual experiences, specifically the content of one's perceptual experiences, can be influenced by the content of one's beliefs, thoughts, and desires and other states of the cognitive system, not just in the sense that the cognitive states influence what we choose to perceive via moving our heads and eyes and perhaps focusing attention, but that once those factors are fixed, the cognitive states can influence the nature of that perceptual processing and yield experiences that are different from what would otherwise have been produced in the absence of those cognitive states. Whether the senses are cognitively penetrable or not is a highly disputed matter in contemporary philosophy and psychology. [13] However, if one believed it to be true, one would think that one cannot neatly carve up physiological mechanisms into two sets of isolated mechanisms: all and only those involved in perception (the precognitive) and all and only those involved in cognition (postperception). Therefore, one might think that the sensory mechanisms are not discrete since they each have the cognitive system as a common part.

In summary, the last two examples show that to determine how distinct physiological perceptual processes must be in order for there to be distinctive sensory modalities is a tricky business. It is made even more difficult by some awkward physiological facts surrounding some of our senses. For example, we normally think of touch as one sensory modality, but scientists have revealed that there are in fact at least four different, somewhat discrete physiological mechanisms corresponding to the detection of pressure, pain, warmth, and cold.

Here we face a decision: Does this evidence show that one sensory modality can have distinctive physiological sensory mechanisms associated with it, or does it show that what we typically think of as one sense is really four separate ones? The difficulty in making progress on this question shows that determining the physiological facts may not always be of great help in determining how many senses there are.

Another possible answer to the question of how one determines how many sensory modalities a creature has makes reference to the number of experiences a creature has. For example, consider Four-Eyes again. One might think that whether its eyes yielded one visual experience—as our two eyes do—or whether they yielded two, three, or four separate visual experiences will determine the number of token visual modalities it has. However, it is not obvious that there are good criteria for what makes "one" experience or multiple ones. There are a number of competing views on this issue.

One view is that there are separate experiences just to the extent that there are separate sensory modalities. Such an answer would not be helpful in determining what was a sensory modality on pain of circularity.

A second view is that at any one time we do not have multiple experiences—be they visual, auditory, tactile, or smaller units. Rather, we just have one "large" or "total" experience at any one time. On this view, this experience should not be thought of as having parts that could be enjoyed by themselves and that would constitute experiences. Whatever the merits or demerits of this view, like the previous one, it would not be helpful in

determining the number of token visual senses that Four-Eyes had since, in every case, it would claim that Four-Eyes had only one experience.[14]

A third view is a counterfactual one. To see this view, consider the individuation of experiences (not modalities). Call the totality of one's experiences at a time one's "total" experience. One might think that one's total experience comprises states that are themselves experiences. The parts of one's total experiences that are themselves experiences would be those parts that could be had, counterfactually, without any other experiences. For example, it seems plausible that I could have my auditory experience of music right now without my visual experience or my tactile one or one in any other modality. It also seems failry plausible that I could have the visual experince of the left-hand side of my visual field without that of the right-hand side. But, it does not seem plausible that I could have the experience as of the shape of the square that I am now having without an experience as of its size or position that I am now having. Given these facts, according to a counterfactual view, my auditory experience would comprise an experience, and the visual experience of each half of my visual field would constitute experiences, but my visual experience as of the shape of the square would not for it is not a separate experience from that as of its size or position. (Of course the experience of the square together with all its visible properties might constitute an experience.)

One could use such a counterfactual view to try to settle the question of how many token senses Four-Eyes has. Here is one suggestion for how one might do so. Suppose there is some way of dividing up Four-Eyes' total visual experience into parts, each of which could be had alone and each of which

corresponds to the contribution of a whole number of eyes, and no eye contributes to more than one such part of the experience. Then one could reasonably claim that number of parts is the number of token visual senses that the creature has. For example, if Four-Eyes' experience was such that there were only two parts, each of which could be had alone, and one part was had when Four-Eyes closed its top pair of eyes and the other part was had when Four-Eyes closed its bottom pair of eyes—then according to this view Four-Eyes would have two token senses of vision. The sense organ of one of these senses would be the top pair of eyes; the organ of the other would be the bottom pair.

However, one might object to the counterfactual view. Recall that the McGurk effect seems to show that some auditory and visual experiences had simultaneously by the one subject cannot be divided into parts, each of which is attributable to different sense organs. Thus, the counterfactual view would count them on this occasion as one sense. Nonetheless, vision and hearing seem to be different modalities, and one would have to be radically revisionary to think otherwise. Thus, one might think that the proposed counterfactual methodology may lead one to count too few senses.

One might solve this by insisting that the division of the senses using this technique take place when there is no illusion involved. Then one could hope that cross-modal effects of the McGurk kind all involve illusion—although whether this is true is a matter for further investigation. Alternatively, one might insist that the division of the senses depends on whether the test would be *typically* passed by Four-Eyes' visual experiences and parts of experience. Thus, one might allow that cross-modal effects can take place on some occasions as

long as they are not the norm. Thus, one might hope that cross-modal effects rarely occur.[15] If these hopes do not transpire, then one could do one of two things. One could just conclude that what were thought to be two senses really are one. Or one could hold that sometimes a creature has two senses, say vision and audition, but sometimes the mechanisms underlying these senses combine to produce a different third sense, an audiovisual sense. (At that time, the original senses [vision and audition] could still be operative, producing other "pure" visual and auditory experiences, but they need not be. Audition and vision could cease to be activated, and only the new, special, audiovisual experience might exist.)

In fact, it might be rather plausible to hold a view like this concerning taste and smell. It is widely noted that what are commonly taken to be experiences of taste are really experiences created by both taste and smell. For example, when one has a bad cold and loses one's sense of smell, one's food tastes bland. Of course, we can have pure taste experiences and pure smell experiences. However, what we usually take to be experiences of taste (and are often in modern parlance dubbed experiences of "flavor" to distinguish them from pure experiences of taste) are produced by mechanisms required for both pure taste and smell. When these mechanisms work together to produce experiences of flavor, one could reasonably say that the modality in operation was the flavor modality.

In short, one's theory of how to individuate experiences will significantly alter the position one might take here as to what is to count as one experience. In turn, this will affect whether this criterion for identifying whole modalities will

be useful, and, if it is helpful, it will affect the results that such a criterion might yield.

We have seen then, in this section, that there are a large number of complex issues to think about when considering the question of how to count the number of token senses that humans and other creatures have. The physiology of the creature may be an important consideration as may be the nature of its experiences.

## 2. How Many Senses: The *Type* Question

So far I have been discussing issues involved in answering question 1 (how many token senses does a creature have?) and the closely associated questions 3 and 4. But how should one go about answering question 2 (what types of senses does a creature have?)? One would need to know the following:

(1) How many token senses does it have?

(5) What types of senses are there?

(6) What makes a token sense an instance of one type rather than another?

I have dealt with question 1 in the preceding section. In the next section I look at question 5, and then in the following section I examine question 6 at length.

### 2.1. What Types of Senses Are There?

Many people have thought that there are only five types of senses. For example, Aristotle, in *De Anima*, famously said that there are five and only five senses: sight, hearing, touch, taste, and smell.[16] (He is talking here both about the number and kind of senses that humans have and the number and kind that animals have.) This view has echoed down the centuries, advocated by a number of scholars, most recently perhaps by Matthew Nudds. Nudds says that it is "obvious" that humans have five senses and that their having this number is a truth of folk psychology. Moreover, he thinks that it is not the case that "common-sense embodies the kind of proto-scientific understanding of the senses which is *liable* to revision or replacement."[17] Therefore, he holds that no amount of extra data from science, of the kind referred to at the beginning of this introduction, could change our minds on the question of how many types of senses there are.

The commitment to the existence of only a relatively small, specifiable number of types of senses—typically, but not necessarily, five—forms part of what I call the "sparse view" of the counting question. The sparse view maintains the following:

- The number of possible sensory modalities is relatively limited.
- The sensory modalities are discrete.[18]

To say that the modalities are discrete is to say that all of the possible modalities are rather different and distinct from each other (not that the modalities cannot interact).

Should one believe the sparse view? I think not, for two reasons. First, there is evidence that many more than five sensory modalities *actually* exist. From these cases we can go on and extrapolate and thus come to believe that the number of *possible* sensory modalities is large.

One candidate sense in humans in addition to the Aristotelian five is proprioception, which consists of awareness of the position of the parts of the body. It also encompasses awareness of movement of the body and of how much force is required to move the body.[19] Scientists commonly distinguish between *exteroceptive* senses (such as sight and hearing), which detect objects and properties in the world external to the body, and *interoceptive* senses, which detect changes to the body. They classify proprioception as one of the interoceptive senses. Furthermore, there appears to be good reason to classify it as a sense.

First, proprioception involves a detection of information via dedicated receptors in the muscles, tendons, and joints, and these receptors can be regarded as constituting the sensory organ of this sense. Many people have claimed that there cannot be a sense unless there is a dedicated sense organ. It is not obvious, in fact, whether this criterion *has* to be met in order for a sense to exist; however, for those who think it is crucial, proprioception passes this test.

Second, subjects frequently have experiences with phenomenal character corresponding to the information picked up by the stretch receptors, and they can come to know the position of their body by virtue of having these experiences. (Interestingly, proprioceptive experiences often quickly disappear—as experiences of smell do—upon prolonged exposure to a stimulus, due to habituation.) Of course, the proprioceptive process can go wrong, and one

can have illusions of bodily position. Proprioceptive illusions of size, position, and movement of limbs, fingers, and other body parts, as well as illusions of the force exerted by one's muscles, can occur after brain damage or can be induced in a variety of ways.[20] For example, illusions of movement can be induced by applying vibrations to muscle groups. Illusions of bodily position can be induced by anesthetizing a limb and asking a subject to move it. When such subjects cannot see the results of their efforts, they estimate on the basis of the illusory experience that they have that the limb is not in its original position (which it is) but is where they intended to move it. There can also be proprioceptive hallucinations, for example, when subjects who have lost a limb nonetheless feel that it is present and in a particular position.[21]

These features of proprioception and proprioceptive experiences—the existence of dedicated receptors that carry information, the existence of distinctive experiences that allow subjects to come to know this information, and the existence of cases of accurate perception, illusion, and hallucination—are shared by perceptual experiences in the traditional five Aristotelian modalities and together make a strong case that proprioception is a sensory modality.

Another candidate sense in humans is the vestibular sense, or sense of balance. Equilibrioception, as it is also known, provides us with awareness of the head's orientation with respect to gravity and informs us of the movement, particularly acceleration, of the head: up and down, side to side, and rotationally. As opposed to proprioception, equilibrioception is typically classified as an exteroceptive sense because it detects something outside the body—the gravitational field—although it also detects the relationship of the head to that field. Like proprioception, the sense of balance has a dedicated sense organ: the

fluid-filled, semicircular canals (which respond to rotation), and the otolithic organs (which respond to linear accelerations) in the ears. Also like proprioception, subjects typically have distinctive conscious experiences corresponding to the information detected by equilibrioception. For example, if one's vestibular sense is stimulated when one's eyes are closed, one has an experience of self-movement. A more specific example is that when one is in an elevator, one can come to know by one's experience whether the elevator is moving up or down even when one has no visual experience to drawn on. Another example is that, if one is sitting in a swivel chair in the dark, one can come to know whether one has been spun clockwise or counterclockwise via the experiences of rotational movement. Via their equilibrioceptive experiences, subjects can come to know the position of their head with respect to gravity and whether their head is moving and accelerating. Again, as was the case in proprioception, one can also have illusions and hallucinations of equilibrioception. For example, after getting off a roundabout or merry-go-round, one may still feel as if one is rotating. Illusions and hallucinations from the vestibular sense, particularly when the information from vision conflicts with it, often makes people unstable, vertiginous, and nauseous. Sufferers of Ménière's disease experience such strong illusions of vertigo, or feelings of being pushed or pulled, that they may fall. Permanent or temporary damage to the vestibular sense from inner ear infections, brain tumors, and brain damage can cause persistent, unpleasant equilibrioceptive hallucinations.[22]

Despite these reasons to think that proprioception and equilibrioception are senses, counterarguments could be mounted from several directions. One might argue that proprioception is not a sense as information about the world

external to the body is not detected—and one might think that this is crucial for something's being a sense. Such an argument could not be mounted against equilibrioception, however, as it is an exteroceptive sense. In any case, it is not clear why one should accept this restriction on what is to count as a sense.

Another reason one might proffer in order to deny that proprioception and equilibrioception are sensory modalities is that proprioception and equilibrioception are really parts of other senses. For example, one might think that proprioception is really a part of touch. When we perceive the shape of something—say the roundness of the rim of a glass on which all and only the fingertips of one hand rest, the detection of the location of our fingertips relative to each other is crucial for detecting the shape of the rim. Similar but lesser-known interactions between touch and proprioception exist. How hot or cold an object feels partly determines how heavy it feels. Objects that feel cold feel heavier than ones that feel hot. Perceived temperature can also affect tactile acuity.[23] Thus, touch and proprioception often influence each other and work in unison, and so one might think this warrants thinking of proprioception as just a part of the sense of touch.

It is more difficult to assimilate equilibrioception within another sense. On the one hand, one might think that it forms part of the sensory modality that comprises touch and proprioception because it provides another a way of determining information about the position, location, and movement of one's body. On the other hand, there are also close links between equilibrioception and vision. The vestibulo-ocular reflex refers to the involuntary mechanism whereby information from the vestibular system about head movement feeds into the system that controls eye movement to allow fixation on an object despite head

movements, both large and small. This reflex is essential for having clear, nonblurry vision because we cannot but help small movements of our head.[24] Thus, it is not even clear which sensory modality equilbrioception should be assimilated to, if indeed it should be assimilated to any.

These points do not decisively show that proprioception or equilibrioception are not separate modalities. We know that there can be substantial intermodal links between the traditional Aristotelian senses, such as the interaction between hearing and vision, which occurs in the McGurk effect, described earlier, which suggests that the existence of links between senses should not automatically lead to the assimilation of the two. It seems then that we must weigh various factors in determining whether proprioception and equilibrioception are distinctive senses. Certainly many scientists think that they are. Investigations into each of these sensory systems form significant research areas, which are as independent as the study of the Aristotelian senses. I am inclined to think that on balance we should count these as distinctive senses.

A third candidate for a sense in humans in addition to the Aristotelian five is the vomeronasal system, which detects pheromones using the Jacobson's organ in the nose. This system is distinct from the olfactory system. The existence of this system in some nonhuman animals is uncontroversial, and detection of pheromones clearly affects these creatures' behavior—particularly sexual behavior. The existence of a working vomeral system in humans, however, is highly disputed, but there is some evidence that it exists and that the detection of pheromones may have an effect on human behavior.[25] If this system does exist in humans, then it has some claim to be a sensory system, but not as much claim as the proprioceptive or vestibular systems. One reason is that it

does not seem to produce conscious experiences. Thus, whether it is a sense will depend on whether a sensory modality might operate in an unconscious fashion—a question on which people could hold rather disparate views.

Candidates for yet more human senses include, as briefly mentioned earlier, distinctive pain, temperature and pressure senses instead of one more general sense of touch. Scientists have found that there are distinctive receptors that detect temperature, pressure, and painful stimuli and that there are separate spots in the skin receptive to pressure, warmth, cold, and painful stimuli. This has been the main reason that has persuaded some people that there are several senses here. However, in addition to this, some people have thought that the experiences of pressure, temperature, and pain are fairly distinctive; that is, they have rather different phenomenal characters. For example, it is sometimes claimed that Plato thought that temperature perception was a sense separate from that of touch and also that he thought pain was distinctive, being a sensation or "passion of the soul."[26] Moreover, he did this not because he knew of the differences in physiology that we know of today, for they were not known at the time, but did so at least in part on phenomenological grounds. He was not alone in doing so prior to the new physiological knowledge coming to light. A number of other scholars, including Aristotle's commentator Themistius, Avicenna, Averroes and Galen, thought that more than one sense was associated with touch.[27] So, based on considerations of phenomenal character and physiology, a good number of people have claimed that there are in fact multiple distinctive senses here, whereas the mainstream view is that we have one unified sense of touch.

Whether these are good enough reasons to postulate many senses in this case is highly disputed. One might doubt that pain, temperature, and pressure are particularly phenomenologically distinct. There seems, for example, to be a phenomenological continuity between experiences of excesses of pressure and temperature and experiences of pain. We also have evidence that a physiological overlap exists between the sensors that detect pressure, temperature, and painful stimuli—in both normal and pathological conditions. For example, pain seems to be elicited by extreme pressure or temperature (both hot and cold), suggesting that the mechanisms underlying experiences of each are not separate. However, this result might be explained away because it is hard to stop intense pressure and temperature stimuli from stimulating adjacent pain receptors in the skin. Nonetheless, there is more persuasive evidence in favor of continuity. Experiences of cold or vibration can inhibit the feeling of pain, and tactile acuity is diminished by painful heat experiences. Indeed, there is evidence of "multireceptive" neurons that are responsive to two or even three of these allegedly separate modalities, which some commentators claim indicate that the allegedly separate modalities are integrated centrally in the brain.[28]

Critics of the aforementioned evidence may think that these interactive phenomena are merely similar to the McGurk effect—and thus think of them simply as intermodal interactions between different senses. So, unfortunately, such evidence does not clearly settle the matter. Moreover, appeal to phenomenology to settle these issues is not straightforward since phenomenal facts are notoriously subject to dispute. Thus, there seems to be a large open question about whether there is one sense of touch or multiple, distinctive tactile senses.

Other candidates that have been considered as being additional human senses include senses of hunger, thirst, wet and dry, the weight of objects, fullness of the bladder, suffocation and respiration, sexual appetite, and lactiferousness.[29] Indeed, in their survey of the human senses, Rivelin and Gravelle have concluded that "Five is obviously just not enough to account for the huge range of sensory possibilities of which the human species is capable; seventeen senses is probably a more accurate count."[30] Some other estimates are even higher and may be well beyond the number one should endorse, but their survey gives an indication of the number of candidates that one may have to consider.

Outside the human sphere, there are even more candidates in the animal kingdom for being senses in addition to the Aristotelian five. For example, pigeons and other birds seem sensitive to the magnetic field of the Earth, which gives them a fantastic sense of direction.[31] It has also been shown that trout can be trained to strike at targets distinguished only by their position in a magnetic field. Moreover, a distinctive sensory organ and sensory system have been identified in trout that detect magnetic fields. This evidence has led people to think that all of the conditions required for positing a magnetoreceptive sense in trout have been established.[32]

Many fish and sharks seem to have an electric sense. Sometimes this sense takes a passive form, meaning that the creatures can detect electric fields that exist independently of them in the environment. However, there is another active form of the sense where the creatures produce an electric field and then sense changes to it. Some fish use this active electric sense for navigation and to detect other living creatures.[33]

A further apparently distinctive animal sense is infrared (IR) detection. All pit vipers and some boid snakes have pits on their heads that contain cells that are sensitive to infrared light. The pits are organs distinct from the snakes' eyes and nostrils and can be used to accurately detect prey when the eyes are covered.[34]

From this evidence, one can see that many good candidates exist for being a sense, distinct from the Aristotelian five.[35] Even if we required further information about these cases before we confidently asserted that they constituted senses, these examples suggest that there at least *could* be senses of many different kinds other than the Aristotelian five. The only way to resist this thought would be to claim, as we saw Nudds do earlier, that the folk psychological notion of the senses is such that, according to it, there are only the five Aristotelian senses and that this concept of the senses is such that it is not liable to revision or replacement by scientific discovery. Do we have good reason to believe that the folk conception of the senses is as Nudds claims? I think the answer is no.

One reason to think that the folk notion of a sense is not restricted to the Aristotelian five is that scientists are some of "the folk" and the number of senses that they recognize has frequently been altered. As we have already seen, the debate about how many senses there are is a present concern to scientists. Moreover, as Rivelin and Gravelle (1984) claim, although the recent debate about the number of the senses, provoked by the vast increase in knowledge about human and animal physiology and behavior since the 1950s, has been the most notable and revisionary, the debate is not a modern phenomenon. The

number of senses has been disputed throughout history by both philosophers and scientists. The historical debate is outlined in Dallenbach (1939).

Another reason is that it is very plausible to think that if ordinary people heard the facts about other creatures' sensitivity to things such as magnetic fields, and they found out how creatures can act because of such sensitivity, or if they heard the facts about human proprioception and equilibrioception, they would, I believe, unhesitatingly think of these as senses. I am happy to do so, and, in my experience, the average person shows no resistance to doing so.

An even more telling fact in favor of the view that the folk concept of the senses is not restricted to the Aristotelian five is that, in popular culture, the idea of senses other than the Aristotelian five abounds. How could this be unless the folk concept of a sense was such that it countenanced the possibility of additional senses? For example, in fiction there are accounts of possible senses such as these:

- X-ray vision
- mind-reading sense
- sixth sense—the ability to perceive the future, ghosts, and so on
- the Predator's infrared perception
- the Terminator's perception, which can analyze the composition of objects
- spider sense—the ability to perceive danger via a special tingling in the extremities

Thus, I see no good reason to think that the folk conception of the senses is committed to there being five and only five senses. Thus, I see no need to revise

the folk conception in light of scientific evidence. I believe that the folk concept is simply silent with regard to the question of how many number of senses there are.[36] The number of senses seems to be left open by the concept of the senses that we have. The folk already embrace the idea that the number of *actual* senses is a matter to be determined by empirical findings, and they embrace the idea that the number of *possible* senses is greater than this. Thus, I believe, the folk concept is such that when new empirical evidence of the right kind is brought to light, that which is taken to fall under the concept of the senses can easily be enlarged without changing or revising the concept. This, together with the facts mentioned earlier, gives us good reason to think that there are, and could be, many more sensory modalities than the Aristotelian five. How many actually exist is a question that only progress in science, together with philosophical investigation into the conditions required for the existence of sensory modalities, will be able to shed light on.

Can we say anything further about the question: How many senses could there be? The answer depends in part on the question that forms the main topic of the next section. Therefore, I return to this question after considering how to individuate the senses.

### 2.2. What Makes a Token Sense an Instance of One Type Rather Than Another?

Consider the final question that one would need to answer in order to determine what types of senses a creature has:

(6) What makes a token sense an instance of one type rather than another?

To answer this question one would need to know what determines that a sensory modality is of one particular modality rather than another. In other words, one would need to have a principle for *individuating the senses*. That is, you would need to be able to say what establishes that a sense is visual, say, rather than auditory, tactile, gustatory, or olfactory.

This individuation question has been the focus of much of the work in philosophy concerning the senses. As noted at the end of the last section, there is an obvious relationship between this question and that of how many senses there are. I believe that an explicit or a tacit acceptance of the sparse view about how many senses there are has influenced what people have often said about the individuation question—in a detrimental fashion. After elucidating the standard answers to the individuation question, I suggest another answer that rejects the sparse view and suggests that the number of actual and nomologically possible senses is rather larger than many have thought.

There are four main philosophical approaches to individuating the senses.[37] Important versions of the first two are broadly experiential approaches, holding that which sense is being used is determined by which features the perceptual experiences produced by the sense have. The other two are broadly physical approaches that hold that which physical factors are at play in the use of a sense determine which sense is being used. I discuss them in turn.

### 2.2.1. The Representational Criterion

One predominantly experiential approach is that a sense is individuated by which objects and properties the experiences in that modality represent. The classic Aristotelian view is one variety of this approach. According to Aristotle, there are "common sensibles"—objects or properties that can be detected by more than one sense. For example, shape is a common sensible as it can be detected by both sight and touch. Others include motion, rest, magnitude number, and unity. There are also "proper sensibles"—objects or properties that can be detected by only one sense. With one exception, each sense has its own proper sensible, and representation of it is what makes the sense the sense that it is. For example, the proper sensibles of hearing, tasting, smelling, and seeing are sound, flavor, odor, and color, respectively. Touch is the odd man out as it has multiple proper sensibles, which Aristotle thinks are reducible to four basic ones: dry, fluid, hot, and cold.

There are many variants of the representation view. For example, one might think that there are a number of features, representation of which is necessary or sufficient or both for a sense to be the sense that it is. For example, one might think that vision essentially involves representation of the shape and size of objects in three-dimensional space at a distance from one's body, as well as color and shades of light and dark. One might think that touch essentially involves the representation of the shape and size of objects that are in contact with one's body and must involve the representation of temperature, pressure, and texture. What exactly one specifies for each of these senses will depend on thinking through a large number of examples of instances of sight and touch.

Another variant of the representation view would insist that the representation that we should consider when individuating a sense should not be, or should not *just* be, what is represented in experience at the conscious, personal level but what is represented by unconscious, subpersonal brain states or mechanisms. In other words, they would invoke an information-processing notion of representation wherein one attributes content to (perhaps) unconscious brain states involved in perceptual processing. In the same way that words are symbols that carry meaning, information-processing states of the brain are thought of as vehicles or symbols that carry information that is determined by the cause (and perhaps effect) of those brain states and perhaps the evolutionary history, or function, of such states.

Some people will think that what is crucial in individuating a sense is the behavior that the sense allows a creature to engage in. For example, a sense might allow a creature to negotiate through its environment, avoiding obstacles at a distance from its body, or it might allow the creature to determine its position with respect to gravity or to magnetic fields. It is not unreasonable to include positions that make essential reference to behavior under the representational criterion. This is because when we ask how a creature can behave, the answer will very likely depend on what it knows or believes about the environment—in short, how it represents the environment to be. Some people might resist this because they hold a view of perception that denies that, in perception, representations are created in one's mind or one's brain. Rather, when perceiving, a creature directly responds either to the world or to the pattern of light in space and time that directly stimulates it.[38] However, although

these views deny that representations are involved, one can argue that there is always at least a minimal sense in which perceptual states are representational. This is because, at the very least, experiences or other perceptual states of the creature can be assessed for accuracy, and the conditions in which the experience or state would be accurate can be taken to specify what representation is involved.[39] Alternatively, one could claim that the accurate description of the actions involved can be used to generate a set of objects and properties taken to specify a relevant representational content. For example, if a creature can "avoid the obstacle to its left" or "bat the ball," then these descriptions of actions in part specify ways the world is or could be and thus could be taken as descriptions of representations relevant to determining the sense involved.

No doubt some philosophers would prefer to keep separate a representational criterion and a behavior or action criterion. However, nothing of import turns on this for my purposes. As long as one is clear about what form of representation, behaviour, or action one is using to individuate the senses, it does not matter whether one calls this type of criterion a representational one, a behavioural one, or an action one.

### 2.2.2. The Phenomenal Character Criterion

A second experiential approach is to think that what makes a sense the type of sense it is will be the nature of the phenomenal character of the experiences that the sense produces or involves. Immediately, however, one is faced with the

question of how one might specify the sort of phenomenal character that all of the experiences of one sensory modality must have. It seems that when we specify the phenomenal character of an experience, we almost always say what it was an experience as of—that is, what the experience represented, whether or not that representation was accurate. So one might specify a class of experiences with a certain phenomenal character by specifying a class that represents certain things. In this respect, the phenomenal character criterion could turn out to look very much like the representational criterion. (Indeed, whether the nature of the phenomenal character of an experience can be fully specified *just* in terms of what the experience represents is a point much disputed in the philosophy of mind.[40]) For those philosophers that think the phenomenal character of experience can be identified with the representational content of experience, the representational criterion and the phenomenal character criterion will be the same, but for those philosophers who deny this, they will be distinct.

Another way one might specify the sort of phenomenal character that all the experiences of one sense must have is to specify one type of experience and then cite a group of experiences related to it. An important and influential way of doing this is to define classes of experiences using the notion of indiscriminability. If two experiences are discriminable, then they have different phenomenal characters. If two experiences have the same phenomenal character, then they will be indiscriminable. However, it is not true that if two experiences are indiscriminable, then they have the same phenomenal character, for A might be indiscriminable from B and B from C, yet A and C might be discriminable.[41] Furthermore, B cannot have the same phenomenal character as

either A or C as they can each be discriminated from something that B cannot. One can define sameness of phenomenal character, however, by appealing to global indiscriminability: Two experiences would have the same phenomenal character if they were indiscriminable and if there were no other experience that could be discriminated from either A and not B or B and not A. One can form a similarity class of experiences by identifying groups of indiscriminable experiences that are related by sharing one or more members. For example, if A and B were indiscriminable and B and C were indiscriminable, then A, B, and C would be members of the similarity class.[42] One might hope that if one took an arbitrary but clear case of an experience in a particular modality, one would be able to define a similarity class using the methodology described earlier and that the experiences in this similarity class would correspond to all and only those experiences that we intuitively would think of as experiences in that modality. One might then define that sensory modality as being the one that produces the experiences in that similarity class.

For example, one might take an experience as of a shade of color, say a mid-red, and then identify all indiscriminable experiences to it. Each of these experiences might belong to different groups of indiscriminable experiences, some as of slightly darker shades of red and some as of slightly lighter shades of red. One could imagine that the similarity class comprising all of the members of all of these groups of experiences might be identical to the class of all color experiences. In fact, one might imagine that it is possible to construct a similarity class that encompassed all visual experiences. One might be able to form a similarity class of experiences of all sounds in this way, too, providing a

similarity class for audition, and so on, for each of the sensory modalities. Advocates of this view would hold that one could never form a group that encompassed both color and sound experiences if they thought vision and hearing were different senses.

### 2.2.3. The Proximal Stimulus Criterion

A physical approach, and one quite unlike the two typically experiential approaches so far considered, is to individuate the senses by the nature of the proximal physical stimuli that affect the sense organ. The proximal stimulus is that which directly impinges on the sensory organ of the sense. For example, one might think that electromagnetic waves of between 380 and 750 nanometers are the proximal stimuli of vision, for those are what directly stimulate the cells in the eye. On this view, one is seeing if and only if one's method of perceiving the world involves the direct stimulation of one's sensory organ by such electromagnetic waves. One might think that pressure waves in a medium are the proximal stimuli associated with hearing. Thus, one would be hearing if and only if the proximal stimuli that affect the organ that one is using to perceive are pressure waves in some medium such as air or water. One might think the proximal stimuli of smell are the members of a class of airborne chemicals. One could identify similar proximal stimuli for each sense.

### 2.2.4. The Sense-Organ Criterion

The second physical approach is to individuate the senses by the nature of the sense organ that one is using when perceiving. One might think that if eyes are used, then one is seeing; if ears, then one is hearing, and so on. However, it would seem incumbent on one to then give an account of what made something an eye, an ear, and so on.

One tempting way to do this would be to specify the nature of the sensory organs by specifying the nature of the proximal stimulus that affected them. For example, perhaps one might define an eye as being an organ that detects light waves and ears as organs that detect pressure waves, and so on. If one proceeded in this way, then the difference between this approach and the previous one would essentially collapse.

One could also define the sensory organs in physical ways. Thus, the physical makeup of the organ would be important. Indeed, one might not only want to mention the physical makeup of just the sensory organ but also include as part of the criterion the physiology of the whole sensory system, such as the nature of the nerves leading to the brain and even the relevant parts of the brain itself, in particular the cortical regions to which each sensory system projects. When I speak of sense-organ approaches, I include approaches such as these that include the whole sensory system.

### 2.2.5. The Standard Views and the Aristotelian Senses

Much of the philosophical literature on individuating the senses involves presenting reasons to favor one of these views over another. For the most part,

the five Aristotelian senses differ fairly markedly on all four approaches from each other when they are operating normally and in optimal conditions. Those who support the sparse view of the senses would claim that this is evidence for their view that the senses are very different and discrete. To illustrate this, see the following table, which displays how one might think the Aristotelian senses differ on all four criteria suggested by the theories.[43]

| | **Vision** | **Touch** | **Hearing** | **Taste** | **Smell** |
|---|---|---|---|---|---|
| **Representation** | Colour, shape and movement at a distance from our body in front of our eyes | Temperature, pressure, shape and movement at the surface of our body | Sounds, volume, pitch, objects being struck or vibrated at locations in and at distance from and all around our body | Flavours (sweet, salty, bitter, sour, umami) in the mouth or on the tongue or in the food touching the tongue | Odours located either in the nose or in the air around the nose, perhaps coming from a certain direction |
| **Phenomenal Character** | Visual experiences | Tactile experiences | Auditory experiences | Taste experiences | Olfactory experiences |
| **Proximal Stimulus** | Electromagnetic waves | Mechanical pressure and temperature | Pressure waves in a medium such as air or water | Chemicals that affect receptors on the tongue | Volatile molecules that affect the epithelium |
| **Sense Organ** | Eyes, particularly the retina | Skin or receptors in the skin | Ears, particularly the cochlea | Tongue, particularly the taste-buds on the tongue | Nose, particularly the nasal epithelium |

However, the following create havoc with this neat taxonomy:

(1) non-Aristotelian senses

(2) tampering with the Aristotelian senses

(3) malfunction of the Aristotelian senses

(4) the Aristotelian senses operating in odd environments

These cases show (as will shortly be illustrated) that none of the four criteria allow us to neatly categorize each of the senses as being one of the Aristotelian senses or as being one of a small number of discrete senses. Furthermore, the four criteria pull us in different directions when we try to determine which type of sense a given sense is. This is one reason that people have thought that one has to choose between the four criteria for individuating the senses—they have thought that one has to pick the best out of the *competing* theories for individuating the senses. However, after outlining four examples that bring to light the most important problems these theories face, I suggest an alternative approach to individuating the senses. I claim that, in light of these examples, we have reason not to be sparse theorists and that, once we give up that commitment, we can come to see the four criteria in a new light. They are criteria that can be used together to allow us to accurately, nonarbitrarily, and in a fine-grained manner taxonomize the actual and possible senses.

### 2.2.6. The Standard Views and Bat Echolocation

Bats send out a high frequency "chirrup" and listen for the returning echo. Both the time it takes for the sound to bounce off objects and return to the bat and the direction from which the sound is returned (determined by the different times at which each ear is stimulated by the returning echo) are used to determine the size, shape, and position of objects at a distance in front of the bat. This means of

perception allows bats to negotiate through their environment skillfully and quickly, dodging obstacles and catching moths and other prey in the dark.[44]

What do your intuitions say about this sense?

(1) Bats have an incredible form of hearing.

(2) Bats can see in the dark using this mechanism.

(3) Bats have a sense that we do not: echolocation.

The proximal stimulus and sense-organ criteria tend to suggest that the bat has a form of hearing because the proximal stimulus is pressure waves and the sensory organ is an ear, or at least something more like our ears than any other organ. However, the frequencies that bats can hear are different from those that we can hear. So, to judge that the bat is hearing is to think that hearing involves the detection of any frequency of pressure wave, as opposed to just those that humans can detect. Similarly, the bat's ears are not physically exactly like ours. In addition, if within the sense-organ criterion we wish to include the brain mechanisms that process the signals coming from the ear, then because a bat's brain receives or calculates so much more information from its auditory signal compared to humans, there are numerous differences between the bat's brain and ours. So the bat's sensory organs are somewhat like ours, but somewhat not. In short, while the proximal stimulus and sense-organ criterion most naturally suggest that the bat is hearing, one could hold that the proximal stimulus and the sense organ are different enough from ours that the bat should be counted, on application of these criteria, as having a sense that we do not.

The representational criterion yields unclear results. One might think that it will yield the result that the bat is seeing because, using this sense, the bat can detect three-dimensional objects at a distance from its body, which humans can do with their sense of sight. However, the bat does not detect color, and some people have thought that perception of color is required for seeing. So alternatively, one might think that the bat really has a sense of hearing, for surely the bat's experiences will represent the sound that bounces back in the form of the echo. And indeed, one might question whether the bat's experiences represent where objects are at a distance from its body. One might think that instead, postperception, the bat judges where these objects are on the basis of things that it hears.[45] Alternatively again, one might be inclined to think that the bat's experiences represent both sound *and* objects at a distance from its body. If this is right, then perhaps the bat both sees and hears with the one sensory organ. Or perhaps it would be best to say that it has a different sense altogether from any of the ones that we have.

The phenomenal character criterion is unhelpful in this case. To the extent that we can imagine what it is like to be a bat one might think that the experiences share some auditory and visual characteristics and perhaps some unlike either of these.[46]

So what should we decide? In part we are ignorant of some facts, knowledge of which might help us determine which sense the bat has. However, I believe that even if we knew all of the relevant facts, our intuitions and criteria would tell us that the bat's sense is like our vision in some respects and like our hearing in

others and like neither in some respects. Before exploring what we should do in the face of this, consider the other cases.

### 2.2.7. The Standard Views and Bee "Vision"

Bees are sensitive both to what we call visible light and also to ultraviolet (UV). If we look at many flowers in visible light, they often look like the flower on the left of the diagram below—they have a small dark center and then a uniform color on the petals. However, if we photograph them using a camera sensitive to ultraviolet light, then the flowers often look like the flower on the right of the figure. The extra markings that can be detected using ultraviolet are called the "nectar guide" pattern, and they guide the bees to the source of the nectar.

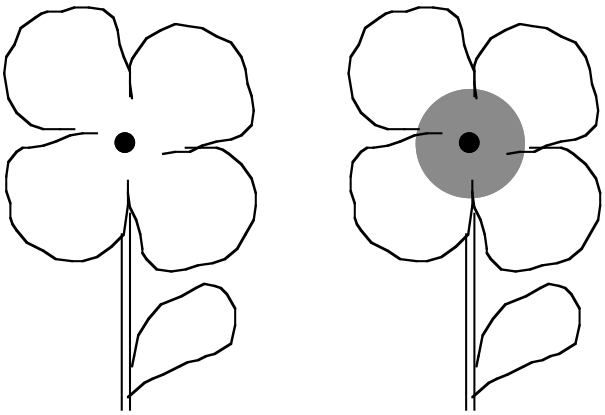


Diagram of typical markings on flowers: in visible light on the left, and in ultraviolet light on the right.

It is natural to say that bees have vision—a form of vision in which both the human visible spectrum and ultraviolet light are detected by the bees' eyes. But should we? Recall the nature of the electromagnetic spectrum, of which visible light and ultraviolet are parts. It simply consists of all of the wavelengths

of electromagnetic waves. The shortest wavelengths are gamma rays, at around 0.0005 nanometers (nm). Next are X-rays (around 0.5 nm), then ultraviolet wavelengths (around 250 nm). Slightly longer still, the visible spectrum consists of wavelengths between 380 nm and 760 nm. Above that are infrared wavelengths, centered around 10,000 nm. Microwaves have longer wavelengths still, up to about 1 meter, and wavelengths longer than that are classified as radio waves.

The proximal stimulus criterion is the reason for mentioning these facts. If we think that bee "vision" really is vision, and we think we should individuate the senses by the proximal stimulus criterion, then one must think that the proximal stimulus of vision is wider than the visible spectrum and also includes ultraviolet electromagnetic waves. However, if one is willing to extend the proximal stimulus beyond visible light, then should one extend it to the whole electromagnetic spectrum? One might think that one ought to. After all, one might think that all the wavelengths form a natural kind. What makes them different is merely their wavelength. However, if one does that, then one would be committed to thinking that a creature that detected only radio waves was seeing and that one that detected only gamma rays was seeing. Nevertheless, it is far from obvious that creatures with such detecting mechanisms, even if we were confident that they were senses, would really be ones that we would want to count as vision. I certainly would want to know a lot more about the sense in question, such as the nature of the sense organ, what the subject's experiences represented, and what their phenomenal character was before I would feel confident that the sense was vision.

Alternatively, perhaps we should limit the proximal stimulus of vision to encompass just visible light. In that case, the bee would either have vision plus some other sense, an ultraviolet sense, or just some sense other than vision—one that detected both ultraviolet and visible light. (A further case for the thought that we should limit the proximal stimulus of vision is outlined when we come to discuss snake infrared perception later.)

The sense-organ criterion yields unclear results. We do classify the bees' organs that detect visible light and ultraviolet light as eyes. Nonetheless, bee eyes are very different from human eyes. Bees have two large, compound eyes and three small, simple eyes (called "ocelli") arranged in a triangle on their forehead. When we learn just how different the organ of the bees' "vision" is to ours, it is not completely obvious that we should think of bees as having eyes.

The representational criterion perhaps delivers the clearest verdict that bees have vision. They would seem to represent what we represent—three-dimensional objects at a distance from our bodies. Perhaps they represent all of the qualities that we represent the world as having, plus some others visible only to those who can detect ultraviolet. Still, if that is right, then perhaps we should think that they have their own special vision-plus-ultraviolet sense. This is made all the more plausible when we consider that it is not clear that bees simply represent more than us—some extra ultraviolet facts. Humans have three types of cells in their eyes that are responsive to long, medium, and short wavelengths of visible light. The nature of these cells, plus subsequent processing, determines the kind of color vision that we have. Bees have three kinds of receptor, too, but theirs span both the visible and the ultraviolet ranges. Thus, the kind of "color

vision" that bees have is rather different from ours. Bees do not see the colors that we see plus some other colors. They do not see, for example, how the flower looks to us under visible light *and* how it appears to us in a picture taken by a camera sensitive to ultraviolet light. Rather, they see the flower in just one way, determined by both the reflectance of visible light and ultraviolet light and by the nature of their light-sensitive cells. Because of this, it is tempting to describe the case as one in which bees do not see colors—or at the very least do not see the colors we do. And then if, with Aristotle, we thought that what made a sense vision was the representation of the colors—or at least the ones we see—it would be right to conclude that the bees do not see, although they do something similar.

Finally, think about the phenomenal character criterion. Of course, it is hard to know what the phenomenology of bee experience is like, but our best guess would be that to some extent it is the same and to some extent different from human vision.[47] The facts that make us think that what the bees' experience represents partially overlaps with human visual experience and partly does not motivates this thought. Here, a mixture of our ignorance and our best guess leaves us unsure as to how to classify bee "vision." It is somewhat like our vision and somewhat not.

Thus, although a few criteria suggest that bees have vision, the sense they have is sufficiently different from our vision that one might think it a different sense, even if it is most like our vision. This case shows that for each proposed criterion for individuating the senses, it will be difficult to decide upon the

necessary and sufficient conditions that it takes to have a particular sense. We will see this problem manifest itself further in the next example.

### 2.2.8. The Standard Views and Snake Infrared Perception

It is interesting to contrast and compare the case of bee vision with that of snake infrared perception. Some snakes, such as pit vipers and boid snakes, have organs separate from their eyes that detect infrared. These organs are situated on the front of the snakes' faces, below the eyes and close to the snakes' nostrils. They consist of pits lined with infrared detecting cells.[48] Using this sense alone, snakes can detect prey in front of them and discriminate the shape of the prey enough to allow them to make precise strikes on vulnerable parts of the prey's body. (This ability has been documented in a congenitally blind rattlesnake.[49]) Snakes can also detect the heat trails of prey that have passed by their location some time previously and then follow that trail to the creature's burrow and thus find their meal. Is this a form of vision or not? Let us run through the list of criteria again.

The proximal stimulus criterion is unclear. As with bee "vision" we face a decision as to whether we should extend the proximal stimulus of vision beyond that of human visible light, this time to include not ultraviolet but infrared radiation. If one thinks that one should do it for ultraviolet, then it will be hard to find principled grounds on which to exclude an extension to infrared. Then again, the question comes up, Should it be extended to include detection of any part of

the electromagnetic spectrum, including gamma or radio waves even if, intuitively, the detection of these waves would not yield a sense like vision?

The sense-organ criterion does not yield perspicuous results, either. The snakes' pits are like our eyes in some respects but not very many. The obvious question facing this criterion on consideration of this example is, What is it for something to be an eye? Right away we can see that any criteria for being an eye will be very malleable. For example, is an eye any electromagnetic detector or just a detector of all and only visible light or something else?

Another interesting question that the snake infrared sense raises, in addition to that of which sense it is, is whether it is a separate sense from what is commonly taken to be the snake's visual sense. Certainly the eyes and the infrared pits are different sensory systems to the extent that we think of them as formed by just the physiological structures near the surface of the snake's head. However, if we think of the sense organs as composing the whole physiological structure leading from the cells that light and infrared impinge upon to the central parts of the brain, which process the information gathered by those cells, the issue is far from clear. It has been found that the maplike visual and infrared representations of the world in the snake's brain are partly overlaid in the optic tectum. Some neurons in the tectum respond only to visual stimulation or only to infrared stimulation; others respond to either visual or infrared stimulation; still others respond only to a combination of visual and infrared stimulation. There may be enough overlap that one is tempted to think that both sets of organs (the snakes' eyes and infrared pits) are really organs of the one sense in the way our two eyes are organs of the one sense.

The question of whether the snake has one visible-light-plus-infrared sense or two token senses—either vision and an infrared sense or two token senses of vision—muddies the water in considering the nature of the snake's senses. For the rest of this section, I assume that there are two token senses and address the question of whether the sense that detects infrared is a sense of vision or not.

What does the representational criterion tell us? It is a reasonable assumption that three-dimensional objects at a distance from the snake's body are represented on account of the precise targeting of prey by snakes using only this sense. The infrared sense then shares a representational aspect with human vision. Nonetheless, the snake's infrared sense detects heat and does not detect the color properties that we detect, so there are considerable differences with regard to representation, too. These representational similarities and differences suggest that the phenomenal character of the snake's infrared sense may be somewhat like our vision but somewhat different. It is hard to say very much more than this.

In summary, the snake infrared sense is somewhat like our vision and somewhat not. Unlike the case of bee "vision," which involves detection of the part of the electromagnetic spectrum humans can detect plus an additional part, snake infrared perception does not involve detection of a part of the electromagnetic spectrum that humans can detect, merely detection of shorter wavelengths.

### 2.2.9. The Standard Views and Tactile-Visual Sensory Substitution

Tactile-visual sensory substitution (TVSS) devices try to replace the sense of sight by exploiting the sense of touch. A camera image drives a grid of vibrating pins that press against the back or other suitable expanse of skin. Areas of the camera image correspond to isomorphic areas of the grid of pins, and pressure and vibration against the skin correspond to the light levels the camera detects. With practice, subjects can use the system to skillfully navigate their way through the world and identify three-dimensional objects at a distance from their body.[50]

At first, subjects report that they are aware of the sensations on their skin, but as they continue to use the system they stop paying attention to or noticing the tactile stimulation, at least *as such*, and instead attend to or notice what seems to them to be the objects in the world in front of them. Reports about such subjects suggest that their experiences have much in common with visual experiences, particularly with regard to their spatial nature. For example, Nicholas Humphrey reports the following:

> By making use of information in the image about perspective and motion parallax, the blind subjects came to perceive external objects as being located in a stable three-dimensional world. They did not locate objects as lying up against their skin—any more than we with normal vision locate objects as lying up against the retina of our eyes—but immediately perceived them as being out there in space. (1993, 59)

Are people who use TVSS devices seeing, feeling, or perceiving in some different way? That is, are we replacing their vision, or are we extending their

existing sense of touch to allow the detection of objects and properties it usually cannot detect, or are we creating a brand new sense? The sensory-organ criterion would yield different answers depending on what we say the sense organ here is. If it is the camera, then perhaps we should think that the sense at play is vision. If it is the skin, then we should think it touch. If it is the camera plus the skin, then perhaps the sense is neither vision nor touch but a new sensory modality. The proximal stimulus criterion is open to just the same sort of speculation. Is the stimulus the pressure on the skin, light on the camera, or both? Which one decides upon will determine whether the sense is touch, vision, or neither.

What does the representational criterion tell us? Certainly at first, when using the TVSS system, there is a representation of the pins touching the body. This surely remains over time as the subject gets used to the TVSS system, even if it is not the main focus of subject's attention. The subject also seems to acquire a representation of objects in three-dimensional space in front of them. To this extent their experiences seem to represent in part what visual experiences do (minus color). Then again, if the subject has experiences with both vision-like and touch-like representational characteristics, then perhaps the subject has a sense that ordinary humans do not. The phenomenal character criterion yields much the same result here: one imagines the experiences, phenomenally speaking, to be partly like touch, partly like vision, and partly distinctive.

Thus, people who use a TVSS system, at least once they have adapted to it, are using a sense partly like vision, partly like touch, and partly unique.

### 2.2.10. Rejection of the Sparse View and How to Individuate the Senses

The criteria and our intuitions tell us that in each of the following cases:

- echolocation
- UV vision
- IR vision
- tactile vision

the sense involved is in some respects like our vision and in some respects different—sometimes like another one of our senses and sometimes different altogether. I suggest that these examples and others show that the actual and the possible senses cannot be clearly divided into a limited number of discrete kinds. The differences between the senses amounts more to a difference of degree rather than a difference of kind.

Rather than try to pigeonhole all of the senses into a small number of discrete categories we should simply note what each sense is like with regard to each of the four criteria proposed by philosophers:

- proximal stimulus
- representation
- phenomenal character
- sense organ

(and perhaps others if they are required to fully capture all of the important aspects of the senses). For each criterion we can note how different or similar each sense is to one of the five Aristotelian senses if we like, but that is relatively

unimportant. We should stop trying to artificially determine or stipulate which Aristotelian sense any sense is—or to shoehorn each sense into one of a small number of discrete kinds. It is because people have tried to do this and because the four criteria pull in different directions in problem cases that people have thought that they have to choose among the four criteria—rather than embrace them all.

For example, Matthew Nudds has suggested that our choice of which of the standard criteria we use to individuate the senses should be determined by their significance. This seems like a good methodology. We should ask, Why does distinguishing the senses matter to us? Nudds's own answer is that, "In distinguishing different senses we are distinguishing different ways of perceiving" (2004, 45). He goes on to explain that different ways of perceiving will involve perceiving different ranges of properties. Telling you which sense I am using to perceive something lets you know the type of properties that I (normally) know about.

However, I think that distinguishing the senses matters to us because we care about all of the following:

- representation
- proximal stimulus
- phenomenal character
- sense organ

Philosophers have argued over which is important, but why not think they all are? All can matter practically, and all can matter for determining both philosophical and scientific issues.

I hold that the four criteria are relatively independent dimensions along which different possible kinds of senses could take different values. We can think of these four criteria as defining a multidimensional space within which we can locate each of the Aristotelian senses, the four examples of unusual senses discussed earlier, and any other sense. Thus, human vision, bee "vision," snake infrared perception, and TVSS perception would each be located at a different place in the multidimensional space. Indeed, this multidimensional space is a way of delineating the space of all possible senses. All possible senses will occupy a place in the space.[51] (The actual senses will occupy a small number of these places.[52])

Plotting the actual senses in this space will allow one to see the similarities and connections between them yet, at the same time, to individuate the types of sense in a nonsparse, fine-grained manner. When we do such a plotting for the actual senses, we could do it for each token instance of a sense, or we could do it for idealized versions of the senses in each species. If we did the former, then my sense of vision might turn out to be a different sense from yours, for I may be much more nearsighted than you. If we did the latter, then we would have the same sense, for we each have tokens of the idealized sense of vision in humans. Also, if we did the latter, we might find that the actual senses are to be found in clusters in this space. For we will find, for example, that human vision and bee "vision" are closer together in this space than human vision and bat

echolocation. Perhaps these clusters would correspond to the Aristotelian senses or the Aristotelian senses plus a few others. I suspect this might be the case. This would show us that the folk were trying to reflect complex facts about the types of senses that we find in the world using an oversimplistic model, but one whose origin is explicable given the facts. However, if two senses are close together in this space, we should not concern ourselves with the question of whether they are the same sense. Once we have plotted their location in the space and noted their similarities and differences, we have said everything we need to say about the senses. That is when we should cease to ask how to individuate the senses.

## 3. The Classic Works

The issues that I have outlined in this introduction are explored at length by the essays in this volume.

In the classic works section, Aristotle's famous contribution outlining his version of the representational criterion, in which the senses are individuated in terms of the objects and properties that can be discerned by means of them, is followed by a detailed and erudite commentary by Richard Sorabji. Sorabji explores not only what Aristotle's view was but also whether any version of Aristotle's view can plausibly be held. He concludes that the sense that is the most difficult to individuate in the way Aristotle recommends is touch.

Grice's essay opens by considering when it would be appropriate to claim that a creature has a sense that is not one of the senses that humans possess. After a short discussion of how to distinguish perceptual processes from

nonperceptual ones he lists the four main criteria, outlined in this introduction, that one might use to individuate the senses. He discusses their relations and plausibility. He then argues that there is an ineliminable role for the phenomenal character of experiences in individuating the senses.

In addition to considering how one might individuate the senses, Roxbee Cox discusses how a subject can know from the inside which sense is being employed to perceive. He claims that a representational view is the best approach to answering both questions. He develops in detail his version of this view, which he calls the "key feature" view.

Coady discusses Grice's work at length and the idea that the phenomenal character of experience is essential to individuating the senses. He rejects the idea and discusses the extent to which one could practically determine or know about this criterion. He concludes that the other criteria, particularly the representational criterion, are important.

The proximal-stimulus criterion for individuating the senses is explored and developed in Heil's essay. Heil comments that the senses may not be sharply distinguished from one another, but to the extent that they can, he believes this criterion is the best. He acknowledges the work of J. J. Gibson in developing his approach.

Like Grice, defending the ineliminability of the phenomenal criterion is Leon's purpose. He also discusses the representational nature of experience at length and in doing so tries to distinguish perception from other belief-forming

mechanisms. He raises problems for the representational criterion for individuating the senses.

Nelkin defends the idea that the senses are to be individuated by a combination of the types of belief that are formed using the sense and the nature of the sensory organ in which the belief-forming process originated.

Martin's essay examines to the extent to which one can use the phenomenal criterion to individuate the senses. He shows that an account of the phenomenal differences between the experiences in different modalities can be given by reference to the various structural properties of those experiences. He argues that sight can be differentiated from touch because, in sight, a perceptual field contributes to seeing in a way that any field associated with touch does not contribute to touch.

Finally, Keeley draws our attention to the criteria used in science and to neuroethology in particular, which is regularly faced with the task of classifying the senses in unusual animals. He argues that four criteria are required to individuate the senses: the proximal stimulus; the nature of the sensory organ and the relevant, associated brain mechanisms; the creature's ability to discriminate between stimuli associated with one type of proximal stimulus; and the evolutionary or developmental importance of the sense to the creature.

## 4. The New Works

Gray contrasts a scientific picture of the senses as natural kinds, which would be individuated in the manner that Keeley suggests in his work, with what he takes

to be the antirealist position of Nudds (2004). He claims that Nudds holds that the way we individuate the senses is, largely, a conventional matter. Thus, Nudds merely seeks to elucidate the folk criteria by which we do individuate the senses. Gray defends the scientific approach over the antirealist approach.

Perceiving is often thought to have something in common with sensory imagining. For example, it is often said that such imagining is phenomenally similar to perceiving, simply less vivid or lively (as Hume famously suggested). Might one make progress with individuating the senses by thinking about how to individuate sensory imaginings? Hopkins argues in favor of this idea. Taking sight and touch as examples, he claims that different forms of perspective are involved in each. He explores this idea and, like Martin earlier, thinks that the structural features of experiences play some part in individuating the senses.

In Heil's new contribution to this volume he further defends the view he set out in his earlier work. He claims that we should distinguish the senses on the basis of the kinds of information-bearing stimulation to which they are sensitive.

O'Dea defends a representational theory of phenomenal character from Grice's contention that some phenomenal aspects of experiences are not representational. O'Dea argues that our perceptual experiences represent not only things in the world but also which organ of sense we are using to perceive. Thus, he claims that perceptual experiences have an interoceptive, as well as an exteroceptive, aspect, which can allow subjects of experience to know which sense or senses are employed when they perceive.

The questions of individuating the senses and what constitutes a sensory modality occupy Nudds in his contribution to this volume. Unlike O'Dea, he claims that that it is doubtful that the operations of the different sensory mechanisms are available to us in introspection. He thus claims that we should not give an experiential (representational or phenomenal) account of the individuation of the senses. Rather, we distinguish the senses in light of our understanding of the different mechanisms that allow us to perceive and their connection to the experiences that we have. So the senses, according to Nudds, are different forms of sensory mechanism. However, he goes on to argue that, although our concept of the senses is that there are five, we do not find five sorts of sensory mechanism in humans. In light of this, he claims that either we are mistaken about how many senses there are or our concepts of the senses are not concepts of natural kinds. Nudds provides reasons to think that the latter position is correct and suggests that our concepts of the senses may be social ones.

Smith's essay focuses on the question of what makes an experience a perceptual one or at least a perceptual experience of something other than our own body. Focusing on the case of experiences of pain, he investigates the reason we do not locate painful qualities in the objects that produce experiences of pain and finds an answer in a detailed investigation of the nature of the phenomenal character of pain experiences.

As we have seen in this introduction, there are many candidate sensory modalities in humans and animals besides the Aristotelian five. One candidate is the sense of agency—the sense of acting. Taking this as a case study, Bayne

considers whether it is right to think that there is a sense of agency and concludes that there are some good reasons to think that agentive experiences are produced by a dedicated perceptual system that represents one's own agency and makes these representations available to the cognitive system in experiential form.

Finally, Clark looks at intriguing new evidence concerning cross-modal effects involving spatial attention. Reflection on these results, he claims, gives us new reasons to think that spatial properties are common sensibles of all sensory modalities.

## 5. Conclusion

The topic of individuating the senses is a fascinating field, one that not only is of interest in its own right but also promises to provoke further investigation into the nature of perception and perceptual experience in modalities other than vision—an area of philosophical inquiry long overdue for attention. It promises to provoke an investigation of perception in all of the modalities that must reflect the ever-growing number of fascinating empirical results on the nature of perception—in each modality and across and between modalities—and to find a role for those findings. As we have seen, the responses to those findings can be many and varied. Finally, it promises to uncover interesting avenues of investigation for thinking about the nature of perception itself in all its myriad forms.

## Notes

1. Total blindsight is rare. Blindsight has been studied and discussed by

Weiskrantz (1986, 1997).

2. See Farah (2004).

3. See Bach-y-Rita (1972) and section 2.2.9 below.

4. See section 2.1 below.

5. Grice (1962) considers a creature like Four-Eyes. However, he puts his imagined creature to very different philosophical use than I do. Grice assumes that his creature has two token senses—one associated with each pair of eyes—and then asks what conditions would have to be in place for us to think that these senses were both senses of vision and what conditions would have to be in place for us to think that one of these senses was a new nonvisual sense that we had not yet encountered. In contrast to this, I am not considering what types of senses Four-Eyes has but how we might decide how many token senses it has, irrespective of their type.

6. Some people have suggested that we do have a sense that detects the emptiness and fullness of our stomachs. However, even if that were true, it would not mean that digestion itself was a perceptual process, merely that there was some perceptual process associated with it, perhaps monitoring it.

7. However, as was briefly mentioned earlier, the condition called "blindsight" may be present.

8. The question of what it is for something to be physical is a complex one. Some would say that being spatiotemporally located is a necessary and sufficient feature. Others would say that being a posit of our best fundamental science, physics, is essential.

9. See Nagel (1974).

10. A few philosophers deny that we should think of perceptual experiences as being representational states. Furthermore, there is enormous debate within philosophy about the nature of perceptual content. These debates lie well beyond the scope of this introduction. Siegel (2008) provides an excellent overview of them.

11. See McGurk and MacDonald (1976). Other striking cross-modal effects continue to be discovered. For example, the auditory motion aftereffect is affected by perceived visual motion. See Vroomen and de Gelder (2003). An excellent reference work on cross-modal interaction is Calvert, Spence, and Stein (2004).

12. There is increasing evidence of such interaction between sensory systems in the early stages of perceptual processing. For example, it is well documented between taste and smell. See Auvray and Spence (2008).

13. The debate about whether perception is cognitively penetrable or not is reported and discussed in, among others, Churchland (1979), Fodor (1983), Pylyshin (1999), and Macpherson (forthcoming).

14. This view is advocated by Tye (2003).

15. However, this seems unlikely in the face of recent research. Cross-modal effects may be more the rule than the exception. See, for example, Auvray and Spence (2008).

16. See book III, chapter 1. It is reasonably clear that Aristotle was claiming that as a matter of fact there are only five senses, and, given the nature of the world as he took it to be (composed of elements, each of which had different properties), there could be only five senses. Thus, he was claiming that

it is nomologically necessary that we have only five senses. He was not claiming that it is metaphysically necessary.

17. Nudds (2004, 35). On the same page, not only does he say that he has "not come across a good argument" for the idea that the folk notion of the senses is liable for revision, but he also says, "There have been authors who attempt to give a 'scientific' account of the senses, but they do nothing to show that they haven't simply changed the subject. Whatever they are giving an account of, it's not the senses as we commonly understand them" (fn11).

18. It may be that no one has ever held the sparse view that I outline here, but parts of it have certainly been avowed, and the position serves as a useful stalking horse.

19. The term "kinesthesia" is sometimes used interchangeably with "proprioception" thus defined. However, sometimes "kinesthesia" is used exclusively as a term for our sense of awareness of the movement of the body, while "proprioception" is reserved for the sense of the body's position.

20. See, for example, Head and Holmes (1911), Jones (1988), Paqueron et al. (2003), and Gandevia et al. (2006).

21. See Ramachandran and Hirstein (1998).

22. See Baloh and Honrubia (2001).

23. See Stephens (1982) and Stephens and Hooper (1982).

24. See Cohen and Raphan (2004).

25. See Hughes (1999) and Meredith (2001).

26. See Classen (1993, 2).

27. The history of the early debate over whether touch is one sense or not is explicated in great detail in Dallenbach (1939).

28. The evidence adduced here about touch is summarized in Craig (1996). Craig claims that temperature and pain processing are closely coupled structurally in the brain and that brain lesions rarely affect one without the other. The brain's processing of pressure is structurally more distinct.

29. See Dallenbach (1939). The last three were proposed, among others, by Erasmus Darwin. Of course, one might dispute whether these are particularly good candidates, but that is beside the point.

30. Rivelin and Gravelle (1984, 17)

31. See Hughes (1999).

32. See Walker et al. (1997), reported in Hughes (1999).

33. See Hughes (1999).

34. See ibid.

35. There are other examples that I have not discussed here. See, for example, ibid. and the essays in this volume.

36. Matthew Nudds (personal correspondence) is concerned that my account does not explain why people do say that there are five senses when asked and why this has not changed. I think that it is changing. Some people do not reply that there are five. Others who do, quickly rescind the view when other candidate senses are mentioned to them. No doubt most people have given the question little thought and reply automatically with the answer they learned from their preschool books.

37. See Grice (1962).

38. Some disjunctivists, followers of J. J. Gibson's ecological approach, as well as sensorimotor theorists, hold such a position.

39. This has been argued for by Susanna Siegel (2010), where accuracy is elucidated as the conditions in which there is freedom from error.

40. Tye (1995) and Dretske (1995), among others, argue that it is. I (2003, 2005, 2006), among others, argue that it is not.

41. Plausibly this situation would arise, and one would have such experiences when one looked at color samples in the world where one sample was indiscriminable from a second, the second from a third, yet the first and third were discriminable. See Clark (1993).

42. For more information on this methodology see ibid.

43. Of course, there are some reasons to question this neat dichotomy, even for the Aristotelian senses, as we will see in due course. In particular, it turns out that distinguishing taste and smell is particularly difficult.

44. Further details of the bat's echolocation, together with excellent informed speculation on the representational and phenomenal nature of the bat's experience, is given in Akins (1993).

45. Whether we can draw a sharp line between perceptual content and judgment is a highly debatable matter.

46. Famously, philosophers have thought that one cannot know what it is like to be a bat. (See Nagel [1974].) However, Akins (1993) persuasively claims that we can know quite a lot about what it is like, even if not everything.

47. Some people might even wonder whether bees (and other animals) are the subjects of any states with phenomenal character.

48. See Hughes (1999). The relevance of this case to individuating the senses is also discussed by Gray (2005).

49. See Kardong and Mackessy (1991).

50. See Bach-y-Rita (1972).

51. In the actual world there will of course be contingent connections between the criteria. For example, the proximal stimulus and the sense organ/physiology of the sense probably partly determine the representational properties and the phenomenal character of perceptual experience. The extent to which any necessary connections exist among the criteria is a difficult question and one's answer to it will depend on one's views on (at least) the following: the nature of phenomenal character, what types of metaphysically possible worlds there are, and whether a sense must generate conscious experiences. Thus, one might hold that while each possible sense will occupy some place in the multidimensional space, not every position in the space is a place that a possible sense could occupy.

52. Of course, when faced with certain senses we may be ignorant of the nature of those senses with regard to the facts pertaining to one or more of the criteria, but that is merely our unfortunate epistemic situation. When we embrace all four criteria and resist shoehorning all of the senses into a few discrete kinds, we can simply note, for each criterion, all of the facts we know. For example, in assessing the nature of the sensory organ in TVSS we should mention both the camera and the skin of the subject and the connection between them.

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