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The medieval theory of the inner senses

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This article analyzes the theory of the inner senses, a theory of cognition and neuropsychology that had wide acceptance in Europe from the fourth to the sixteenth centuries. The theory proposed that incoming sensory information was processed successively in three linearly arranged ventricles of the brain. It was based on the psychology of Aristotle and the anatomical discoveries of Galen; its demise followed Vesalius's discovery that the anatomy on which it was based was incorrect. The theory of the inner senses contains many modern features and can be regarded as a considerable scientific achievement.

This article describes and discusses a cognitive and neuropsychological theory that attained almost universal acceptance in Europe from the fourth to the sixteenth centuries: the theory of the inner senses. The origin, nature, and demise of this theory are outlined, the theory is compared with present-day psychological theorizing, and an attempt is made to evaluate the scientific status of the theory.

Origins of the theory of the inner senses

According to many medieval theorists, human cognition consisted of two components—universal and particular knowledge. Universal knowledge comprised general principles or ideas, such as the mathematical fact that 2 plus 2 equals 4, or knowledge of abstract propositions about the nature of God (e.g., Aquinas, 1270[1]/1937; Boethius, 524/1969). Particular knowledge, on the other hand, was more closely tied to perception, and it concerned particular objects in the world. Knowledge and thinking about universals was carried out in the mind, a faculty that was not associated with any bodily organ. On the other hand, following Aristotle's (350 B.C./1931) suggestion, a number of other cognitive processes were believed to take place in bodily organs. These processes included the "common sense," a term not to be understood here in its modern connotation, which was

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believed to combine input from different sense modalities (like touch and vision), imagination (which included the power of retaining and recalling sensory images), and memory.

Aristotle did not believe that these latter processes took place in the cerebral ventricles or even in the brain, but rather in the heart or the sense organs themselves (Aristotle, 350 B.C./1931, *De anima*, 429a, *De partibus animalium*, 656a). However, medieval theorists tended to follow the lead of Claudius Galen, one of the anatomists of the early Roman Empire, in locating these processes in the head. Galen (170/1980) believed faculties such as memory were housed in the cortex of the brain, but his anatomical investigations, which led him to describe the operations of bodily spirits, provided the physiological foundation for the ventricular theory.

Spirit, according to Galen (170/1968, 170/1980), was extracted from food in the liver, refined in the heart, and spread throughout the body. The most refined spirit, known in the Middle Ages as animal spirit, was believed to be produced in the rete system, a complex of blood vessels that is actually found in the heads of some mammalian species (e.g., Baker, 1979), although not, as Galen erroneously believed, in humans. Animal spirit was believed to fill the ventricles of the brain. Passages from the anterior ventricles permitted the spirit to fill the sensory and motor nerves, and hence connected the sense organs and muscles with the brain. In sum, the animal spirit served as "the first instrument of the soul" (Galen, 170/1980, p. 445).

It is not known for certain who first suggested that cognitive processing took place in the cerebral ventricles rather than in the cerebral cortex or the heart, but the third-century physician Posidonius has been suggested as the originator of the theory (e.g., Roccatagliata, 1986). Certainly the idea was widespread by the end of the western Roman Empire. Different versions of the basic theory, for example, are stated as fact by both St. Augustine (426/1982) and Nemesius of Emesa (400/1955).

Before we consider the workings of the model in detail, it is worthwhile to consider the question of why the theory was accepted at all. This is particularly relevant because a major problem with the theory from the medieval perspective was that it posited that a number of cognitive functions were housed in physical organs which would, of course, not survive death. This raised a number of theological problems: How, for example, could immortal souls remember or imagine anything after death (e.g., Aquinas, 1273/1964)?

In brief, the theory was believed because of two compelling arguments derived from observation. First, the model provided an account of animal behavior. It was often remarked that animals displayed

behavior that suggested they were capable of what appeared to the theorists to be at least some cognitive processing: for example, the building of geometrically constructed webs or hives (R. Bacon, 1266/1962). Augustine (426/1982) observed that the fish in the fountain of his town must have memories, because they had learned to swim close to passersby in the hope of being fed. Because it was generally believed in the Middle Ages that animals did not have immortal souls, their cognition had thus to take place in some mortal, physical organ.

Second, the model was invoked to explain why human cognitive functioning occasionally broke down following head injury or fever. For example, Nemesius describes

> a case of a man suffering from inflammation of the brain who was in a room, with a weaver working there. This man started up and took hold of some glass vessels, and running to a window he demanded of the passers-by whether they would like him to throw down such and such a glass vessel, naming each correctly. When some stopped and said they would, he first threw the vessels down, one by one, and then asked those who were there whether they would like the weaver thrown down. Some of them, taking the whole thing for a joke, said, Yes. The man thereupon took and pushed the weaver out, and down he went.
>
> Now this man's actual senses were in perfect order, for he could distinguish the glass vessels on the one hand, and the weaver, on the other. What was deranged was his mind.
>
> (Nemesius, 400/1955, p. 342)

Outline of the theory

In this section, we present a brief outline of the theory of the inner senses and of how this theory was related to the medieval view of behavior and thinking as a whole. More detailed reviews may be found in Harvey (1975), Kemp (1990), and Steneck (1974).

Galen (170/1968) described the physical arrangement of the cerebral ventricles fairly accurately, although he erred in believing that the human brain contained a rete system and in holding that the sensory nerves were connected directly to the ventricles. However, his teachings were considerably simplified in the Middle Ages. Figure 1 shows a diagram of the ventricular arrangement taken from a late medieval source. This figure, which is typical of medieval belief (for other examples see Clarke & Dewhurst, 1972), is a gross oversimplification of the actual anatomy, as it is of Galen's description. Curiously, it seems probable that such anatomical oversimplification was either necessary for the development of the theory or that the theory itself suggested the oversimplification. At any event, it is difficult to see

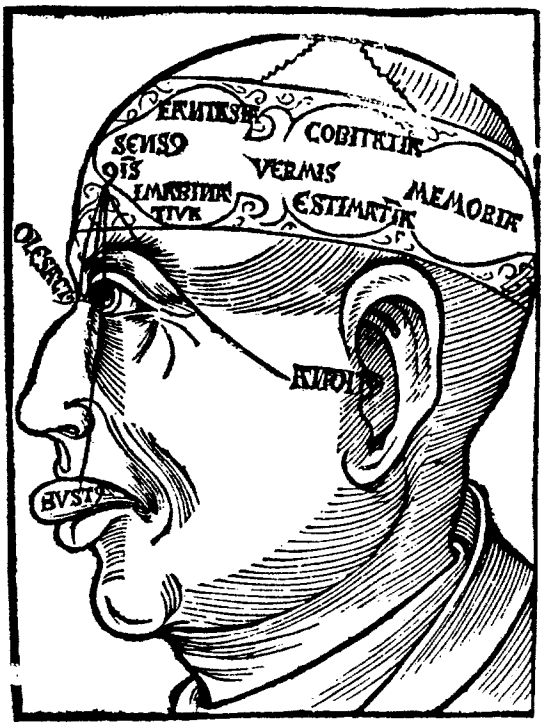

Figure 1. A late medieval illustration of the ventricles of the brain and their functions (after Hieronymus Brunschwig)

how any model would have been suggested by the actual ventricular anatomy which is nonlinear and considerably more complex.

A number of variations on the basic theory of the inner senses existed, differing mainly in how many and what kinds of faculties or inner senses were discussed. Bartholomaeus Anglicus (1260/1975), in his popular thirteenth-century encyclopedia, followed the lead of Nemesius (400/1955) in positing three inner senses, one for each of the supposedly linearly arranged ventricles. Thomas Aquinas (1273/1964) opted for four, and Guy de Chauliac (1363/1971), in his fourteenth-century surgical text, suggested six, two for each of the three ventricles.

A version with five inner senses was suggested by the Arab physician and philosopher Avicenna (1030/1952, 1020/1968), and his version seems to have had most influence in Christian Europe. It was employed by leading thirteenth-century Christian scholastics, including Albertus Magnus (Steneck, 1974), Roger Bacon (1266/1962), and Pope John

XXI (1260/1941). Figure 2 gives a schematic view of this version, showing the cerebral ventricles and their presumed functions, as well as some idea of the cognitive processes presumed to be deployed by the rational soul.

All the sensory nerves were believed to be connected to the front ventricle, in the front of which the common sense was located. The common sense discriminated modalities of perception from each other, such as whiteness from sweetness, to use the often-quoted Aristotelian example (Aristotle, 350 B.C./1931; R. Bacon, 1266/1962). It also compared and summed information received (often known in the terminology of the day as *species*) from the different sense modalities. This, wrote Avicenna (1020/1968), is how an animal associates the sweet taste it craves with food of a particular appearance. At the back of the front ventricle was located the imagination, where images were stored. It was often supposed that the consistency of the front ventricle was more liquid and slippery than the back, so that sensation was rapidly received by the common sense but also quickly lost if the stimulus were removed. On the other hand, the imagination at the back could retain images because it was drier. A frequently employed metaphor that explained the difference between the common sense and the imagination compared the different impressions made by a signet ring in water and wax. An impression made in water vanishes

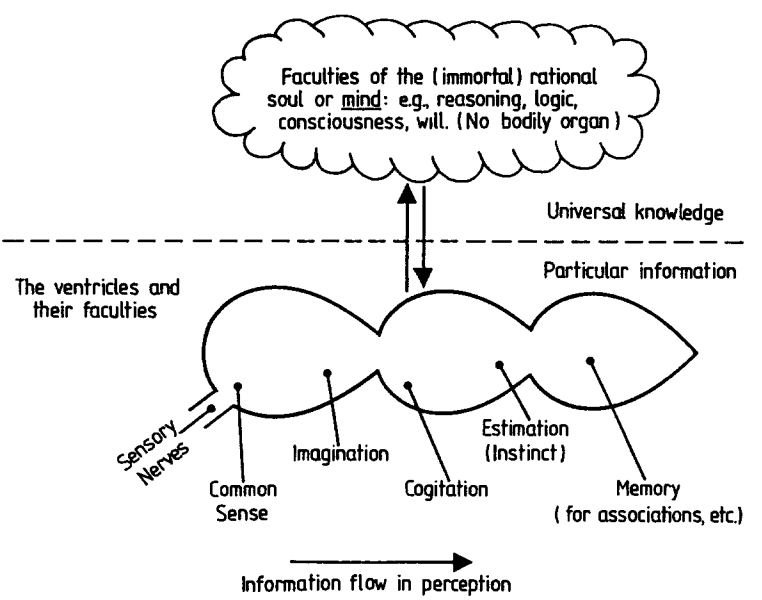

Figure 2. Schematic illustration of cognition in Avicenna's scheme

when the ring is removed, but one made in wax remains (e.g., Augustine, 417/1956; R. Bacon, 1266/1962).

In normal waking perception, information passed from the common sense to the imagination and then to the other cognitive faculties. However, in dreams, the order could be reversed so that the imagination, itself stirred by memories or other input from the later faculties, affected the common sense and even the sense organs (e.g., Averroës, 1180/1961; Avicenna, 1020/1968).

The idea that visual images had a picturelike representation appears to have been usually taken for granted in the Middle Ages, but Avicenna did give two reasons why he thought an internal representation of an image on some part of the body should take place. First, he argued, it was difficult otherwise to see how the sizes of two bodies could be compared. Second, he remarked that it was impossible to visualize two different colors as occupying the same imagined space, implying that different colors could only be displayed on different parts of the same surface (Avicenna, 1030/1952, 1020/1968).

The images present in the imagination were believed to be passed on to the middle ventricle via a narrow passage whose opening and closing were supposed to be controlled by a small wormlike organ known as the *vermis*. The middle ventricle, like the front one, contained two faculties. One was the cogitative faculty, "the mistress of the sensitive faculties" in R. Bacon's (1266/1962, p. 426) phrase, and the highest faculty present in animals. The rational soul in humans was supposed to be directly connected with it.

The possession of the cogitative faculty enabled animals to perform complex functions, like the spider weaving its web or the swallow building its nest (R. Bacon, 1266/1962). In humans, this faculty enabled the putting together of images to make new forms. This was how, for example, one could visualize things never seen before such as a golden mountain or a unicorn. The power of this faculty could most easily be appreciated in dreams, when the will, a power of the rational soul, was effectively disconnected. However, in some disorders, or even as an effect of witchcraft, the cogitative faculty might operate independently of the rational soul, thus giving rise to hallucinations (Avicenna, 1020/1968; Kramer & Sprenger, 1486/1971).

The second faculty in the middle ventricle was the estimative faculty or instinct, "which perceives the non-sensible intentions that exist in the individual sensible objects, like the faculty which judges that the wolf is to be avoided" (Avicenna, 1030/1952, p. 21). Thus, this faculty was believed to extract the meaning or significance for the organism of an object that had been perceived or imagined. Clearly, in pos-

tulating its existence, medieval theorists were acknowledging that the potential for good or harm was not directly perceptible in the object.

The rear ventricle contained only one faculty, that of memory. This was held to act as a storehouse for the cogitative and estimative faculties in the same way that the imagination acted as a storehouse for the common sense (e.g., Averroës, 1180/1961; Avicenna, 1020/1968). The contents of the memory consisted of the meanings derived from experiences or objects; for example, a dog's fear of a stick with which it has been previously beaten.

It is important to realize that although the operation of the inner senses was intended to provide a complete description of animal cognition, this was not true of human cognition. Human beings possessed in addition a rational soul or mind, which, according to both Aristotle and the medieval philosophers, comprised the will and the understanding. The mind was immortal, not located in any bodily organ, and concerned knowledge of universals, like language or the ability to reason logically (Aquinas, 1270/1937; Aristotle, 350 B.C./1931; Avicenna, 1030/1952). Human cognition, then, was supposed to be performed partly by the operation of the inner senses, partly by the operation of the mind, and more usually by both acting in concert under the direction of the will.

Decline of the theory

The main cause of the decline of the theory of the inner senses can be readily discerned: It was discovered to be in profound disagreement with anatomical fact.

Contrary to common belief, dissection of human cadavers was both permitted and practiced by medical schools in medieval Europe (Bullough, 1958; Demaitre, 1975). However, the occurrence of these dissections does not seem to have produced much change in the accepted lore of either philosophers or physicians concerning the anatomy of the human brain, and it was not until the beginning of the sixteenth century that some revision was suggested. The first step may have been taken by Leonardo da Vinci around 1504 to 1507 when he injected the cerebral ventricles of an ox with wax and was thus able to obtain a cast of their shape (Clarke & Dewhurst, 1972). His work, however, seems to have had little influence on his contemporaries. Dryander's work on the anatomy of the human head, published in 1536, for example, essentially gives the medieval account of the ventricles (Lind, 1975). It was the work of Andreas Vesalius (1514–1564) that revolutionized understanding of brain anatomy, and in the process undermined the physiological basis of the theory of the inner senses.

Vesalius's discussion of the anatomy of the human brain forms part of the *De humani corporis fabrica,* which he published in 1543 (Singer, 1952). The work was superbly illustrated, and obviously written by someone with a keen eye for both dissection and the real or imagined errors of his predecessors. There were several key findings of relevance to the theory of the inner senses. First, the arrangement of the cerebral ventricles is not as simple as the medieval anatomical descriptions suggested. Second, there is no rete system at all in human beings, and therefore the refining of spirit would have to take place elsewhere. Finally, and most damaging of all, there is no direct connection between the anterior ventricles and any of the sensory nerves.

Vesalius was fully aware of the consequences for the theory of the inner senses, whose principles he described as "the inventions of those who never look into our Maker's ingenuity in the building of the human body" (Singer, 1952, p. 6). He ascribed only the power of refining spirit to the ventricles, and confessed himself "unable to understand how the brain can perform its office of imagining, meditating, thinking, and remembering" (Singer, 1952, p. 4). Ironically, however, although his finding that the sensory nerves are not connected to the ventricles was a genuine and perhaps even insuperable difficulty for the theory of the inner senses, his rejection of the theory was based mainly on another consideration: namely, that the ventricles in humans are very similar in structure to those in animals, although humans have larger brains. But surely, he argued, we should expect humans, as more intelligent and rational creatures, to possess more developed ventricles (Singer, 1952, pp. 6–7, 40). Yet Vesalius's argument is fallacious, and, as with some of his other comments, actually demonstrates some misunderstanding of the theory of the inner senses. An important aspect of the actual theory, as has been discussed above, was its ability to explain the cognitive processes that were believed to operate in both animals and people.

The theory of the inner senses did not recover from Vesalius's attack. Robert Burton (1621/1904) in *The Anatomy of Melancholy* described the theory accurately and without criticism, but his was an antiquarian work. More usually, the philosophers of the seventeenth and eighteenth centuries seem to have either deliberately ignored the issue of a possible site of cognitive capabilities such as memory or imagination, or to have rather loosely ascribed them to an unknown part of the brain, as, for example, Hobbes (1640/1840) and Leibniz (1765/1981) did.

However, the lack of a coherent theory linking cognitive processes with brain anatomy did not go unlamented. Francis Bacon (1605/1857) noted that the theory of the inner senses was erroneous, but

remarked that "that part of inquiry is most necessary, which considereth of the seats and domiciles which the several faculties of the mind do take and occupate in the organs of the body; which knowledge hath been attempted, and is controverted, and deserveth to be better enquired" (F. Bacon, 1605/1857, p. 240).

There were certainly attempts to fill the theoretical gap. One of the most ingenious of these was suggested by Descartes (1662/1972) in his *Treatise of Man.* Descartes's model, like the medieval one, was Aristotelian in postulating both traditional cognitive functions, such as memory and imagination, which had a physical substratum, and an immaterial mind. Unlike the theory of the inner senses, however, Descartes's was basically a hydraulic model in which cognitive processes were attributed to different patterns of flow of spirit between and within the nerve fibers in the brain.

The model that Descartes proposed was heavily criticized and not widely adopted. The anatomist Thomas Willis (1664/1965, 1672/1971) suggested locating the Aristotelian faculties in different regions of the brain itself rather than in the ventricles. In his scheme, the sensory nerves were connected to the medulla oblongata, the common sense was in the corpus striata, and images were represented on the corpus callosum, "as it were upon a white wall" (Willis, 1672/1971, p. 25). Memories of the images were contained in the cortex.

Willis's scheme was more influential than that of Descartes. La Mettrie, for example, regarded the imagination as a kind of screen in the medulla "upon which images of the objects painted in the eye are projected as by a magic lantern" (La Mettrie, 1748/1953, p. 107). But Willis's account never attained the medieval status of the theory of the inner senses. Indeed, the philosopher John Locke (1690/1975), who was once Willis's student, was one of those who refused to speculate on the physiological basis of cognitive function.

Aristotelian psychology was rather more durable than the physiological component of the inner senses theory. Both the Descartes and Willis models followed the medieval tradition of dividing cognitive faculties into those of the immaterial mind and those that were carried out by bodily organs, and, indeed, this tradition, and discussion of the inner senses, is still followed by some Catholic theorists (e.g., Gaffney, 1942; Gasson, 1963). Nevertheless, the philosophers of the seventeenth and eighteenth centuries produced changes in the psychology as well as the physiology. Locke's (1690/1975) account of cognition, for example, was rather different from Aristotle's. In Immanuel Kant's (1798/1978) psychology, not only was the account of cognition different, but many of Aristotle's processes were redefined. For example, the term "common sense" [Lat. *sensus communis*] at-

tained its modern meaning rather than Aristotle's one of combining sense modalities, and there was now one "inner sense": the "consciousness of what man experiences, as far as he is affected by the play of his own thought" (Kant, 1798/1978, p. 49).

Overall, the post-Vesalian history of the theory of the inner senses can be summed up by two statements. First, belief in the theory seems to have been widely and relatively quickly undermined by Vesalius's anatomical evidence. Second, there was no real paradigmatic replacement. Although various theories were put forward to replace that of the inner senses, none of these theories was at once so well-elaborated and so commonly believed as its medieval predecessor, a fact that remains true to this day.

Evaluation of the model

Comparisons with modern theories. One of the fascinating aspects of the theory of the inner senses is that it shares a number of features with cognitive theories in modern psychology. To begin with, it is clear that the medieval theory, in substantial part, is an information-processing model. In the process of perception, information enters through the sensory nerves and passes through a number of well-defined processing stages in the cerebral ventricles. In doing so, the information becomes more abstract. Avicenna, for example, claimed that the information represented in the imagination was abstracted from the world in the sense that the original object no longer needed to be present for the object to be imagined. He went on to point out that "the faculty of estimation goes a little farther than this in abstraction, for it receives the intentions which in themselves are non-material, although they happen to be in matter. . . . Good and evil, agreeable and disagreeable . . . are in themselves non-material entities" (Avicenna, 1030/1952, p. 39).

In this respect, the theory is consistent with discrete stage-processing models which have been popular in twentieth-century cognitive psychology. Like the theory of the inner senses, such models assume that information is transformed in discrete stages, with the information becoming more abstract. Consider, for example, Bruce and Young's (1986) model of face recognition in which the incoming visual information (faces) passes through an input coding stage and a face recognition unit before semantic representation is achieved and a person identified.

Similarities between the medieval model and modern theories may also be found in other more specific aspects of the model. One example concerns the way in which memory capabilities are divided up. It is common today to regard human memory as consisting of a number

of different capabilities. One frequent distinction, for example, is that between short- and long-term stores (e.g., Warrington, 1982). Long-term memory itself is often divided into separate domains. One influential suggestion, originating with Tulving (1972), distinguishes episodic memory (specific past experiences) from semantic memory (general knowledge or knowledge of fact). A third common category is procedural memory which stores acquired motor or other skills (e.g., Tulving, 1982).

The medieval account of cognitive processes also postulated three different stores. Two of these, the imagination and the memory, are located in the ventricles. The third, which is a storehouse of concepts, is contained in the mind (e.g., Aquinas, 1258/1965; Augustine, 398/1955; Avicenna, 1020/1968). The distinction between the capabilities of the imagination and the memory does not closely correspond to modern distinctions, although the imagination resembles an iconic or short-term store in being more closely tied to the attributes of the physical stimulus than was the memory in the rear ventricle. However, the distinction between the memorial capabilities of the inner senses (the imagination and the memory) and that of the mind resembles the present-day distinction between episodic memory and semantic memory. In the medieval theory, information about particular objects or events was believed to be stored in the ventricles, images of objects and events in the imagination, and their meaning for the individual in the memory of the rear ventricle. In contrast, knowledge of word meanings or intellectual skills that are involved in knowing a foreign language or knowing how to perform mental arithmetic, were believed to be contained in the immaterial mind.

In present-day scientific psychology, distinctions between types of memory are used to explain empirical phenomena (e.g., Tulving, 1982). This also occurred in the Middle Ages, an interesting example being given by Aquinas's (1258/1965) discussion of metamemory, as it is now known. The phenomenon of metamemory is the knowledge that we know something even if we cannot remember what it is. A common everyday example is seeing someone familiar whose name cannot immediately be recalled. Aquinas explained this phenomenon by referring to the different memories of the mind and the inner senses. General knowledge, which also comprises references to particular items stored in the inner senses, is contained in the mind. In metamemory, the references in the mind are found, but some physical indisposition prevents the information in the physical store from being recalled.

Another example of correspondence with a modern theory concerns the phenomenon of hallucination. In the theory of the inner senses,

hallucination occurred when there was some disorder that prevented the will from exerting its normal control over the functioning of the ventricles, particularly the cogitative faculty. The control might, for example, be relaxed as a consequence of demonic activity or witchcraft, or as a result of the action of the melancholic humor (Averroës, 1180/1261; Kramer & Sprenger, 1486/1971). In either case, hallucination resulted from unintended and hence abnormal operation of the cogitative faculty in synthesizing new images.

One recent account of hallucination has a similar flavor. According to Hoffman (1986), the normal process of discourse planning involves the creation or rehearsal of verbal images. In schizophrenics, this process may occur unintentionally: The crucial feature of hallucination in Hoffman's model is thus "the experience of unintendedness" (p. 503) that accompanies the verbal imagery in a pathological case.

One can also discern more general points of similarity and difference between the theory of the inner senses and modern cognitive theories. An obvious point of similarity is the common concern that the theory should be consistent with the findings of neuropsychology and physiology. In particular, as we have seen, phenomena uncovered from individuals with abnormal cognitive processing were commonly thought important by the theorists of the inner senses, just as they are by present-day psychologists. On the other hand, it would be a rare modern theorist who proposed that some cognitive processes are carried out in a mind that has no physical organ or counterpart at all.

An important difference between the theory of the inner senses and modern theories lies in the scope and detail of the theory. The medieval theory was less well specified. Important details, such as how the individual images could be retrieved from the imagination or how instinct derived the importance of the object, were simply not considered. In part this relative lack of interest in detail may be associated with another obvious but important difference: Medieval cognitive theorists did not carry out any of the psychological experiments that might have elucidated such details.

Integration with other medieval beliefs

Although the medieval theory lacked detail, it cannot be accused of being applicable to only a narrow range of phenomena. Its breadth of application was probably a consequence, in part, of its long period of acceptance in educated medieval circles. It was embraced by philosophers, theologians, and physicians, and mentioned by medieval poets: Geoffrey Chaucer (1400/1966) in *The Knight's Tale* refers to mania being generated in the front ventricle; John Gower (1384/

1901) in his *Confessio amantis* speaks of the goddess Minerva as sovereign of the wit and reason in the "celles of the brayn" (Book 5, lines 1460–1464).

A further indication of the breadth of the theory is the way it was integrated with other beliefs common in medieval Europe. For example, when combined with another medieval doctrine, that of the humors, it was readily expanded to explain why there are individual differences in cognitive abilities. According to the Arab philosopher Averroës (1180/1961), people with a relatively dry rear ventricle will tend to have good memories, because the traces will persist rather than being washed away. If people are dominated by moist humors, as, for example, children were generally believed to be (e.g., Aquinas, 1273/1964), their memory will be inferior but they will be quicker at retrieving and understanding. Individuals dominated by black bile, a cold dry humor, will have excellent imaginations: The dryness enhances the definition of the images, whereas the coldness makes them stable (Averroës, 1180/1961).

The theory was also integrated with medical as well as theoretical knowledge, and was commonly used in the Middle Ages to distinguish the mental disorders of mania and melancholy. Mania or madness was believed to be a disorder of the front ventricle; melancholy affected the middle ventricle. A third disorder, lethargy, resulted from impairment of the rear ventricle (e.g., Bartholomaeus Anglicus, 1260/1975; Clarke, 1975).

Yet another example of the medieval capacity for synthesizing the theory of the inner senses with other beliefs was given by Heinrich Kramer and James Sprenger (1486/1971) in the infamous *Malleus maleficarum,* a book that provided a manual for witchhunting. According to *Malleus maleficarum,* witches caused their victims to hallucinate by inciting demons to stir up the cerebral ventricles so as to mimic or cause the effects of mental disorder.

The scientific status of the theory of the inner senses

A popular notion in mainstream psychology, and one advanced by some influential historians of psychology, for example Boring (1950), is that medieval psychological theories are not part of genuine scientific endeavor, because they were neither based on careful observation nor tested empirically. This characterization seems true to some extent. Medieval scholars were certainly not involved in conducting careful experimentation in the same fashion as modern-day scientists. However, it is clear from the previous discussion that it would be wrong to interpret the theory of the inner senses as insulated from observational data. First, the development of this theory was clearly related

both to the neurophysiological knowledge of the day and also to a variety of behavioral observations. Second, the demise of the theory appears to have come about because of new information regarding the structure of the brain.

Moreover, developments in the philosophy of science and the philosophy of psychology over the last few decades have made it clear that there is something deeply problematic about setting up rigorous empirical testing as the sole criterion for evaluating the scientific status of a theory or investigative process. This approach is typically labeled empiricism. We have not the space for an exhaustive treatment of this point here, but, to put the problem in a nutshell, the connection between theory and data is much looser and more fickle than a rigid empiricist account allows. Data are always subject to multiple interpretations or explanations that can leave the original theory intact. There is also the possibility of measurement of methodological difficulties in research results that apparently falsify a theory. Accordingly, there is no algorithm that precisely connects data to theory selection.

The solutions that theoreticians and philosophers have offered following the demise of empiricism are diverse. However, one popular approach, which we favor, is to view theory selection as a judgment call that is subject to a diverse range of scientific values or criteria, which include but go beyond consistency between theory and observational prediction. Such criteria include *explanatory depth, unifying power, internal* and *external coherence,* and *application* (e.g., Fletcher, in press; Greenwood, 1989; Hooker, 1987; Howard, 1985; Laudan, 1984). How does the theory of the inner senses perform according to this set of criteria? The notion of explanatory depth invokes the idea that one important task of a scientific theory is to postulate underlying causal mechanisms that generate or account for the surface phenomena. Clearly the theory of the inner senses merits a high score on this criterion. The postulation of a bundle of inner cognitive constructs that have the power to generate cognition and behavior may have seemed quaint and thoroughly unscientific in the 1940s when behaviorism and positivism were ascendant, but in today's cognitive zeitgeist it is a paragon of scientific respectability.

The theory of the inner senses also managed to integrate and explain a good number of apparently disparate items of knowledge and hence possessed the valuable property of unifying power. Ironically, the majestic sweep of the theory also proved to be its Achilles' heel, in that the theory was laid open to empirical attack along a wide front. In fact, the theory was refuted by the attack on its neurophysiological underpinnings.

The theory was logically internally consistent, and the medieval philosophers and doctors labored long and hard to render the theory consistent with other entrenched theoretical knowledge of the day; hence, the degree of internal and external coherence of the theory was impressive.

Finally, as previously outlined, the theory was successfully applied to many real-life phenomena of the day (such as witchcraft and mental illness) and so scored high in applicability.

To sum up, in terms of many scientific criteria, the theory of the inner senses stacks up surprisingly well. One final important point concerns the aims of the theory. It is typically considered that the sine qua non of science is that the central aim is toward explanation or understanding (e.g., Howard, 1985). It is the centrality of this aim, for example, that distinguishes science from other pursuits or institutions, such as art or engineering, that may also embrace some commitment to truth or to the assessment of causal structures in the world. Again, according to this criterion, the theory of the inner senses was obviously a scientific theory—the major thrust of the theory was clearly toward the understanding and explanation of human behavior. Indeed, this central concern with these scientific aims is typical of medieval thought in general. The idea of developing a theory that was purely concerned with pragmatic aims, such as the control of behavior, was quite foreign to their thinking.

Conclusion

Clearly, modern psychology has advanced beyond the theory of the inner senses, and certainly there are important differences between medieval and modern psychology. However, we would claim that the theory of the inner senses was an elaborate and innovative exposition that, even in retrospect, can be regarded as a considerable scientific achievement.

Notes

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1. Dates before 1450 A.D. are those when the work was written rather than when it was first printed. These dates are often approximate, and should be regarded as indicative only.

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