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Seminal Researchers & Theorists

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Susan Blackmore (1951—)

Blackmore received a PhD from the University of Surrey and began a research career in parapsychology, which she eventually abandoned for lack of demonstrable evidence for things paranormal. She subsequently published influential books on consciousness, and published *The Meme Machine* in 1999. Her prolific publications, interviews, and public speeches have done much to raise society's awareness of the contributions of psychological research to significant questions of humanity's place in the world.

Chapter 12

Consciousness

> Consciousness is . . . "[A] whole kingdom where each of us reigns reclusively alone, questioning what we will, commanding what we can. A hidden hermitage where we may study out the troubled book of what we have done and yet may do. An introcosm that is more myself than anything I can find in a mirror. The consciousness that is myself of selves, that is everything, and yet nothing at all—what is it? And where did it come from? And why?"
>
> Julian Jaynes (1976), p. 1

Chapter Outline

Preview Questions

- *How is consciousness defined?*
- *Can we determine whether animals are conscious or whether machines will ever be conscious?*
- *How did consciousness evolve and what is its purpose?*
- *What is the purpose of sleep and dreaming?*
- *What are some of the major disorders of consciousness?*

12.1 Introduction

Consciousness is a term that is used in everyday conversation, such as when we talk about self-consciousness, unconscious behavior, altered states of consciousness, heightened consciousness, losing consciousness, and coming back to it again. This common usage would lead one to believe that it is a well-understood concept. It is not. Even trying to define it in everyday terms leads one to fumble about *I* and *me* and *self-concept* and *awareness* or perhaps *spirit* or *soul.* Yet, most people agree that they have a feeling of an inner self that sees through their eyes and hears through their ears, as though a little homunculus exists inside each of us and experiences our inner world while directing our outer actions. Centuries of debate about what consciousness is, what it does for us, or if it even really exists have produced remarkably little progress and consensus. It is probably the most commonly experienced and least understood aspect of the human condition.

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Gottfried Leibniz (1646–1716), who is acknowledged, along with Isaac Newton, as the founder of calculus, was the first philosopher to distinguish between conscious and unconscious perception (Walker, 1987). He argued that we can sometimes recall things that we had apparently ignored and were not conscious of when they first occurred, such as some details of a scene or conversation that we had not noticed when first experienced. He also cited as an example the sound of waves at the seacoast that are made up of splashes of individual water droplets that we could not possibly hear by themselves. He anticipated the topic of **subliminal perception**, the unconscious processing of information, or lack of awareness of things, that can influence our behavior later. If some parts of perception, learning, memory, and action are unconscious, then other parts must be conscious. But what does this distinction mean, and is there any evidence other than our own subjective feelings that can separate conscious from unconscious processes? As Blackmore (2004, pp. 1 & 3) states:

> If you think you have a solution to the problem of consciousness, you haven't understood the problem . . . I imagine that right now, this very minute, you are convinced that you are conscious—that you have your own inner experience of the world—that you are personally aware of things going on around you and your own inner states and thoughts . . . But what makes consciousness so interesting is that it cannot be agreed upon . . . It is private. I cannot know what it is like to be you. And you cannot know what it is like to be me.

Subliminal perception

The idea that stimuli can result in sensations that are perceived below the conscious level of awareness, yet nevertheless can influence our current or later behavior

Christoph Bernhard Francke, public domain, via Wikimedia

Gottfried Leibniz, 1646–1716

12.2 Theories of Consciousness

12.2a The Mind–Body Problem

Among many other things, Descartes proposed that the mind and the body are composed of different stuff. The body is materially physical, occupies a definite space and time, and is governed by the laws of biology and physics. The mind, on the other hand, is ethereal, occupies indefinite space and time constraints, and belongs to the world of the spiritual. Although these two entities can interact to produce behavior, they remain largely separate—a doctrine known as **dualism**.

Dualism

The belief that the mind and the body are different, and that mental processes cannot be reduced to biology alone

Alternatively, Cartesian dualism can be reduced to one or the other of its two components (i.e., mental or physical). In idealism or **mentalism**, it is argued that the only reality we can ever know is our awareness as determined by our sensory systems, perception, and memory. The exact nature of the world, if we can ever come to know it, can only be interpreted by the mental states that result from our interactions with it. At the other extreme, physicalism or **materialism** asserts that all mental life can be reduced to biological and physical processes that occur in our brains. In this sense, there is no mind separate from a functioning brain, and consciousness is a product of a material process.

Mentalism

The belief that the only reality in the world is due to the activity in the mind

Materialism

The belief that mental activity can ultimately be reduced to biology, chemistry, and physics

12.2b Dualism

Modern proponents of dualism are relatively few, but they remain influential. For example, the philosopher Karl Popper and the neurophysiologist John Eccles argued that the thoughts and feelings of the self cannot be reduced to activity in the synapses of the brain, rather, the self controls many mental processes and thus, indirectly, the brain itself (Eccles, 1994; Popper & Eccles, 1977). Consciousness is viewed as an **emergent property** of a thinking brain that is more than the sum of individual neuronal responses. Emergent properties exist in many realms; an example is the wetness and surface tension of a glass of water, which cannot be predicted from characteristics of its component oxygen and hydrogen alone. Other examples include the complex behaviors generated by apparently simple systems, such as the structure and functions of ant or termite nests from individual organisms or the development of the modern internet from a simple file-sharing system. By this argument, it is impossible to reduce mental processes to specific, underlying material processes because of the complexity and indeterminacy of the links involved.

Emergent property

A property of some combination of parts that cannot be predicted by the respective properties of the parts themselves, such as the fact that dry sand can be poured like a liquid, yet its individual particles are solid

Chalmers (1996; 2004) has also argued for a type of dualism in which there is a distinction between behavioral studies of human perception, learning, and memory and subjective studies of one's sensations, feelings, and thoughts. He asserts that the former behavioral studies provide data about objective structures and processes of physical systems. Subjective, introspective reports can also be treated as data, but they cannot be wholly explained by objective means. In Chalmers's view, we can search for correlations between objective studies of human behavior and subjective experiences of individual subjects. However, since causality cannot be inferred from such correlations, it remains unclear whether behavior causes subjective impressions, or subjective impressions cause behavior, or both are caused by unknown third factors. He maintains that a science of consciousness can proceed by improving on the introspective methods that famously failed in the 19th century, and that these introspections can be studied without needing to address details of the mind-body problem.

12.2c Monism

As an alternative to dualism, monists argue that there is only one kind of stuff in the world. Mentalists, or idealists, argue that this stuff is the content of internal sensations, perceptions, and ideas. There is no reality other than that which exists in our experiences of it. George Berkeley (1685–1753) actually took the extreme stance that there is no matter in the universe, only sensations in our minds. He was reacting against what he viewed as a dangerous trend in science—the reduction of everything in nature to mechanics and mathematics. In response, Berkeley's contemporaries in the British Royal Society, ". . . to his chagrin and surprise, were inclined to praise him for his dialectical ingenuity, but to dismiss his conclusions as the paradoxes of an amusing Irishman" (Warnock, 1987, p. 82). They then encouraged him to emigrate to America.


John Smibert, public domain, via Wikimedia
George Berkeley, 1685–1753

At the other extreme are materialists, who argue that the only kind of stuff is matter, and that all structures and processes in the universe can be reduced to interactions between matter and energy according to physical laws. These structures and processes would perforce include the human mind and the personal feeling of consciousness; "Some people find materialism unattractive as a theory of consciousness because it seems to take away the very phenomenon, subjective experience, that it was trying to explain" (Blackmore, 2004, pp. 9 & 11).

The fact that such extreme, contrasting views persist and are actively maintained by various philosophers and researchers in the behavioral sciences is indicative of the difficulty of trying to define consciousness. Consciousness is the prototypical mental process that we all seem to agree that we have, yet there is no consensus about what it is, what it means, and what it is for, or even if it exists at all or is merely an illusion. Despite considerable inroads recently made into understanding the structure and processes of the brain (through cognitive neuroscience and brain imaging) and the development of increasingly sophisticated theories of mental processes involved in perception, imagery, and language, consciousness itself remains mysterious. As Dennett (1991, p. 21) said, "Human consciousness is just about the last surviving mystery."

12.3 History of Psychological Approaches to Consciousness

The history of consciousness studies in psychology has had a cyclical journey. Its place in theory has wavered between being the centerpiece of psychological analysis to banishment as a backwater quagmire. In Wundt's laboratory in 19th century Leipzig, the contents of consciousness were treated as the main area of research interest. His students were trained in the art of introspection, but the emphasis on pure subjectivity and the demands of satisfying certain theoretical assumptions doomed the method to failure. Introspection was shown to be unreliable across individuals as the only window into mental life. Chalmers (2004) has argued that the method still has its uses in consciousness studies, but it must be anchored in parallel empirical investigations as one step in making first-person accounts more reliable. That is, one's subjective impressions at least must be consistent with laboratory data in similar task environments, or one or the other cannot be trusted. There is a strong bias in the research community to reject introspections that are inconsistent with objective data about human abilities.

Other 19th and early 20th century scholars readily used introspection as a source of theories about human behavior, a trend that continues today. James (1890) had no difficulty with including his own thoughtful introspections in his theories, and he made the stream of consciousness the central component of his idea of self. Yet, he was aware that many psychological processes and behaviors are more or less unconscious, and others are not available to consciousness when one is asleep or under the influence of psychoactive drugs. He agreed with John Locke, who argued that we could not be held responsible for all of our actions if they fell out of the realm of consciousness and were thus forgotten (a scandalous idea for the religious people of his day).

Sigmund Freud (1949) lifted the unconscious into a prominent position in his psychoanalytic theory. Unconscious memories and desires and their competition for control of the self were supposedly at the root of neurotic behavior. The unconscious was to be explored indirectly in his patients through the interpretation of dreams and other therapeutic methods of analysis. His ideas were also treated as scandalous, not only for their emphasis on childhood sexuality, but for the role of unconscious motivation in controlling human behavior.

Max Halberstadt, Public domain, via Wikimedia

Sigmund Freud, 1856–1939

The introspective traditions and reliance on analysis of case studies in the work of James and Freud were rejected by the behaviorists in America in the early 20th century. Both Watson and Skinner found no use for either conscious or unconscious mental processes. To them, these ideas smacked of subjectivity and could not be measured in the laboratory. They thought that laws of behavior could be perfectly well-developed and tested without recourse to hypothetical mental states. If consciousness is a state of mind that is only a feeling without a clear purpose, then it is an **epiphenomenon**—an unnecessary and useless by-product of behavior. Torey (2014, p. 28) counters that, ". . . the claim that consciousness is an epiphenomenon without causal relevance speaks only of ignorance of how the brain works." Cohen (1987, p. 72) chides behaviorism as ". . . a self-conscious revolution against consciousness." Perhaps this is not surprising, since a true science of consciousness still eludes us.

Epiphenomenon

A consequence of some occurrence or event that has no function or necessity, and no explanatory value for the event that caused it

Many modern philosophers and cognitive psychologists are concerned with how the brain works to interpret experience, retrieve relevant information from memory, and act on the products of the two. The fact that inner thoughts and feelings typically accompany all these activities indicates that we are consciously involved with our environment and many of our responses to it. But this approach to consciousness is what Chalmers (1995, 1996) identifies as the *easy problem* of consciousness. That is, the standard methods of cognitive science address data from experiments that test theories of the neural mechanisms or more abstract computations that lead to human behavior. Even though the problems of explaining human perception, memory, reasoning, and language might not be actually *easy,* we have confidence that knowledge accumulates through proper application of the scientific method. In that way, we are assured that our theories conform ever more closely to the realities of behavior and its underlying neural substrates. The hard problem seems to be resistant to such an approach. The hard problem ". . . is the question of how physical processes in the brain give rise to subjective experience" (Chalmers, 1995, p. 63). This is the gap that was ignored by the behaviorists, but now is demanding attention by cognitive scientists: How do we relate brain activity to conscious experience? Perhaps consciousness remains a mystery because we have not yet learned how to think about it, and eventually it will lend itself to empirical study (Churchland, 1996; Dennett, 1991).

A different approach to the definition of consciousness is in terms of its functions, rather than its potential structures and processes in the brain. Just as attention has been defined as the process that gives rise to the contents of consciousness (James, 1890), consciousness can be defined in terms of what it does for us. Although some cognitive scientists argue that consciousness has no obvious function, others disagree. Koch and Tsuchiya (2006) list some functions attributed to conscious processes, including summarizing current information and making it available to planning areas of the brain, detecting anomalies and errors, decision-making, language usage, and inferring the mental states of other people. In addition, consciousness is argued to involve deliberate working memory processes, rational thought, and the setting of long-term goals. These complex processes are the basis of the distinction that Koch and Tsuchiya make between attention and consciousness. They argue that attention can lead to conscious activities, but there are other conscious processes that occur without attention, such as the popping out of salient objects in visual search and the determination of the gist of a scene with only a brief pictorial presentation. Similarly, there are attentional processes that do not result in consciousness, such as **subliminal priming** or adaptation effects (demonstrated by the presence of aftereffects from staring at a moving grid or a homogeneous colored field, which produce opposing perceptions after significant exposure times). Thus, although attention and consciousness are supposedly intimately related, they also can operate independently of each other and serve different functions for human behavior. These ideas have been addressed directly by Montemayor and Haladjian (2015), who have argued persuasively that attention and consciousness have followed separate evolutionary paths and remain separate in many if not all cognitive functions.

Subliminal priming

The effect of some stimulus (the prime) on the response to a subsequent stimulus (the target), even though the prime is presented too briefly or under such illegible conditions that it cannot be recognized or even result in awareness that it occurred

12.4 The Evolution of Consciousness

12.4a The Adaptive Value of Consciousness

"In the scheme of evolution, every major structure and behavioral trait must have a purpose. Nothing remains for long if it does not confer some advantage to the organism" (Bridgeman, 2003, p. 276). By this argument, consciousness, or at least the feeling that we have conscious experiences and awareness, must serve some purpose. What is the purpose of consciousness, and where did it come from? Or is it some vestigial process without much use, such as our appendix? Such evolutionary developments that are by-products of adaptation but later show no useful function or selective advantage have been called “spandrels” after the name of decorations added to arches for aesthetic purposes that add nothing to the structural support or stability (Gould & Lewonton, 1979; Montemayor & Haladjian, 2015). Koch (2019) finds it unconvincing that consciousness is an epiphenomenon or a spandrel, without behavioral or adaptive consequences for humans. If conscious experiences have no adaptive function, the selective process of evolution over thousands of generations would not have produced the intensity of feelings we share when viewing a beautiful sunset, hearing an emotionally arousing piece of music, or reliving painful or satisfying memories of past experiences. Consciousness is also argued to be part of planning or fantasizing about future activities and events.

Others have argued that consciousness has evolved slowly and is present, albeit in more primitive forms, in many nonhuman species. Both Damasio (2000) and Tulving (1987) have identified three levels of consciousness that have evolved sequentially in higher organisms. The lowest level is manifested by brief representations of external reality, such as sensations and perceptions, that allow registration, recognition, and appropriate responses to stimuli. These largely unconscious processes are equated to procedural memory by Tulving and to a proto-self level by Damasio, and they are present in many animals. The second level is called a core-self by Damasio, and it refers to second-order awareness of the proto-self. For Tulving, this level includes memory and awareness of objects and events that are not physically present, but can be the basis of adaptive actions and planning. He equates this level of consciousness to semantic memory. Many animals, including birds and squirrels, for example, remember where they have hidden food caches. Finally, a third level represents a type of autobiographical or episodic memory for both Tulving and Damasio that includes a sense of self and the reconstruction of one’s role in past events and anticipation of one’s involvement in the future. All of these levels might be represented in some animals (although Tulving argues that the third level is unique to humanity), but they are developed to their highest levels in humans (see Feinberg & Mallat, 2016). Finally, Koch (2019) is supportive of the idea that some levels of consciousness might exist at various levels in the animal kingdom, but, at least for the foreseeable future, artificial intelligences cannot be considered conscious. For machines to be conscious, they would have to be affected by their past and determine their future in a way that is influenced by experiences and feelings that have as yet to be captured in hardware or software (see also Dehaene, Lau, & Kouider, 2017).

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Many animals, such as squirrels, remember where they have hidden food caches.

Figure 12–1 **Consciousness Theories of Koch (2019), Damasio (2000), and Tulving (1987)**

Koch (2019)	Damasio (2000)	Tulving (1987)
♦ In humans, conscious experiences are adaptive.	♦ Level 1: Unconscious processes are equated with the "proto-self."	♦ Level 1: Unconscious processes are equated to procedural memory.
♦ Consciousness is part of planning or fantasizing about future activities and events.	♦ Level 2: "Core-self" is a second-order awareness of the proto-self.	♦ Level 2: Memory and awareness of objects and events are equated to semantic memory.
♦ Artificial intelligences are not conscious.	♦ Level 3: Autobiographical or episodic memory includes a sense of self, reconstruction of one's role in past events, and anticipation of involvement in the future. Occurs in humans and in some animals.	♦ Level 3: Autobiographical or episodic memory includes a sense of self, reconstruction of one's role in past events, and anticipation of involvement in the future. Unique to humanity.

12.4b Consciousness for Cognition

One argument for the evolution of consciousness is that it evolved in order to plan and execute complex sequences of events. This includes the ability to engage in behaviors in the present that result in benefits that are realized only in the future. Preparing tools and containers for use in hunting and gathering falls into this category, as does the use of language to make requests or to persuade others to join in some activity. Planning complex sequences of actions is associated with frontal lobe activity, and the frontal lobes in primates and humans are especially well-developed relative to those of other mammals. In humans, the frontal lobes make up almost 30% of all cortical tissue, whereas the frontal lobes comprise 17% of the cortex in chimpanzees, 7% in dogs, and 3.5% in cats (Bridgeman, 2003). The executive functions of working memory have been equated both with consciousness and with frontal lobe processes in humans.

Research has shown that consciousness is related to such activities as attention and working memory that are important components of making and executing plans. For example, Merikle et al. (1995) used a task in which a priming word was briefly presented and followed immediately by three letters and a number of blank spaces, indicating a word that was to be filled in and spoken aloud. The perverse requirement of the task was that even though the initially presented priming word (e.g., spring) could be used to complete the following word fragment, (e.g., spr_ _ _), the subjects were instructed to respond with some other word (e.g., sprint) rather than the one originally shown. The interesting result was that if the initial priming word was shown for a relatively long time before the fragment appeared (e.g., 214 ms), people usually came up with a word different from the one used as the prime. However, if the prime was briefly presented (e.g., 50 ms) and immediately followed by the fragment, the priming word was most commonly blurted out as a response. One interpretation of these results is that, given sufficient time, conscious processes can suppress an automatic response to a priming word, but unconscious processes dominate over the short term (see also Neely, 1976).

Similar results have been obtained in attention studies. It is well known that the sudden onset of a new item in peripheral vision will automatically and rapidly attract visual attention (e.g., see Chapter 5). However, if subjects are instructed to maintain the focus of attention in a different part of the visual field, onsets have little disturbing effects on the locus of attention (Juola et al., 1995; Theeuwes, 1991). In Bridgeman's (2003, p. 277) words, the role of consciousness is to ". . . force behavior to follow a plan . . . to escape the tyranny of the environment." Bridgeman goes on to claim that at least four types of cognitive activities rely on conscious effort for their successful completion; namely (1) planning, (2) executing plans, (3) directing attention, and (4) retrieving long-term declarative memories. At least one of the roles proposed for consciousness in all of these activities is to direct attention and maintain its focus on the task at hand and to avoid distractions by unwanted thoughts or unimportant stimuli.

12.4c Consciousness for Socialization

An alternative explanation for the evolution of consciousness is that it evolved along with the development of complex social groups in primates and other animals. In order to get along in such societies, it became necessary for individuals to understand, predict, and eventually try to control the behavior of others. According to Humphrey (1987), the development relevant for consciousness occurred when one of our ancestral creatures went beyond just observing others' behaviors in order to learn about them. The crucial extra step was to look inward toward oneself and think, "What would I do in this situation?" Then one could make social decisions and predictions based on one's own motivations as compared with those that are expected in others, in effect developing a general *theory of mind*. Humphrey argued that natural selection would favor those of our ancestors who developed a means to examine the inner self in order to predict the behavior of others and take advantage of social situations. That is, by coming to understand the desires and motivations that we all share in common, it should be possible to arrange situations to manipulate others into doing what we want and need. Dawkins (1976, p. 59) sounded a similar theme when he speculated that, "Perhaps consciousness arises when the brain's simulation of the world becomes so complete that it must include a model of itself." Consciousness then might serve the function of providing the self with a unified and coherent view of the world as it unfolds across experiences with environmental objects, events, and social partners (Humphrey, 2011; Montemayor & Haladjian, 2015).

12.4d Consciousness for Language Use

Besides arising from selective pressure in cognitive and social functions, consciousness could also have evolved from direct interpersonal communication. In order to use language, individuals must try to convey a meaningful message such that the sender and receiver agree on its content. Mithen (1996) argued that language first served a social purpose, as a concomitant to body language, gestures, and grooming one another to promote group unity and social organization. As language evolved, however, its usefulness extended to group planning and coordination of activities in hunting, gathering, toolmaking, food production, and child-rearing (see Kolodny & Edelman, 2017, for a conjecture about the development of language


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Consciousness may have evolved from direct interpersonal communication for the coordination of activities such as hunting, gathering, and food production.

based on the rise of toolmaking in coordination with its cultural transmission through deliberate instruction). Language then took on other uses as a means of representing internal thoughts and feelings, gaining leverage as a tool for conscious planning, attention, and complex thought processes. By this theory, language gave us the means to think consciously and reflectively as well as to express ideas about conscious experiences themselves. Many authors have argued that language formed the basis of conscious thought (Gordon, 2009; Jaynes, 1976; Nietzsche, 1887/1974).

Torey (2014) has also argued that language as an evolutionary development in humans allowed the brain a means to monitor itself and provide a sense of self, conscious control, and free will. He claimed that, ". . . language creates the . . . sense of self or agency . . . human experience . . . is comprised of what we experience and of the sensation that we are experiencing it . . ." (Torey, p. 149).

12.5 Neural Bases of Consciousness

The hard problem of consciousness would be solved if we could somehow look into the human brain and determine which structures and processes give rise to conscious experience, at least according to the materialist point of view. It should also be possible to distinguish between individuals who are conscious or unconscious (see *For Discussion 12–1: Pathologies of Consciousness*). Dualists and people who believe that consciousness is merely an epiphenomenon related to the real work of the brain assert that such an enterprise would be useless. At best we might be able to find correlations between brain activity and conscious experience, but they would remain just that—correlations with no explanatory power and no power to determine either what causes consciousness or what, if anything, consciousness causes.

For Discussion 12–1

Pathologies of Consciousness

Unconsciousness can be produced by powerful anesthetics and by brain injuries that are temporary or permanent. Unconscious patients show no, or only minimal, responses to external stimulation, and any verbal or motor responses that they do make seem to be unrelated to such stimuli. Severe brain injuries can result in withdrawal from consciousness, characterized by different levels of functioning called coma or persistent vegetative states.

There are many different types of brain injuries that can result in coma—which looks much like sleep, but it is prolonged and does not go through the cycles of brain activity evidenced in normal sleep (see *For Discussion 12–2: Sleep and Dreaming*). Damage to the centers of the brain that control sleep and wakefulness cycles can induce comas that are permanent. These centers are mainly located in the brain stem, which extends from the top of the spinal cord to the pons and collicular region. This area of the brain stem has traditionally been called the reticular activating system, and it modulates arousal of the thalamocortical regions as well as sleep and wakefulness cycles. Damage to posterior (back) parts of the brain stem can produce a permanent coma—a state like deep sleep from which the patient typically will never recover, while respiratory, circulatory, and digestive functions continue fairly normally. Brain activity also continues, although metabolism is typically reduced. In contrast, damage to the anterior (front) part of the brain stem can produce the condition known as locked-in syndrome, of which it has been said that, "The cruelty of this state is almost unrivaled in all of medicine" (Damasio, 1999, p. 243). Since most motor neurons pass through the anterior portion of the brain stem, the patient is left with complete paralysis, yet is fully conscious. Because very few motor neurons pass through the posterior portion of the brain stem, only these will remain intact, enabling voluntary control of eye blinks and upward or downward direction of gaze as the sole means of communicative expression from a fully conscious and comprehending patient. The difficulties associated with this disorder, and the specific example of Jean-Dominique Bauby's case presented in the 1997 book and movie *The Diving Bell and the Butterfly,* are described in more detail elsewhere (Bruno et al., 2016; Koch, 2019).

In contrast, damage to higher cortical and noncortical centers of the brain can result in comas that sometimes improve to persistent vegetative states or to higher levels of consciousness, with or without some residual impairments. It is interesting to note that the areas in which damage produces reduced levels of consciousness tend to be the phylogenetically older portions of the brain. These include the thalamus, and the medial (central) regions of the frontal lobes (specifically the cingulate gyrus) and parietal lobes. Damage to these regions can result in initial coma-like states followed by states of wakefulness called akinetic mutism, in which voluntary movements, speech, and interpersonal engagements are virtually absent, or zombie-like behavior exists, in which the patients are incapable of caring for themselves. Damage to the medial parietal region is also common in patients with Alzheimer's disease. (See the Appendix for full-color figures of the brain; see also Chapter 13, Figure 13–3, for images of Alzheimer's brain abnormalities.)

In contrast, damage to most higher cortical centers can result in severe loss of perception, memory, language, and motor responses without loss of consciousness. These include most of the frontal and temporal lobes and the primary somatosensory and visual and auditory projection areas. Although behavioral deficits in patients with brain damage in these regions can be profound, they remain conscious and are usually unhappily aware of their loss of functionality.

In some cases, damage to multiple brain regions, or less severe damage to critical regions for consciousness, can result in relief from a coma into a persistent vegetative state (PVS). The PVS patient differs from someone in a coma in that EEG activity is generally higher (although some comatose patients show normal EEG activity), and EEG patterns show normal cycles of sleep and wakefulness. In addition, occasional voluntary movements can be made, including emotional expressions and vocalizations, although these tend to be random and not responsive to events or people in the environment. Even rudimentary recovery from a PVS that extends more than a few months

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(continued)

is extremely rare, and the proper care of such patients can result in controversies about whether life should be artificially prolonged, as in the court case in Florida involving Terri Schiavo, who was kept alive for 15 years only through the use of a feeding tube. Determining the levels of consciousness in patients in comas, PVS, or locked-in states, or even whether they are conscious at all, presents difficult clinical decisions. Fortunately, significant progress is being made in identifying residual levels of consciousness in such patients as well as in informing us about their prognosis and treatment options (e.g., Koch, 2019).

12.5a Separating Conscious from Unconscious Processes

Philosophers have entertained the notion that consciousness is not a necessary component of all human activity. It is at least conceivable that we could be like zombies and behave in most, if not all, ways like normal humans, yet have no internal awareness of our experiences and activities (Chalmers, 1996; Searle, 1992). Others have argued that the zombie mode is in fact sometimes necessary, much as is Broadbent's (1958) filter theory, to prevent attention from being diverted from the main (conscious) task at hand to other, parallel activities. The late Nobel Prize-winner Francis Crick, along with the biologist Christof Koch, argued that:

> It would be a great evolutionary advantage to have both zombie modes that respond rapidly in a stereotyped manner, and a slightly slower system that allows time for thinking and planning more complex behavior. The planning system would be one of the functions of consciousness. (2004, p. 1135)

Obviously, most simple reflexes and many habitual, overlearned responses could be executed automatically, without conscious control, but consciousness would be demanded by important tasks that require planning and control of sequential activities. With practice, even complicated sequential processes can become automatic, such that activities like running, reading, and playing a musical instrument can be largely under nonconscious control. Other activities could be shared among conscious and unconscious components, as in Kahneman's (2011) distinction between fast and slow thinking, which we discussed in Chapter 11.

Attention is often viewed as a necessary, but not sufficient, determinant of consciousness. Crick and Koch (1995) view attention as guiding the selection of one from among many possible parallel activities in the brain, as in the biased competition model of Desimone and Duncan (1995). The idea is that various cell assemblies in the central nervous system are rivals for control of conscious processes, and that attention and other processes bias the competition among them so that one becomes at least temporarily dominant. This dominance is maintained by forming coalitions of cell assemblies distributed widely across the brain, perhaps through synchronized firings of the component neurons. Consciousness is then the product of the winning coalition—or perhaps consciousness influences which one wins. There is much that remains mysterious about the hard problem of consciousness, but advances are being made (see, e.g., Eriksson et al., 2020, for a review of empirical methods to separate conscious and unconscious processes).

12.5b The Global Workspace Model of Consciousness

One idea that is consistent with the biased competition theory is Baars's (1988) cognitive theory of consciousness. He distinguished between a vast array of unconscious, specialized processors operating in parallel and a single, serial workspace that has access to many of the ongoing subprocesses. This workspace is usually equated with conscious activity, and it is distinguished from unconscious processes because of its global representation of sensory, perceptual, memory, and thought processes that are involved in interpreting input and arriving at an appropriate response. Extracortical areas can also be involved, as damage to certain nuclei in the thalamus can result in symptoms ranging from mutism to coma that mimic brain death. It seems that normal cortical-thalamic connections are necessary for consciousness.

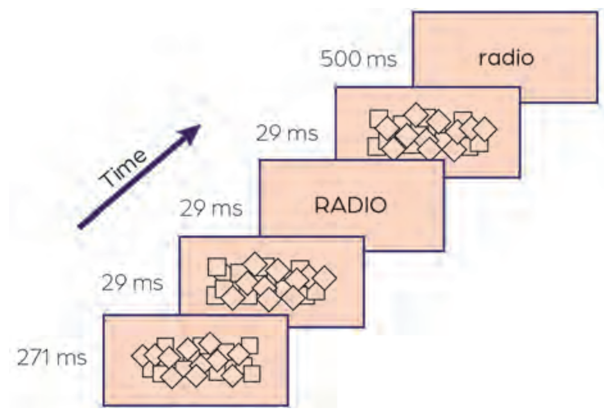
Dehaene and Changeux (2004) have developed a similar model based on sets of neurons with long-distance connections to multiple sites in cortical and subcortical brain regions. These specialized neurons are most densely represented in parietal, prefrontal, thalamic, and cingulate regions of the brain. In their view, consciousness is determined by the activity of a self-sustaining, reverberating neuronal assembly active in many parts of the brain. The circuits are dynamic, and they can operate as independent modules (as in the zombie mode) to affect behavior subliminally. However, when they are part of the dominant, far-reaching assembly, they contribute to conscious experience and determine its contents.

In order to demonstrate relations between conscious and unconscious processes, Dehaene and others made use of a word priming paradigm like that of Meyer and Schvaneveldt (1971; see Dehaene et al., 2004; Dehaene et al., 2001). In this paradigm, two words are presented successively, and subjects are to respond by naming only the second word as rapidly as possible. Response times to the second word are reliably shorter if the two words are the same (repetition priming) or are related in some way (associative priming, like *doctor* followed by *nurse*) than if they are unrelated (no priming; control condition). The critical manipulation is the degree of information available about the priming word. In Dehaene et al.'s studies, the first word was presented briefly (50 ms or less) and was sometimes preceded and followed by jumbled geometrical forms used as masks. The unmasked word could be clearly seen and identified, even when presented briefly, but when the priming word was masked, it resulted in no conscious perception or awareness of any word at all. Nonetheless, a related, masked and apparently invisible first word still produced priming by facilitating the response to the second, target word (i.e., the prime worked subliminally or without conscious awareness; see Neely & Kahan, 2001, for a review). Although the priming effects were not as strong as when the first word was clearly visible, they nevertheless demonstrate a type of unconscious or subliminal priming between two identical or related words, even when only the second word is consciously perceived.

It should be noted that although there are a number of researchers who have developed alternative theories of consciousness, there is no consensus yet on which theory might be the most descriptive and explanatory. In fact a recent paper in *Nature Neuroscience* (Cogitate Consortium et al., 2025), is a direct attempt to compare the global workspace model with the integrated information theory model (Tononi et al., 2016). Unsurprisingly, the results are not conclusive, as there appear to be more similarities than differences among most of the competing theories of consciousness.

Figure 12–2 An Example of Stimulus Sequence from Dehaene et al. (2001)

RADIO is a prime, followed by a mask, then radio is a target. The prime and target are either the same (repeated) or different (nonrepeated). Dehaene et al. showed priming effects even when the masked prime was "invisible" and could not be reported by the subjects.



Source: Adapted from "Cerebral mechanisms of word masking and unconscious repetition priming," by S. Dehaene, L. Naccache, L. Cohen, D. Le Bihan, J. F. Mangin, J. B. Poline, and D. Rivière, 2001, *Nature Neuroscience*, 4, pp. 752–758.

In addition to demonstrating what appears to be priming from an unconsciously perceived word, Dehaene and his colleagues (2001, 2004) measured brain activity using fMRI (to indicate changes in blood flow) and ERP (to indicate changes in electrical activity) across brain areas in their word priming experiments. The critical comparisons involved the amount of brain activity for the different kinds of primes when they were presented subliminally (i.e., short stimulus exposure duration preceded and followed by masks that prevented their identification). When the prime and target words were completely identical, there was less activity in the occipital cortex than when the two words differed in some way, even if the difference was only between upper- and lowercase versions of the same word. That is, two successive words that are different typically produce more activity for the second word than when they are the same. When the two words were identical, but differed in case, brain activity was reduced mainly in the left fusiform gyrus of the temporal lobe, sometimes called the visual word form area (see Chapter 3, Figure 3–17). This reduction of brain activity when the same item is repeated is termed repetition suppression, which is viewed as the neural correlates of repetition priming. These results indicate separate feature- and meaning-based activation of word information, even though the words were processed unconsciously.

When the subliminal prime and visible target words were different, but related in meaning (e.g., 9 versus nine), related items showed differences in activity of intraparietal regions thought to be responsible for the semantics and representation of numerical quantities (Naccache & Dehaene, 2001). Finally, when the two items were completely unrelated, but nevertheless, mapped onto the same response (e.g., the prime was two and the target was four in a task in which different buttons were to be pressed for numbers above or below five), same-response items showed priming activity in the motor area of the frontal cortex (Dehaene et al., 1998). Thus, all four lobes of the brain can show differential activity for subliminal primes, indicating widespread activity due to unconscious perception of masked primes. However, when the primes were unmasked, and therefore were consciously perceptible, activation greatly increased in all of these areas and additionally resulted in activation of new sites in the parietal, prefrontal, and cingulate areas of the cortex.

Together, the results support two aspects of global workspace theories: (1) Many areas of the brain operate as single-domain modules that can be activated in response to subliminal or otherwise unconsciously perceived stimuli, and (2) These same areas of the brain can become correlated and contribute to a more widely spread processing network. These global activations are more likely to occur when the stimuli are consciously perceived (Dehaene & Changeux, 2004). However, it is uncertain whether global activation causes items to be conscious, or whether conscious processes result in global activations. There even is the possibility that some other underlying mechanism causes both global activation and conscious awareness, so the basic mystery remains unsolved.

12.5c Brain Damage and Consciousness

Sometimes we can gain insight into conscious and unconscious processes when certain types of brain damage render patients incapable of performing some tasks with conscious awareness. Even if these patients retain some ability to perform the task, they seem to lack any awareness of their behavior. One classic example is the curious case of **blindsight**. As we discussed in Chapter 2, blindsight might be seen in patients with a scotoma, which is a patch of blindness resulting from the loss of conscious vision in part or all of the visual field due to damage along the optic pathway from the thalamus to the occipital cortex. One such person is Weiskrantz's (1997) patient D.B. who lost vision on one side of his field of view due to a tumor that had spread into area V1, the primary visual cortex, and was surgically removed. D.B. was functionally blind in one half of the visual field, a condition known as hemianopia. When patterns of stripes were shown on the blind side, D.B. reported that he could see nothing at all. However, when he was asked to guess whether the stripes were horizontal or vertical, he was right 90% of the time!

Blindsight

The ability for a person with no functioning visual cortex to report certain aspects of visual stimuli (such as location or motion) correctly, even though they deny conscious awareness of the stimuli

Other subjects, with cortical damage in the occipital region that rendered them completely unaware of visual stimuli, could nonetheless report the speed and direction of movement of the unseen stimuli. These patients often claimed that they were guessing and had little confidence in what they had been asked to report. The results indicate that even though the 85% or so of the visual pathway that leads from the eyes via the thalamus to the visual cortex (geniculostriatal pathway) might be dysfunctional, the remaining visual pathways (techtopulvinar pathways), mainly through the superior colliculus in the brain stem to other cortical areas, enable some residual vision (see Chapter 2, Figure 2–6). The interesting thing about blindsight is that the separation between these two pathways mirrors that between conscious and unconscious vision. The thalamus-cortical (geniculostriatal) pathway is the basis of conscious vision, and the information channeled through the colliculus-cortical (techtopulvinar) pathway is unconscious; yet, it provides enough vision for the person with blindsight to discriminate certain visual features, such as orientation, location, and motion (Weiskrantz, 1997).

Damage to the parietal lobe of the brain, particularly on the right side, has also been shown to produce some curious anomalies between consciousness and behavior. For example, a patient might be completely paralyzed on the left side of the body, yet deny this condition and make excuses for not rising out of bed; a condition known as anosagnosia (Damasio, 1999; Weiskrantz, 1997). Right parietal damage also can result in visual neglect (see Chapter 5), in which people can detect and respond to stimuli presented in the left visual field, but they typically ignore them and deny that they are present.

Damage to the occipital lobe of the brain produces a different picture of conscious versus unconscious processes. Milner and Goodale (1995) worked with patient D.F., who suffered diffuse brain damage due to carbon monoxide poisoning. However, the primary visual cortex was largely spared, but the ventrolateral areas (lower sides) of the occipital lobe were particularly compromised. Although she could not recognize drawings or objects by sight, she could accurately reach out and grab them and identify them by touch. This disability is called *visual agnosia* (or *visual form agnosia*, see Chapter 3), and it is common in individuals with damage to the ventral visual stream from the occipital lobe to the temporal lobe that is important for visual object recognition. The dorsal stream, important for spatial vision and for directing reaching and grasping behavior, was apparently intact in D.F., as indicated in the following demonstration reported by Goodale and Milner (see Figure 12–3). When D.F. was given a card to hold in her hand and match its orientation to that of a visible slot, she was unable to do so with any accuracy. However, when she was asked to insert the card into the slot, she did so effortlessly and accurately, properly aligning the card with the slot as her hand approached it! Apparently, her conscious intent to match the two orientations failed her, but the unconscious operations involved in fitting it into a slot were intact (Goodale, Milner et al., 1991).

A similar dissociation between visual perception and visually guided reaching was reported in normal control subjects by Aglioti et al. (1995). They used a version of the circles illusion (Titchener-Ebbinghaus illusion), shown in Figure 12–4, in which the central circle in each pattern is identical in size, but the circle surrounded by small circles appears larger to most people than the same-sized circle surrounded by large circles. This visual illusion is consciously available to us through the ventral visual stream, but apparently does not fool the dorsal visual stream. When Aglioti et al. used discs in place of circles, the visual illusions remained as strong. However, when their subjects were asked to pick up the central disc, the finger-thumb aperture adjustment was measured to be the same in both cases as the hand neared the disc. Again, the conscious visual size illusion (ventral visual stream) is not present in the unconscious manual adjustments (dorsal visual stream) used to determine actions.

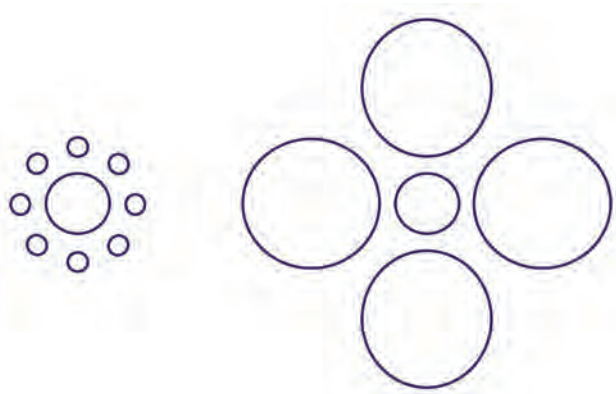
Figure 12–3 **Apparatus and Procedure Used by Goodale et al. (1991) to Illustrate a Dissociation Between Visual Perception and Visually Guided Reaching**

The apparatus has a visible slot that can be turned to any orientation. In one task (shown on the left side in both halves of the figure), the subject was to hold a card in his or her hand at an orientation that matched the slot. D.F. (a patient with ventrolateral occipital lobe damage) failed at this task, by holding the card at a variety of angles distributed randomly around the target orientation. Normal control subjects oriented the card accurately. In a second task (shown on the right sides), the card was to be posted into the slot. Both D.F. and control subjects performed this task accurately.

Source: Gazzaniga, Michael S., ed., *The Cognitive Neurosciences III, third edition*, figure, page 1165, © 2004 Massachusetts Institute of Technology, by permission of The MIT Press.

Figure 12–4 **An Example of the Titchener (Ebbinghaus) Illusion Used by Aglioti et al. (1995)**

A size illusion that fools the eyes (ventral system) but not the hands (dorsal system). The target circles in the centers of the two stimuli appear to be different in size even though they are physically identical. For most people, the circle in the center of smaller circles appears to be larger than the circle in the center of larger circles.



12.6 Altered States of Consciousness

If we know what we mean when we say that we are conscious, then it follows that we might also know what it means to be unconscious, or at least in a different state of consciousness. Most of us would agree that our consciousness is reduced when we are asleep, medicated by anesthetics or certain prescription or nonprescription drugs, or lost in deep meditation. It is also likely that we have experienced heightened states of consciousness, again through the effects of certain drugs or in situations that cause high emotional arousal. But what does it mean to have an altered state of consciousness, and how is it measured in behavior or brain activity?

Ultimately, altered states of consciousness are defined subjectively, just as is the normal state of consciousness. There are as yet few behavioral or physiological measures that can uniquely identify altered states of consciousness, with the single exception of sleep (Blackmore, 2004; see *For Discussion 12–2: Sleep and Dreaming*). Even if altered states are judged subjectively, such perceptions might not be accurate. Most of us are aware of the dangers of alcoholic intoxication, as many people judge their conscious abilities to be impaired by alcohol, but they often underestimate their level of impairment. Such misperceptions of individuals' own states have led to numerous accidents and fatalities. Nonetheless, subjective impressions remain the main way to identify and describe altered states of consciousness, such as the definition offered by Farthing (1992, p. 205): An altered state of consciousness is ". . . a temporary change in the overall pattern of subjective experience, such that the individual believes that his or her mental functioning is distinctly different from certain general norms for his or her waking state of consciousness." As Blackmore (2004) points out, this definition relates altered states to normal states of consciousness, a comparison that itself is subjective.

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Many people judge their conscious abilities to be impaired by alcohol, but they often underestimate their level of impairment.

Another attempt to define altered states of consciousness is through the means used to achieve them. For example, drugs are classified as either stimulants (such as caffeine and amphetamine), depressants (such as alcohol and narcotics), or psychedelics (such as LSD and mescaline) based on their subjective and behavioral effects. However, there are huge individual differences in experience, expectations, and dosage effects that limit the generality of such classifications. Further, researchers have observed that, ". . . most people cannot find the words to explain their sensations" (Earleywine, 2002, p. 98), so details of subjective impressions are not reliable.

Other altered states of consciousness can be achieved through deep meditation, hypnosis, or traumatic experiences, such as recovering from the verge of death. Mystical and religious experiences can also produce altered states of consciousness that can last for 30 minutes or more. Some of these states produce hallucinations, such as an out-of-body experience or traveling along a dark tunnel toward a light at the end. Others might involve being captured by space aliens or other terrifying delusions. Reports of such experiences are fairly common (e.g., 62 of 344 successfully resuscitated cardiac arrest patients reported vivid near-death experiences in a Dutch study; van Lommel et al., 2001), suggesting that there might be some natural physiological process at work that directs feelings and images toward a common set of experiences. Ultimately, however, we are no closer to understanding the nature and causes of altered states of consciousness than we are to defining and measuring consciousness in its normal state. Consciousness remains a challenging research problem for all of us who know and experience what it is every day yet have grave difficulties in defining or measuring it.

For Discussion 12–2

Sleep and Dreaming

The most obvious change in consciousness that we experience each day is the regular change in sleep and wakefulness cycles. We spend about one-third of our lives asleep, yet researchers are not certain why we sleep or what advantage it gives us. Most explanations emphasize the restorative powers of sleep or the fact that sleep deprivation produces unpleasant consequences in alertness, performance, and mood. It is true that biological processes important for memory consolidation occur during sleep (recall is better after a lengthy retention interval that includes sleep than one that does not; see Dehaene, 2020, and Hobson & Pace-Schott, 2002 for reviews). Also, wakeful states produce destructive processes, such as protein degradation and the accumulation of toxic substances, whereas protein synthesis important for the elimination of toxins and other beneficial cell functions occurs at a higher rate during sleep (Oswald, 1987).

Sleep is one of the few changes in consciousness that can be determined by EEG recordings of brain activity. In fact, the several stages of sleep, from resting with the eyes closed to deep sleep, can be differentiated by changes in the frequency of synchronous neural firings across broad regions of the cortex (see Figure 2–14). The deepest stage of sleep, from which it is most difficult to rouse someone, is characterized by low-frequency, high-amplitude delta waves across the cortex. Still, neuroimaging studies have shown that the auditory cortex responds to sounds even in deep sleep, but unlike the waking state, sleeping subjects do not show differential responses to simple tones versus their own names (Portas et al., 2000). Wakeful states and simply resting with the eyes closed produce higher-frequency EEG components. The most common division of sleep stages, however, is that between sleep with rapid eye movements (REM sleep), and the generally deeper stages without such eye movements (NREM sleep).

During REM sleep, EEG activity is similar to that seen during quiet rest with the eyes closed. However, prefrontal cortical areas are much less activated in REM sleep than when one is awake (Hobson & Pace-Schott, 2002), and REM sleep is clearly different than simply resting. For one thing, people in the REM sleep stage can be roused less easily than people who are

(continues)

(continued)

resting, and they also behave as if most motor abilities are inhibited (REM paralysis). It has been suggested that this curious motor inhibition occurs to prevent people from acting out their dreams and perhaps injuring themselves or others. People roused from REM sleep also more commonly report having experienced a dream (about 80% of the time), whereas those roused from a deeper sleep state seldom report having been dreaming (about 14% of the time; Dement, 1972). Most dreams seem to involve fairly ordinary people, places, and events, although some include highly emotionally rousing experiences and fantastic occurrences, such as having the ability to fly. Dreams are the result of cortical activity that is relatively unconstrained by normal sensory inputs. Thus, it most clearly reflects active or top-down constructive processes that might reflect dealings with previous memories or fantasies about the future. Sigmund Freud (2010, J. Strachey translation) viewed the interpretation of dreams as "the royal road to the unconscious," due to the presumed lack of conscious activities controlling most dreams. There is undoubtedly an important function associated with REM sleep and possibly dreaming as well, since sleep deprivation that selectively wakes people at this stage is more disruptive of next-day behavior than the same number of interruptions perpetrated during NREM sleep.

Since disruption of sleep, especially REM sleep, can result in poorer performance the following day, the question naturally arises as to why sleep interruption has such negative effects. Clearly some benefit must occur during sleep, and there are two hypotheses. One is that sleep prevents the attention to and accumulation of new information that can interfere with previously learned information. The other is that processes occurring during sleep can actually increase learning due to memory consolidation processes that normally occur during sleep. Dehaene (2020) argues convincingly, on the basis of much research in this area, that sleep allows for the consolidation of new memories to prevent their loss due to interference from later experiences. Specifically, he argues that deep, delta-wave sleep encourages the development of semantic and declarative memories, whereas REM sleep reinforces procedural memories associated with perceptual-motor activities (Dehaene, 2020).

Like much of the literature on conscious and unconscious states, research on sleep and dreaming has exposed the mystery and paradoxical nature of our natural swings in conscious awareness. Although learning might well be enhanced during sleep, the general problem remains as to why it is necessary for us to sleep, to dream, and to lose consciousness every day only to recover it again.

12.7 Mind Wandering

12.7a Definition and Measurement

At times, we have all experienced our mind drifting from a task at hand, such as when daydreaming, ruminating, or planning for future events. Mind wandering is very common; some researchers have found that 96% of adult Americans report daydreaming of some kind every day (Singer & McCraven, 1961), and as many as 30% of thoughts that people experience in a day could be classified as mind wandering (e.g., Kane et al., 2007; Klinger & Cox, 1987; Killingsworth & Gilbert, 2010), even though it has not been systematically studied until recently. Mind wandering may have some influence on human performance in some areas, such as professional achievement and educational success (Smallwood et al., 2007).

Mind wandering (task unrelated thought, or TUT) is defined as a situation in which our thoughts drift away from a primary task to unrelated mental activity (e.g., Smallwood & Schooler, 2006). In our daily lives, mind wandering might occur while attending lectures, reading books, driving a car, and other activities. Mind wandering has been found to be related to negative or depressive mood states (e.g., Deng et al., 2014; Killingsworth & Gilbert, 2010; Wilson et al., 2014; but see Franklin et al., 2013). Current concerns (or worries) might also increase episodes of mind wandering, and it is associated with cognitive task errors (e.g., Antrobus, 1968).

Mind wandering
A situation in which our thoughts drift away from a primary task to unrelated mental activity

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Mind wandering might occur while attending lectures, reading books, driving a car, and other activities.

There are basically two ways to measure mind wandering in laboratories. These include probe-caught and self-caught methods (e.g., Smallwood & Schooler, 2006). In the probe-caught method, subjects are given a thought-probe during a task and asked what they were thinking about at the moment the probe occurred. Subjects are given some options to choose from; for example, on-task (task-related) thought, or off-task (task-unrelated) thought. Here, on-task means they were focused on the task, and off-task means that they were engaged in mind wandering. However, what types of thought probes to use depends on the goals of the experiments. In the self-caught method, subjects are asked to monitor their mind wandering, and report when they experience it. However, one problem with this method is that subjects need to continuously monitor their thought during the task; and therefore, this method becomes a dual task, in which subjects perform two activities simultaneously. Therefore, the probe-caught method is typically more commonly used than the self-caught method.

12.7b Factors Affecting Mind Wandering

Task Difficulty

Several factors are known to affect mind wandering. In general, people tend to show more mind wandering during easy tasks than difficult tasks (e.g., Forster & Lavie, 2009; Teasdale et al., 1993). For example, mind wandering decreases as stimulus presentation rates increase in vigilance tasks (e.g., Antrobus, 1968; Giambra, 1995). Mind wandering also increases with practice on the primary task (e.g., Mason et al., 2007; Teasdale et al., 1995). Task difficulty and practice are related to each other. With practice, task performance becomes more automatic, and the task can be performed with fewer mental resources. Then, as Smallwood and Schooler (2006) argued, more executive resources remain available for mind wandering. They also emphasized that task performance often suffers when people engage in mind wandering, as mind wandering draws attentional resources away from the task.

Motivation

Unsworth and McMillan (2013) found that subjects' levels of motivation on a reading-comprehension task were negatively correlated with their rates of mind wandering. Mrazek et al. (2012) found that providing monetary incentives for good performance in a laboratory task led to a reduction in mind wandering.

Current Concern and Worry

Current concerns and worry also increase mind wandering (e.g., Klinger, 2009; Poerio et al., 2013; Smallwood et al., 2009). When we have something to worry about (e.g., an upcoming final exam when we are not well prepared), we tend to think about it over and over again. According to Klinger's current concerns theory (e.g., Klinger, 2009), people engage in mind wandering because they have unfulfilled goals ("current concerns") that extend beyond the present moment, and these concerns draw their attention.

Fatigue and Alcohol

Mind wandering increases with fatigue (e.g., McVay & Kane, 2009; Teasdale et al., 1995) and with alcohol consumption (e.g., Finnigan et al., 2007; Sayette et al., 2009; Smallwood et al., 2004). It is likely that mind wandering increases with control-system failures, and more failures—and more mind wandering—should occur as executive control becomes fatigued or impaired by alcohol.

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Mind wandering increases with fatigue.

Mindfulness Traits

Some people tend to engage in mind wandering more often than other people who are better at sustaining attention on the main task at hand. This individual difference is conceptualized as trait mindfulness. The mindfulness trait usually refers to a tendency to focus on the main task and be aware of the present moment (e.g., Baer et al., 2008; Brown & Ryan, 2003; Buchheld et al., 2001). There are a number of questionnaires to measure the mindfulness trait. For example, the Mindful Attention Awareness Scale (MAAS) was developed by Brown and Ryan (2003), and has been widely used as a measure of mindfulness trait. There is typically a negative correlation between mindfulness trait scores and mind wandering (e.g., Mrazek et al., 2012). Higher levels of the mindfulness trait result in lower levels of excessive mind wandering. There are other measures of mindfulness traits, including the Freiburg Mindfulness Inventory (FMI) (Buchheld et al., 2001) and the Five Facet Mindfulness Questionnaire (FFMQ) (Baer et al., 2008).

Working Memory Capacity

As we have already seen, mind wandering is closely related to working memory capacity. For example, Levinson et al. (2012) found that individuals with higher working memory capacity showed more mind wandering during a low perceptual load condition (easy condition) in a visual search task but no relationship was found between working memory capacity and mind wandering in a high perceptual load condition (hard condition). Thus, mind wandering is positively correlated with working memory capacity, at least in the easy task. However, other researchers found a negative correlation between mind wandering and working memory capacity. For example, McVay and Kane (2009) investigated the relationship between working memory capacity, mind wandering and performance on a Sustained Attention to Response Task (SART). The SART is very widely used in research in mind wandering. It is basically a go/no-go task, in which subjects are required to respond to high frequency nontargets and to withhold a response from low frequency targets. For example, digits 1 through 9 are presented on a computer screen one at a time, and subjects are required to press a key as quickly as possible after each digit appears, except for the number 3. McVay and Kane (2009) found that individuals with high working memory capacity showed less mind wandering and better SART performance, suggesting that working memory capacity is negatively correlated to mind wandering. The two studies reviewed in this section showed opposite patterns of results. In one study (Levinson et al., 2012) individuals with high working memory capacity showed more mind wandering, whereas in the other study (McVay & Kane, 2009), individuals with high working memory capacity showed less mind wandering. These results suggest that the effects of working memory capacity on mind wandering probably depend on some other factors that were not included in these studies. We will discuss them in more detail later.

Intention

Research has also found that mind wandering is associated with intention (e.g., Phillips et al., 2016; Robison & Unsworth, 2018; Seli et al., 2015; Seli, Risko, & Smilek, 2016; Seli et al., 2016). Intentional and unintentional types of mind wandering may behave differently in experimental contexts. Importantly, these findings suggest the possibility that increasing subject motivation might specifically lead to a reduction in rates of intentional (but not unintentional) mind wandering. For example, Seli et al. (2015) found that subjects' levels of motivation to perform well were negatively correlated with their tendency to engage in intentional mind wandering, whereas they were not associated with their tendency to engage in unintentional mind wandering during a SART task. Robison and Unsworth (2018) observed that the tendency toward unintentional mind wandering was negatively associated with working memory capacity, but the tendency of intentional mind wandering was negatively associated with self-reported motivation. These results suggest a complex interaction among working memory capacity, motivation, and intentionality of mind wandering. Individuals with high working memory capacity tend to show intentional mind wandering when task demand is low, whereas individuals with low working memory capacity tend to show unintentional mind wandering when task demand is high.

12.7c Psychological Theories of Mind Wandering

There are a number of theories that have been proposed to explain mind wandering. Here we will discuss two theories that have been widely cited. They are both concerned about the role of working memory in mind wandering; however, they make opposite predictions.

Resource theory of mind wandering

Claims that mind wandering requires working memory resources; this theory predicts that individuals with high working memory capacity tend to show more mind wandering.

Smallwood and Schooler (2006) proposed the **resource theory of mind wandering**, which claims that mind wandering requires working memory resources. When task demands are high, few resources are available for either task monitoring or mind wandering. It is only during moderately demanding tasks that resources may be split between performance and mind wandering. In this case, mind wandering may go undetected, leading to performance errors. According to this theory, individuals with high working memory tend to show more mind wandering in general.

Executive failure model of mind wandering

A model of mind wandering that claims that mind wandering is caused by executive failure, which is closely related to lack of working memory capacity; therefore, this model predicts that individuals with low working memory capacity would show more mind wandering

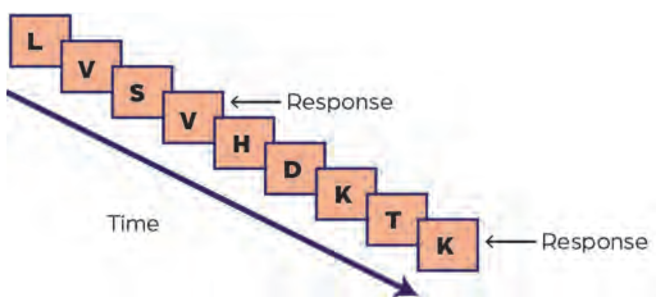
On the other hand, McVay and Kane (2009, 2010) proposed the **executive failure model of mind wandering**, which claims that mind wandering is caused by executive failure. There are mainly two roles that executive control plays during task performance. One is to stay on the task, and the other is to monitor performance. Executive control is closely related to working memory capacity (e.g., Engle, 2002); and therefore, individuals with high working memory capacity should show better executive control compared to individuals with low working memory capacity. Therefore, this theory predicts individuals with high working memory capacity would show less mind wandering and better task performance.

12.7d Integration of the Resource and Executive Failure Models

As we have seen, research has suggested that there are a number of factors affecting mind wandering, including task difficulty, motivation, interest, mood, mindfulness traits, and working memory capacity. In the past, effects of those factors have been studied separately, resulting in inconsistent findings. Recently, however, researchers have begun to investigate interactions among these factors. For example, Rummel and Boywitt (2014) investigated relationships among working memory capacity, task difficulty, and mind wandering. They found that individuals with high working memory capacity showed less mind wandering when the task demand was high, whereas they showed more mind wandering when the task demand was low. The researchers argued that those with high working memory capacity were more capable of self-regulating mind wandering and to be more adaptive to a change in task load than those with low working memory capacity (see also Randall et al., 2019). Ju and Lien (2018) investigated the effects of working memory capacity and task demands on intentional and unintentional mind wandering. They manipulated task demands by using a modified n-back task (0-back and 2-back conditions). An n-back task is a popular working memory task (see Figure 12–5), in which subjects are shown a sequence of stimuli (e.g., letters) one at a time. In a 0-back condition, a target letter is presented at the beginning of each sequence, and subjects are required to press a key when that target appears. In a 2-back condition, subjects are asked to press a key when the present letter is the same as one that was presented two letters before. Therefore, the 2-back condition is more difficult because subjects need to maintain the two preceding letters in working memory. Thought probes were presented at the end of each block of the n-back task, and they included questions regarding intentionality of mind wandering (i.e., "Did you intend to do that?"). Results showed that the relationship between task demand and mind wandering depended on working memory capacity. It was found that mind wandering occurred more often in the 0-back task regardless of working memory capacity. However, the low working memory capacity group showed more mind wandering than the high working memory capacity group in the 2-back condition. In regard to intentionality of mind wandering there was less mind wandering (both intentional and unintentional) in the 2-back task compared to the 0-back task. Working memory capacity did not affect intentional mind wandering in either condition; however, working memory capacity was negatively related to unintentional mind wandering in the 2-back task. Also, individuals with low working memory capacity showed more unintentional mind wandering as task demands increased. Their results suggest that the effects of working memory capacity depend on task demand, which affects types of mind wandering. In sum, research findings so far support the conclusion that individuals with high working memory capacity tend to show intentional mind wandering when task demand is low, whereas individuals with low working memory capacity tend to show unintentional mind wandering when task demand is high.

Figure 12–5 An Example Trial Sequence of N-Back Task

The example shows the 2-back condition, in which each letter is presented for 1 second. Subjects need to hold two letters in their working memory. When they see the next letter, they need to check if it matches the letter that was presented two letters before. If it is a match, they press the response key, then update the content of their working memory. If it is not a match, then they just update the content of working memory.



12.7e Neural Basis of Mind Wandering

Brain imaging studies have shown that mind wandering is closely associated with the **Default Mode Network (DMN)** (e.g., Christoff, 2012; Christoff et al., 2009; Fox et al., 2015; Mason et al., 2007). The default mode network typically includes the medial prefrontal cortex (MPFC), posterior cingulate/precuneus (PCC/precuneus), the inferior parietal lobe (IPL), the lateral temporal cortex, LTC), and the hippocampal formation (HF) (e.g., Buckner et al., 2008) (see Figure 12–6). Research suggests that the default mode network activities might be related to

Default Mode Network (DMN)

A brain network that is closely related to processing of social and self-related information; the default mode network is typically active during mind wandering our self and social functions, such as those focusing on interest in the inner experience, episodic recall, and social cognition (e.g., Buckner et al., 2008; Raichle et al., 2001; Smith et al., 2009). The default mode network was once viewed as a task-negative network (e.g., Fox et al., 2005) that is active during rest and is deactivated during tasks compared to task-positive networks (e.g., the attention network), which is active when we perform a cognitive task. The task-positive network and the task-negative network (i.e., the DMN) were suggested to be anticorrelated, in that when task-positive networks are activated, the default mode network is deactivated when we perform some task, whereas the task-positive networks are deactivated and the default mode network is activated during a rest period (e.g., Fox et al., 2005). This is because our overall attentional capacity is limited; and therefore, when a significant amount of attentional resources has to be allocated to the frontoparaietal network (FPN) to perform demanding cognitive tasks, fewer resources can be allocated to the DMN.

However, in recent years, studies have shown the relationship between DMN and FPN is not globally anticorrelated, but dynamic because they cooperate and compete depending on task requirements. They tend to be cooperative (activated together) when task demands involve internal thought or planning. However, they compete with each other when executing demanding external tasks, such as working memory tasks. For example, Koshino et al. (2011; Koshino et al., 2014) used working memory tasks. They separated task preparation (cue/anticipation phase) from execution (actual WM performance). During task preparation, core regions of the DMN (medial prefrontal cortex, posterior cingulate cortex) co-activate with FPN/working-memory regions (the lateral prefrontal cortex and inferior parietal lobe). This suggests cooperation: DMN provides internally generated preparation, and FPN sustains and buffers this internal thought against external distraction. In the execution phase, DMN regions become deactivated, while FPN regions engage heavily to meet cognitive demands—reflecting competition. In other words, as resource demands in FPN increase, DMN activity decreases to free up more resources.

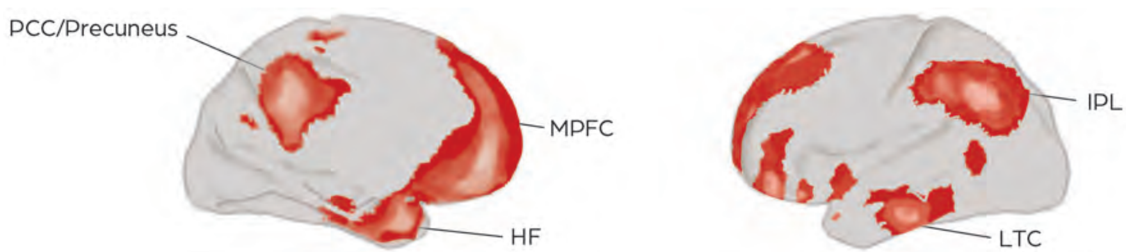
With regard to the relationship between the default mode network and mind wandering, Sonuga-Barke and Castellanos (2007) proposed the **default-mode interference hypothesis**. They claim that the activities of the DMN show spontaneous periodic fluctuations at a slow rate. DMN activity is typically suppressed when the frontoparietal network is active, such as during goal-directed cognitive activities, but it might exceed a certain threshold at some point, and then mind wandering occurs. There are several potential factors affecting when and how the default mode network activation exceeds the threshold, including fatigue, motivation, worry, and psychological and neurological conditions, such as anxiety and depression. Finally, mind wandering may not be necessarily negative, as research has also shown that it could be related to an increase in creative activities (e.g., Baird et al., 2012; Takeuchi et al., 2011).

Default-mode interference hypothesis

The activities of the DMN show spontaneous periodic fluctuations at a slow rate. The DMN activity is typically suppressed when the executive network is active, such as during goal-directed cognitive activities, but the DMN activity might exceed a certain threshold at some points, and then mind wandering occurs

Figure 12–6 The Default Mode Network (Adapted from Buckner et al., 2008)

The default mode network (DMN) typically shows activation when we are daydreaming or mind wandering, thinking about ourselves and other people, remembering past episodes, and planning future events. The DMN regions typically include the medial prefrontal cortex (MPFC); posterior cingulate cortex (PCC)/precuneus; inferior parietal lobe (IPL); lateral temporal cortex (LTC); and hippocampal formation (HF). The figure on the right is a lateral view of the surface of the brain, and the figure on the left shows a view of a slice through the middle of the brain.



Source: Adapted from "The Brain's Default Network," by Randy Buckner, Jessica Andrews-Hanna, and Daniel Schacter (2008). *Annals of the New York Academy of Sciences, 1124*, pp. 1–38, Figure 2.

Figure 12–7 The Default Mode Interference Hypothesis (Adapted from Sonuga-Barke and Castellanos (2007)

The figure demonstrates how initial suppression of default-mode network (DMN) activity occurs when transitioning from a resting state to a goal-directed task, followed by its gradual reactivation over time. This reemergence of DMN activity reflects the return of task-negative processes, such as mind wandering or introspection, as the task progresses. The red (upper) line represents a hypothetical model illustrating how the resurgence of default-mode activity during task execution might impact performance. The units used in the figure are arbitrary.

Source: Adapted from "Sonuga-Barke, E. J., & Castellanos, F. X. (2007). Spontaneous attentional fluctuations in impaired states and pathological conditions: a neurobiological hypothesis. *Neuroscience & Biobehavioral Reviews, 31*(7), 977–986."

12.8 Mindfulness and Mindfulness Meditation

12.8a Mindfulness and Mindlessness

You probably have heard some absentminded professor jokes like the following.

> *A very absentminded professor entered a crowded bus, with no available seats. Suddenly a little girl raised from her seat and offered it to the professor. He was astonished and said to her:*
>
> *"You are a very good girl, what's your name?"*
>
> *"My name is Eve, daddy . . . "*

(Source: http://www.jokebuddha.com/Absent-minded#ixzz6Ybuhlfg6)

We all sometimes show mindless behaviors such as that illustrated above (well, maybe not quite that bad), although it is easier to notice when displayed by someone else (e.g., Langer, 2014; Reb et al., 2015; Smallwood & Schooler, 2006). We discussed absentmindedness in Chapter 8, and mind wandering in this chapter. Now, let's look at them in terms of mindfulness and mindfulness meditation, a technique designed to cultivate mindfulness.

Absentmindedness (or lapse of attention) is one aspect of mindlessness (or lack of mindfulness). When we are absentminded, we are not paying attention to the present task at hand, such as listening to a lecture or reading a book, and we are also unaware of the fact that we are not paying attention. In other words, the mind is absent when one performs a task on autopilot because the mind wanders (e.g., Smallwood & Schooler, 2006).

According to Langer (2014), there are a number of factors that could result in mindless behaviors; for example, when we apply conventional categorization or stereotypes without question to certain people or situations. Automatic behavior (or habitual behavior) may lead to mindless behavior. We may also show mindless behavior when we act from a single perspective, in other words, when we are judgmental.

Langer (2014) states that there are two key components in mindfulness: (1) attention to context, and (2) attention to variability. In other words, it is the feeling of engagement. Mindlessness and mindfulness are closely related to the concepts of automatic and controlled processes (e.g., Shiffrin & Schneider, 1977), as well as the concepts of type 1 and type 2 processing (see Chapter 11; Gawronski & Creighton, 2013; Kahneman, 2011). As we discussed before, type 1 processing is fast and automatic, and it doesn't require working memory resources. On the other hand, type 2 processing is controlled and requires working memory resources. However, Langer claims that mindlessness and automatic processing are not the same, as automatic behaviors could lead to mindlessness, but mindless behaviors may not necessarily be automatic. The same applies to the relationship between mindfulness and controlled processing.

Langer (2014) claims that meditation is a tool to achieve meditative mindfulness. There are a number of ways to reach mindfulness; for example, we can reach mindfulness through meditation or directly paying attention to novelty and asking questions about what we automatically assume. She also states that ". . . to be mindful is to be in the present, noticing all the wonders that we didn't realize were right in front of us." (p. xxv) Mindfulness meditation could cultivate de-automatization. Langer claims, "In this state, old categories break down and individuals are no longer trapped in stereotypes." (p. 80) This type of freedom from rigid frameworks is closely related to mindfulness.

12.8b Mindfulness Meditation

Mindfulness meditation is defined as a process of attending to one's experiences in the present moment, nonjudgmentally and with awareness (e.g., Baer, 2003; Bishop et al., 2004; Kabat-Zinn, 2003; Shapiro et al., 2006). Mindfulness meditation is based on ancient Eastern practices (e.g., Zen, yoga, and other forms of meditation), even though it is not affiliated with any particular religion. The practice of mindfulness meditation has increased greatly in popularity in recent years (e.g., Creswell, 2017). Mindfulness meditation is associated with a variety of benefits, including general physical health and mental well-being (e.g., Brown & Ryan, 2003; Davis & Hayes, 2011) and improvements in attention and working memory (e.g., Brefczynski-Lewis et al., 2007; Chambers et al., 2008; Chiesa et al., 2011; Jha et al., 2007; Jha et al., 2010; Mrazek et al., 2013; Tang et al., 2007). It is also associated with positive benefits, such as life satisfaction, self-esteem, optimism, positive affect, and vitality, and it is negatively related to depression, negative affect, and anxiety in nonclinical settings (e.g., Brown & Ryan, 2003; Hölzel et al., 2011). Mindfulness meditation has also been shown to reduce mind wandering (e.g., Mrazek et al., 2012, 2013). Clinically, mindfulness training has shown benefits for the reduction of pain (e.g., Kabat-Zinn et al., 1985; Zeidan et al., 2010), substance-use disorders (e.g., Bowen et al., 2009; Brewer et al., 2009), anxiety disorders (e.g., Goldin et al., 2009), and depression (e.g., Teasdale et al., 2000). Mindfulness interventions have also been integrated into institutional settings in clinical treatment (e.g., Dimidjian & Segal, 2015), schools (e.g., Sibinga et al., 2016), workplaces (e.g., Good et al., 2016; Reb et al., 2015), military facilities (e.g., D. C. Johnson et al., 2014), and prisons (e.g., Samuelson et al., 2007).

Mindfulness meditation
A process of attending to one's experiences in the present moment, nonjudgmentally and with awareness


Adobe Stock

Mindfulness meditation is associated with a variety of benefits, including general physical health and mental well-being.

12.8c Mindfulness Meditation Techniques

One of the most commonly used methods of mindfulness training is the mindfulness-based stress reduction (MBSR) program developed by Kabat-Zinn (2003). It was developed in a behavioral medicine setting for populations with a wide range of chronic pain and stress-related disorders. In mindfulness meditation practices, participants are told to sit comfortably on a chair (or the floor) with the spine straight. They are told to relax their whole body and sometimes close their eyes. Then, Kabat-Zinn (2003) for example, instructs participants basically to bring attention to the breath, focusing on the feeling of the belly. If attention wanders off the breath, participants are told to try to notice where their mind is going, and just let it go. Then they are to gently bring their attention back to the breath without judging themselves. They are told to try this over and over again each time the mind loses its focus momentarily and moves away from breath.

Researchers have employed a wide variety of methods, ranging from performance of different types of meditation to introduction of emotionally charged sounds during meditation. Observing-thoughts meditation emphasizes awareness and monitoring aspects of meditation, in which participants are told to observe their thoughts without judgment, reaction, or attachment. Studies have shown that this practice increases psychological flexibility and reduces the impact of negative thoughts on mood and behavior (e.g., Kok, & Singer, 2017; Lumma et al., 2015; Matko & Sedlmeier, 2023). Loving-kindness meditation is a contemplative practice that involves silently repeating phrases such as "May I be happy," "May you be safe," or "May all beings be at peace," with the intention of cultivating compassion, goodwill, and emotional warmth toward oneself and others. Typically beginning with self-directed wishes, the meditation gradually extends outward to loved ones, neutral people, difficult individuals, and eventually all beings. This practice has been shown to enhance empathy, reduce negative emotions, and increase feelings of social connection and well-being. (e.g., Galante et al., 2016; Hofmann et al., 2011; Hutcherson et al., 2008; Zeng et al., 2015).

A growing body of empirical evidence suggests that even brief mindfulness practices—lasting as little as 10 to 15 minutes—can produce significant short-term benefits. For example, studies have shown that single-session mindfulness inductions, when followed by just a few additional sessions, can lead to reductions in affective reactivity (such as anxiety, sadness, or anger) and impulsive behaviors (such as cravings or pain sensitivity). In addition, these interventions have been shown to increase state mindfulness, or moment-to-moment awareness and nonjudgmental attention, even in novice practitioners (e.g., Broderick, 2005; Polizzi et al., 2019; Watier & Dubois, 2016; Westbrook et al., 2013; Zeidan et al., 2011).

These findings suggest that while long-term meditation may yield cumulative and possibly deeper changes, even brief, strategically designed sessions of mindfulness meditation can offer immediate psychological benefits, making mindfulness a practical intervention for improving emotion regulation, attention, and self-control—even for beginners.

12.8d Effects of Mindfulness Meditation

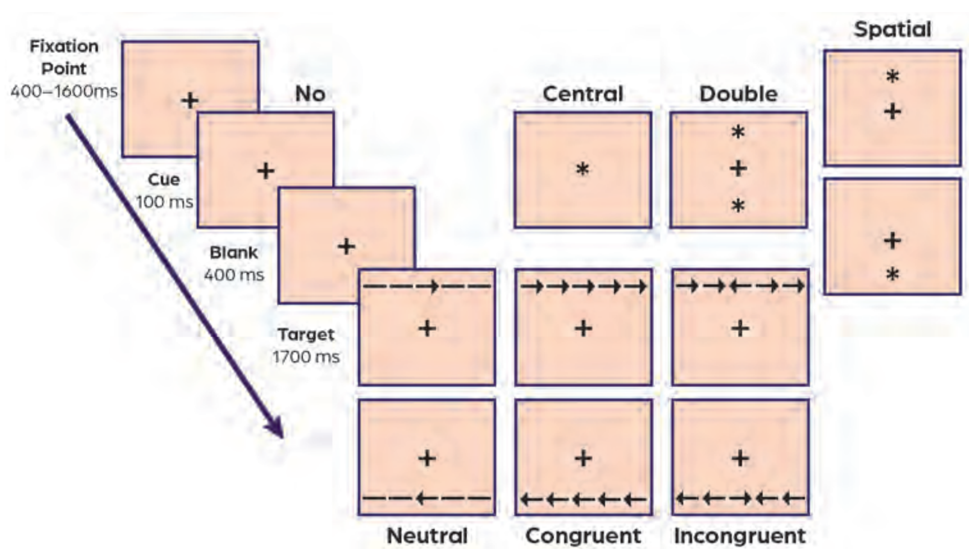
Beneficial effects of mindfulness meditation on attention have been emphasized by both Langer and Kabat-Zinn. As we discussed before, Langer (2014) claimed that there are two key components in mindfulness: (1) attention to context, and (2) attention to variability. Kabat-Zinn (2003) defined mindfulness meditation as awareness that arises through paying attention to inner experience in the present moment, purposefully and nonjudgmentally. Chambers et al. (2008) showed that novice meditators who participated in a 10-day mindfulness meditation retreat showed improvements in self-reported mindfulness, working memory, and sustained attention compared to their control group. Jha et al. (2007) investigated how mindfulness meditation training affects different components of attention, alerting, orienting, and executive control, using the

Attention Network Test (ANT). They found that naive participants who completed an 8-week mindfulness-based stress reduction (MBSR) program showed significant improvements in the orienting aspect of attention, which involves allocating attention according to the cue. The study concluded that mindfulness training can selectively enhance specific attentional subsystems. Zeidan et al. (2010) used a brief meditation training course consisting of four 20-minute sessions, and reported reduced fatigue and anxiety, and increased mindfulness. Also, they found that mindfulness training improved visuospatial processing, working memory, and executive functioning. Mrazek et al. (2013) showed that eight 1-hour mindfulness meditation sessions held across 2 weeks reduced mind wandering and increased working memory span and performance in the verbal comprehension section of the Graduate Record Examination (GRE).

However, there are some studies that found no beneficial effects of mindfulness meditation. For example, Anderson et al., (2007) reported that the subjects in the experimental group did not show improvements in measures of attentional control, including sustained attention, attention switching, and the Stroop task, even though they showed greater improvements in emotional well-being and mindfulness.

Figure 12–8 Attentional Network Test (ANT) (Fan et al., 2002)

The Attention Network Test (ANT) is a set of tasks designed to measure three attentional networks: (1) alerting, (2) orienting, and (3) executive control. The ANT is based on Posner's cueing task (Posner, 1980), combined with Eriksen's flanker task (Eriksen & Eriksen, 1974). On each trial a spatial cue (an asterisk) is presented, followed by an array of five arrows presented at either the top or the bottom of the central fixation point. The subject is asked to indicate the direction of the central arrow (left or right) in the stimulus array. The cue can be nonexistent, a single central cue, a double cue (one presented above or below the central fixation point), or a spatial cue that usually indicates the upcoming target location; i.e., the spatial cue indicates the location of the line of arrows on valid trials, and the arrows appear in the opposite location on invalid trials. Each network is assessed with reaction times (RTs). The alerting component, which is achieving and maintaining a state of vigilance, is computed by the response time difference between a center cue and no-cue condition. The orienting component, which is directing attention to sensory stimuli, is computed by the difference between valid and invalid spatial cue trials. Executive control, which is resolving conflict between competing stimuli, is measured by the difference between congruent and incongruent flanker conditions.



12.8e Mechanisms of Mindfulness Meditation

We previously discussed the benefits of mindfulness meditation—specifically, its ability to enhance cognitive function, emotion regulation, and psychological well-being. The next question is: Why is mindfulness meditation effective? More precisely, how does it produce these benefits?

The mechanisms of mindfulness meditation are closely linked to the activity of the sympathetic and parasympathetic branches of the **autonomic nervous system (ANS)**. These systems play crucial but contrasting roles in maintaining homeostasis—the body's internal balance—which supports cognition, emotional stability, and overall psychological health. Optimal well-being depends on a dynamic balance between these systems, enabling flexible adaptation to stress while maintaining mental and emotional equilibrium. Research has shown that mindfulness meditation increases parasympathetic activity, shifting the body into a more restorative physiological state.

Autonomic nervous system (ANS)

A division of the peripheral nervous system that regulates involuntary physiological functions—those that occur automatically without conscious effort; these include functions such as: heart rate, breathing, blood pressure, digestion, and body temperature

The **sympathetic nervous system** activates the body's "fight-or-flight" response, increasing alertness and physiological arousal. While this heightened state can enhance short-term attention and memory, chronic sympathetic activation may impair complex decision-making and emotional regulation. In contrast, the **parasympathetic nervous system** supports the "rest-and-digest" state, fostering relaxation, emotional balance, and physical recovery. It plays a crucial role in facilitating cognitive function, emotion regulation, and psychological resilience by promoting calm, reflective mental states.

Sympathetic nervous system

One of the two main branches of the autonomic nervous system (ANS); primarily responsible for preparing the body to respond to stressful or threatening situations through the "fight-or-flight" response

Parasympathetic nervous system

One of the two main branches of the autonomic nervous system (ANS); primarily responsible for restorative, maintenance, and energy-conserving functions, and commonly referred to as the "rest-and-digest" response

Parasympathetic activity is inversely related to heart rate (HR): As parasympathetic tone increases, heart rate decreases. Conversely, reduced parasympathetic activity is commonly associated with stress, anxiety, and impaired emotional regulation (e.g., Smith et al., 2017; Thayer et al., 2009). These effects are largely mediated by the vagus nerve, which originates in the medulla of the brainstem and projects to multiple organs, including the heart, lungs, stomach, pancreas, liver, kidneys, and intestines.

When heart rate slows, **heart rate variability (HRV)** typically increases. HRV refers to the variation in time intervals between successive heartbeats and is a widely recognized marker of autonomic nervous system (ANS) function. While influenced by both sympathetic and parasympathetic input, HRV is primarily considered an index of parasympathetic (vagal) activity (e.g., Laborde et al., 2017; Shaffer & Meehan, 2020; Thayer et al., 2009). Higher HRV indicates greater autonomic flexibility and more efficient regulation of internal bodily states. Accordingly, elevated HRV is associated with better stress regulation, emotional stability, and overall psychological well-being.

Heart rate variability (HRV)

The variation in time intervals between consecutive heartbeats, typically measured in milliseconds; the time intervals are known as interbeat intervals (IBIs)

Heart rate tends to slow when breathing is slowed. **Slow-paced breathing (SPB)** is a commonly used relaxation technique in biofeedback and self-regulation practices. SPB involves controlled, rhythmic inhalation and exhalation, typically at a rate of around six breaths per minute, which is significantly slower than the normal spontaneous breathing rate of 12–20 breaths per minute (e.g., Russo et al., 2017; Zaccaro et al., 2018). For instance, experienced practitioners such as Zen monks often breathe at rates well below typical resting levels (e.g., Tobin, 2013). Research has shown that SPB stimulates vagal activity and increases HRV—a

Slow-paced breathing (SPB)

A controlled breathing technique that involves deliberate, rhythmic inhalation and exhalation at a reduced rate, typically around six breaths per minute (i.e., one breath every 10 seconds); significantly slower than the average spontaneous breathing rate of 12–20 breaths per minute marker of autonomic flexibility and emotional regulation (e.g., Gerritsen & Band, 2018; Gevirtz, 2013; Lehrer et al., 2020). In summary, the slow, rhythmic breathing found in many meditative practices is associated with enhanced parasympathetic activation, increased HRV, and greater physical and emotional well-being (e.g., McCraty, 2016). This mechanism is considered a key contributor to the documented health benefits of mindfulness meditation.

During SPB, individuals inhale and exhale in controlled, rhythmic cycles—typically at a rate of about six breaths per minute (10 seconds per breath). At this rate, known as the **resonance frequency** (e.g., Gerritsen & Band, 2018; Lehrer & Gevirtz, 2014; Shaffer & Meehan, 2020), heart rate and respiration become highly synchronized, enhancing vagal tone and activating the parasympathetic nervous system. This synchronization produces a smooth, sinusoidal pattern of HRV. Although the exact resonance frequency varies slightly across individuals, it is consistently associated with improved emotional regulation, increased stress resilience, and greater physiological efficiency.

Resonance frequency

A specific breathing rate—typically around 6 breaths per minute (or 0.1 Hz)—at which the cardiovascular and respiratory systems oscillate in synchrony, producing maximum heart rate variability (HRV) and optimal autonomic regulation

In addition to SPB, autonomic nervous system activity is influenced by the inhalation-to-exhalation ratio (IE ratio). Heart rate typically increases during inhalation and decreases during exhalation—a phenomenon known as **respiratory sinus arrhythmia (RSA)** (e.g., Grossman, 2024). Research has shown that a longer exhalation phase more strongly engages the parasympathetic nervous system, leading to greater increases in HRV (e.g., Laborde et al., 2021; Strauss-Blasche et al., 2000; Van Diest et al., 2014). Meditative practices that emphasize prolonged exhalation relative to inhalation may leverage these physiological mechanisms to promote relaxation and autonomic balance.

Respiratory sinus arrhythmia (RSA)

A naturally occurring variation in heart rate that is synchronized with the breathing cycle. Heart rate increases during inhalation and decreases during exhalation; this fluctuation is normal, healthy, and reflects the activity of the parasympathetic nervous system, particularly the vagus nerve

Neurovisceral Integration Model

As discussed earlier, heart rate is closely linked to breathing patterns via the vagus nerve. This relationship is further modulated by a brain network known as the central autonomic network (CAN), which includes the prefrontal cortex (PFC), anterior cingulate cortex (ACC), insula, amygdala, hypothalamus, and medulla. Thayer and Lane (2009) proposed the neurovisceral integration model (NIM), which suggests that cognitive, emotional, and physiological regulation is coordinated through this central network. The PFC—responsible for executive functions and cognitive control—exerts top-down regulation, along with the ACC and insula, over subcortical structures such as the amygdala, hypothalamus, and brain stem nuclei. This hierarchical control helps regulate emotional responses and bodily states. In this framework, higher resting HRV is considered a marker of efficient neurovisceral integration, reflecting greater flexibility in stress adaptation and promoting self-regulation, emotional stability, and executive functioning. The model underscores how brain–body interactions support both psychological and physiological well-being. Empirical studies provide support for the NIM: HRV is positively associated with cognitive performance—such as working memory, attention, and decision-making (e.g., Hansen et al., 2003; Park & Thayer, 2014)—and negatively associated with anxiety, depression, and impulsivity (e.g., Chalmers et al., 2014; Koch et al., 2019). Brain imaging research further shows that resting-state HRV predicts activity in the PFC, especially during tasks involving executive control (e.g., Sakaki et al., 2016; Thayer et al., 2012).

12.8f Neural Basis of Mindfulness Meditation

As discussed previously, during typical meditation practice, practitioners attempt to maintain focus on a single experience, such as breathing, and whenever they are aware of mind wandering, they try to bring attention back to the breath (e.g., Kabat-Zinn, 2003). Here, it seems at least two brain regions are involved in the process of meditation. We focus our attention on some experience; and therefore, attentional networks should be active. Also, as discussed in Chapter 14, Section 14.4e, mind wandering is closely related to the default mode network activity. Research has provided support for this notion.

For example, Hasenkamp et al., (2012) used the type of meditation practice in Kabat-Zinn's technique to develop a model of mindfulness meditation and mind wandering. To reiterate, in the Kabat-Zinn meditation technique, practitioners try to sustain focus on an experience such as each breath; however, they typically experience mind wandering. At some point during mind wandering, the practitioner becomes aware that their mind is wandering, at which point they disengage their attention from the task-unrelated thought. Then they shift attention back to the breath, where it stays focused again for some period of time. This process was modeled as the following cycle (see Figure 12–9).

(1) Sustained focus

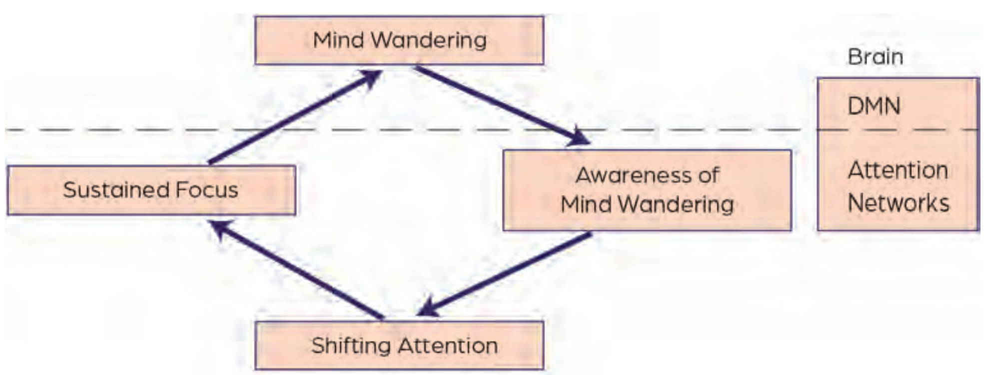
(2) Mind wandering

(3) Awareness of mind wandering

(4) Shifting attention back to breath

Figure 12–9 Model of Mindfulness Meditation Cycle

In mindfulness meditation, we try to focus our attention on our breath. However, at some point, our mind might start wandering, during which time the default mode network (DMN) may show more activity (see Chapter 14, Section 14.4e). When we become aware of mind wandering, we try to shift our attention back to our breath.



Source: Adapted from "Effects of meditation experience on functional connectivity of distributed brain networks," by W. Hasenkamp et al., 2012, *Frontiers in Human Neuroscience, 6*, p. 38.

It has been shown that one of the main effects of meditation training is the reduction of activity in the default mode network (e.g., Goldin et al., 2009; Farb et al., 2007; Pagnoni et al., 2008). Also, experienced meditators show less mind wandering, and less activation in the DMN during various types of meditation (e.g., Brewer et al., 2011).

12.8g Problems with Mindfulness Meditation Research

Even though mindfulness meditation has become very popular as a practice, there are a number of problems in methodology and in demonstrating its effects on cognition and emotion. For example, studies that have investigated effects of mindfulness meditation training have been criticized as lacking clear definitions and procedures (e.g., Clapper et al., 2021; Davidson & Kaszniak, 2015; Levinson et al., 2014; Van Dam et al., 2018; Wong et al., 2018). However, this problem is not easy to solve because a wide variety of traditional and nontraditional techniques have been used under the term of mindfulness. Because of this problem, it is difficult to clarify the specific effects associated with different types of mindfulness techniques, and especially in identifying the specific mechanisms underlying these purported benefits.

There are also some methodological problems with mindfulness research. One is the reliance on self-report measures (questionnaires) that are subject to expectancy, social desirability, and demand characteristics (e.g., Davidson & Kaszniak, 2015; Levinson et al., 2014; Van Dam et al., 2018). For example, a person might report reduced anxiety or improved mood after meditation sessions because subjects may think that is what the experimenter wants to see, or simply because they expect such effects to occur. Another problem with the reliance on questionnaires is that we don't really have valid and reliable measures of what is actually happening in terms of cognitive processes or underlying neural activity during meditation. We can compare subjects' performance in some tasks or responses to questionnaires before and after meditation sessions, but it would not tell us what is happening during the sessions. In other words, we don't really have good ideas about what subjects are doing during meditation sessions. It is possible that some subjects are simply mind wandering. Research in mindfulness meditation has also been criticized as lacking appropriate control conditions. Part of this is related to the fact that many studies have been conducted in clinical settings, where it is sometimes difficult to have completely randomized designs. Also, when mindfulness meditation is embedded in clinical sessions, it is not easy to separate the beneficial effects of mindfulness meditation from concurrent clinical treatments. Despite these concerns, the suggestion that there might be benefits of meditation and mindfulness training on a variety of cognitive processes and emotional states indicates that further research in more controlled settings is important.

Chapter Summary

At various points in the history of psychology, consciousness has been either the central core area of scientific research or an anathema to be avoided at all costs. Today we are witnessing a resurgence in consciousness studies. These efforts have been encouraged by the continuing successes of research into previously hidden workings of the human mind, as observed in studies of perception, imagery, memory, language comprehension, and reasoning. Consciousness is different, however, in that it has no real external manifestation, and there are no clear measures or definitions of what it is. Rather, it is a personal feeling that we seem to share that we are conscious experiencers of our world and conscious actors in its drama. Some psychologists and philosophers have argued that these feelings are the essence of what it means to be human, whereas others have claimed that such feelings are mere illusions of no consequence for behavior or mental life. Such diversity of opinion is certain to spur increased research efforts into what has been called the last great mystery of science—the construction of a conscious reality from neural impulses.

Mind wandering refers to the shift of attention away from a primary task or external environment toward internally generated thoughts, memories, or imagined scenarios. It often occurs spontaneously and is associated with the default mode network in the brain. While mind wandering can impair focus and task performance, it also plays a role in creativity, problem-solving, and future planning. The content and frequency of mind wandering can be influenced by mood, motivation, and cognitive load, with excessive or negatively toned mind wandering linked to stress, anxiety, and reduced well-being. Mindfulness meditation is a mental training practice that involves focusing attention on the present moment with an attitude of nonjudgmental awareness. It typically includes observing the breath, bodily sensations, thoughts, and emotions as they arise—without reacting to or becoming absorbed in them. Regular mindfulness practice has been shown to enhance attention regulation, emotional resilience, and self-awareness, while reducing stress, anxiety, and rumination. Studies in cognitive neuroscience suggest that it can lead to functional and structural changes in brain regions related to executive function, emotion regulation, and psychological well-being.

Review Questions

1. How is consciousness defined?

Consciousness can only be defined subjectively, since there is no way to measure it that researchers can agree upon. Even brain imagery techniques cannot prove whether a patient is conscious or not, although certain injuries seem to preclude what we would call conscious experiences. Therefore, it can only be defined as a feeling unique to each of us—one that we cannot be sure is similar in you or in me—that we are aware of external objects, people, and events, and that we decide how to interpret and respond to them.

2. Can we determine whether animals are conscious or whether machines will ever be conscious?

Such a determination supposes that we have an answer to the first question, that we know how to define consciousness and that we know how to measure it. We do not. In that case, the definition of what it means for an animal or machine to be conscious is just as murky as the definition of our own consciousness. The answer will depend on agreement in the larger scientific community, if a consensus can ever be reached.

3. How did consciousness evolve and what is its purpose?

Consciousness presumably evolved in our species as an aid to socialization, language use, and cognition. Each of these components of early human behavior seems to rely on the conscious awareness of an internal self that is different from the selves of others, and that our actions can influence their actions in positive or negative ways. Since most early hominids shared the common primate need for social groups for survival, a conscious awareness of the benefits of socialization presumably was adaptive in our species.

4. What is the purpose of sleep and dreaming?

Sleep seems to serve some restorative process for neurophysiology and cognitive functioning, since its deprivation increases the apparent need for sleep and results in deteriorating cognitive performance. Research has shown that deprivation of REM/dream sleep is particularly disruptive, and REM-stage sleep increases in the proportion of total sleep time if it is deprived. The wide variety of time spent asleep across different animal species argues against a common restorative function, however, and the interpretation of dreams and their purpose remains more art than science.

5. What are some of the major disorders of consciousness?

Neurologists distinguish between sleep and coma despite their similar appearances. Sleep is the only altered state of consciousness that can reliably be detected by EEG activity, since there is a wide variety of EEG activity (from normal waking to sleep to decidedly abnormal patterns) in comatose patients. Behaviorally, people in a coma cannot be roused as can people who are sleeping, and the prognosis of recovery from coma worsens as the length of time in a comatose state lengthens. People in a persistent vegetative state appear to be more alert than people in a coma, in that they are capable of vocalizations, voluntary movements, and changes in facial expression. Yet, these patients also seem to be unresponsive to their environment, and their observed responses are unrelated to the activity of others. Recovery from a persistent vegetative state also is extremely unlikely if the condition remains unchanged for more than several months. People in a minimally conscious state are more aware of their surroundings and are capable of interacting verbally with other people and motorically with their surroundings. However, as the name implies, their interactions are minimal and can include long periods of repetitive behaviors, or semi-stuporous involvement in watching television or staring out a window.

6. What is the nature of mind wandering?

Recent studies have shown that mind wandering is also affected by complex interactions among various factors, such as task difficulty, motivation, interest, mindfulness traits, emotions (e.g., anxiety and depression), and working memory capacity. There seem to be different types of mind wandering, such as intentional and unintentional mind wandering, and they are also affected by various factors, such as working memory capacity, task difficulty, and motivation. Research seems to suggest that individuals with high working memory capacity tend to show intentional mind wandering when task demand is low, whereas individuals with low working memory capacity tend to show unintentional mind wandering when task demand is high.

7. How does mindfulness meditation work?

Mindfulness meditation works by training the mind to focus on the present moment with a nonjudgmental and accepting attitude. Practitioners typically direct attention to a chosen anchor—such as the breath or bodily sensations—while gently noticing thoughts, emotions, and distractions as they arise without reacting to or engaging with them. Over time, this practice strengthens attention regulation, increases self-awareness, and reduces automatic, habitual responses to stress, fostering greater emotional balance and mental clarity.

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Blindsight **377**

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Default Mode Network (DMN) **387**

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