attentional network). These studies have found independence between the two systems, the degree of which appears to depend on the amount of mental activity required by the primary task.

When required to monitor a stream of auditory information for sound while simultaneously performing a visual orienting task, parietal patients were bilaterally slowed in their ability to orient toward the visual cue. The effect of language task was bilateral rather than mainly on the side contralateral to the lesion. This suggests that language tasks may affect some but not all of the mechanisms involved in the visual orienting of attention. In another study, normal subjects performed the visual orienting task while shadowing an auditory message. The effects of the language task were most pronounced for the right visual field cues, suggesting a common lateralized left hemisphere system. These findings are consistent with close anatomical links of anterior cingulate with both posterior parietal and lateral frontal lobe. Posner and Petersen suggest that there may be a hierarchy of the attentional system in which the anterior attentional network may be the control system that affects both language and spatial functions and controls the posterior visuospatial attentional network.

CONCLUSION

Although some of the neural systems underlying attention have become better understood, the anatomy and function of attention, particularly of the anterior network, require further study. Many disorders are thought to involve deficits of attention, including neglect syndrome, attention-deficit disorder, schizophrenia, Alzheimer's disease, and closed-head injury. The specification of attention in terms of function and anatomy might help determine the underlying bases for these disorders.

—Tatjana Novakovic-Agopian

***See also*–Alertness; Attentional Mechanisms; Attention-Deficit/Hyperactivity Disorder (ADHD); Awareness; Concentration; Executive Function; Memory, Overview**

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Attentional Mechanisms

Encyclopedia of the Neurological Sciences

WHAT is attention? "Everyone knows what attention is. It is the taking possession of the mind in clear and vivid form of one out of what seem several simultaneous objects or trains of thought."

William James defined attention 100 years ago, and the previous quote still illustrates several important aspects of the field. Attention is heavily tied with subjective experience. Moreover, James' effort to deal with both attention to objects and attention to "trains of thought" is important for a grasp of current approaches to sensory orienting and executive control. However, attention in the sense of orienting to sensory objects can be involuntary and can occur unconsciously, so attention is not, as the quote from James implies, precisely the same as being aware.

It is appropriate for neurologists to think about attention as an organ system not unlike the familiar ones of respiration and circulation. Like them, attention has a distinct anatomy that carries out basic psychological functions and that can be influenced by specific brain injuries and states. It is important to ask what are the operations of attention and then to examine how the brain incorporates these operations. This entry covers three major operations: (i) achieving and maintaining the alert state, (ii) orienting to sensory objects, and (iii) selecting among conflicting actions. These operations are discussed using specific terms to better understand how attention can be affected by brain state and injury.

METHODS OF STUDY

The study of attention has greatly expanded as new methods have become available. In the 1940s and 1950s, reflex models that had existed since antiquity were supplemented by recognition of complex central states involved with arousal, such as the reticular activating system. Lesions of this area could produce a permanent loss of alertness. In the 1950s, functional models of information flow in the nervous system were developed in conjunction with interest in computer simulation of cognitive processes. In the 1970s, studies using microelectrodes with alert monkeys showed that the firing rate of cells in particular brain areas was enhanced when the monkey attended to a stimulus within the cells' receptive field. In the 1980s and 1990s, human neuroimaging studies allowed examination of the whole brain during tasks involving attention. These newer methods also improved the utility of more traditional cognitive, lesion, and electrophysiological studies. The ability to trace anatomical changes over time has provided methods for validating and improving pharmacological and other forms of therapy.

ATTENTIONAL NETWORKS

Attention can be viewed as a system of anatomical areas that consists of three more specialized networks. These networks carry out the functions of alerting, orienting, and executive control. We examine first the functional anatomy of these networks from human imaging and lesion studies and then some of the cellular mechanisms involved from animal studies (Fig. 1).

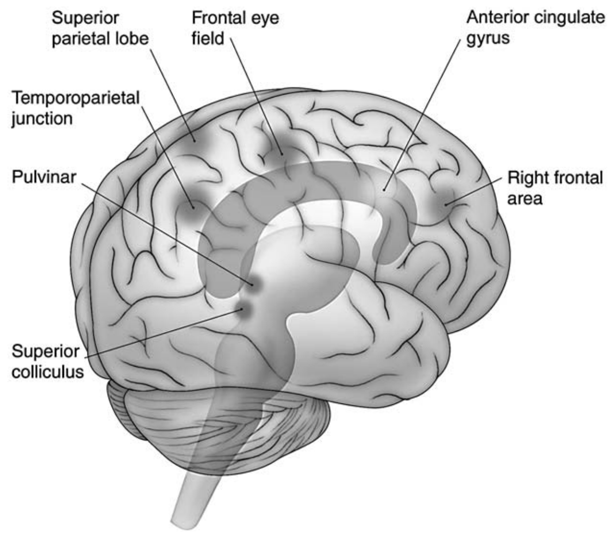

Figure 1
Functional anatomy of the attentional networks. The pulvinar, superior colliculus, superior parietal lobe, and frontal eye fields are often found active in studies of the orienting network. The anterior cingulate gyrus is an important part of the executive network. Right frontal and parietal areas are active when people maintain the alert state. (See color plate section.)

Functional Anatomy

Alerting involves a change in the internal state in preparation for perceiving a stimulus. For example, following presentation of a warning signal there are a variety of changes in heart rate and brain electrical activity that serve to inhibit competing activity. The alert state is critical for optimal performance in tasks involving higher cognitive functions. Neuroimaging studies have shown activity in the frontal and parietal regions, particularly of the right hemisphere, when people are required to achieve and maintain the alert state for even a brief period of time. Lesions of these areas will reduce the ability to maintain alertness. Right frontal lesions have been shown to impair the ability to voluntarily sustain attention, producing more errors over time than are found for left frontal patients in tasks involving continuous performance. Right parietal patients show deficits in maintaining the alert state and difficulties in orienting attention that together produce a profound neglect in the visual field opposite the lesion.

The orienting network involves the selection of information from sensory input. Orienting can be reflexive, such as when a sudden target event directs attention to its location, or it can be more voluntary, such as when a person searches the visual field looking for some target. Orienting often involves head and/or eye movements toward the target. This is overt orienting. However, it is possible to increase the priority for processing the target by orienting attention covertly without a change in posture or eye movements. In experimental studies, orienting has been manipulated by presenting a cue indicating where a person should attend. When a valid cue occurs, the target appears in the location indicated by the cue. Invalid cues indicate a location to which attention should be oriented but the target is subsequently presented elsewhere. There is usually only a small benefit from knowing the correct location of the target, but if one orients to the wrong location there is a much larger cost in the efficiency of processing the target. These findings reflect the high efficiency with which a cue (e.g., a luminance change of motion) can direct attention to a target, particularly if the person is not engaged in processing at another location. In a crowded field, large changes can be made outside the focus of attention, and if luminance and motion cues are suppressed, the person will simply not be aware of even gross changes.

It is important to distinguish between those brain areas that are influenced by acts of orienting (sites) and those that are the sources of the orienting network. Orienting has been shown to increase neuronal activity in most sensory systems. For example, in the visual system orienting can influence primary visual cortex or a variety of extrastriate visual areas, where the computations related to the target are performed. Orienting to target motion influences area MT/V5, whereas orienting to target color will influence area V4. This principle of activation of brain areas also extends to higher level visual input; for example, attention to faces modifies activity in the face-sensitive area of the fusiform gyrus.

The orienting network that is the source of these changes has been shown to involve several cortical areas, including parts of the superior and inferior parietal lobe, frontal eye fields, and such subcortical areas as the superior colliculus of the midbrain and the pulvinar and reticular nucleus of the thalamus. These areas are thought to carry out different mental operations involved in the act of orienting. For example, studies using event-related magnetic resonance imaging have indicated that the superior parietal lobe is involved in voluntary shifts of attention required in reorienting covertly to a new location. The temporal–parietal junction is active when a target occurs at a novel location (i.e., other than the one cued). The pulvinar seems to be related more to connecting the orienting network to sensory areas that contain information about the target features, such as color, motion, or form. The exact functions of many of these areas are under active investigation.

Stroke patients with damage to the temporoparietal junction may neglect locations in the field opposite the lesion. If their attention is oriented to the stimulus on the side of the lesion, these patients show a delay in reacting to events on the side opposite the lesion. The temporoparietal junction appears to be associated with the disengagement from a cue to respond to a target in the opposite side. In clinical studies, the right parietal lobe was more likely to lead to neglect, possibly because of the asymmetrical organization of the orienting network and also because damage to the right hemisphere has greater influence on the alerting network. Patients with bilateral lesions of the parietal lobes show deficits in dealing with two objects simultaneously. The two parietal lobes seem to be coordinated through the corpus callosum since lesions of this structure allow simultaneous search of both visual fields, suggesting that orienting of the two hemispheres is now disconnected.

Results of studies examining reversible lesions in healthy volunteers are often congruent with deficits seen in clinical populations. These transient lesions are achieved by applying a brief transcranial magnetic stimulation (TMS) to the scalp areas overlaying the relevant cortical location. Application of TMS pulses to the parietal cortex has shown that visual extinction (i.e., impaired detection of contralateral stimulus during bilateral presentation) can be produced in normal subjects, similar to the clinical manifestation seen in neglect patients.

Executive control of attention involves more complex mental operations in monitoring and resolving conflict between computations occurring in different brain areas. Executive control is needed most in situations that involve planning or decision making, error detection, novel or not well-learned responses, conditions judged to be difficult or dangerous, and in overcoming habitual actions.

Functional magnetic resonance imaging (fMRI) studies have been conducted using either the Stroop task or variants of it. The Stroop task involves responding to the ink color (e.g., red) used to print a word when the letters spell a competing color name (e.g., "blue"). In another frequently used conflict task, a person is required to respond to a central stimulus (e.g., an arrow pointing left) when it is surrounded by flankers that either point in the same direction (congruent) or in the opposite direction (incongruent). Neuroimaging studies show that these conflict tasks activate midline frontal areas (anterior cingulate), lateral prefrontal cortex, and basal ganglia. These experimental tasks provide a means of fractionating the functional contributions of areas within the executive attention network. One event-related fMRI study showed that lateral areas were responsive to cues indicating whether the task would involve naming the word or the ink color. The cue did not activate the cingulate. When the task involved naming the ink color, the cingulate was more active on incongruent than congruent trials. This result could reflect the general finding that lateral areas are involved in representing specific information over time (working memory), whereas medial areas are more related to the detection of conflict.

Large lesions of the anterior cingulate produce deficits of voluntary behavior. Patients with akinetic mutism can orient to external stimuli and follow people with their eyes, but other voluntary activity is not initiated. Nonetheless, patients often recover from lesions of the anterior cingulate, suggesting that other areas may also mediate executive attention. Lesions of the medial frontal area may produce more permanent loss of future planning and appropriate social behavior. Early childhood damage in this area can produce permanent deficits in decision-making tasks that require responses based on future planning. Patients with traumatic brain injury that involves frontal areas frequently show specific deficits in executive attention and working memory.

Transmitters

Pharmacological studies of alert monkeys have related each of the networks with specific chemical neuromodulators. Alerting is thought to involve the cortical distribution of the brain's norepinephrine (NE) system arising in the locus coeruleus of the midbrain. Drugs such as clonidine and guanfacine that act to block NE reduce or eliminate the normal effect of warning signals on performance. These drugs do not influence the efficiency of orienting, however.

Cholinergic systems arising in the basal forebrain play an important role in orienting. Lesions of the basal forebrain in monkeys interfere with reorienting attention. However, it does not appear that the site of this effect is the basal forebrain. Instead, it appears to involve the parietal lobe. Injections of scopolamine directly into the lateral parietal area of monkeys, a brain area containing cells that are influenced by cues about spatial location, have been shown to have a major effect on the ability to shift attention to a target. Systemic injections of scopolamine have a smaller effect on covert orienting of attention than do local injections in the parietal area. Cholinergic drugs do not affect the ability of a warning signal to improve performance; thus, there appears to be double dissociation that relates NE to the alerting network and acetylcholine to the orienting network.

Patients with Alzheimer's disease are known to have a strong degeneration of the basal forebrain cholinergic system (nucleus basalis). In accordance with this finding, early in the disease patients show a reduction in brain activity in the superior parietal lobe and a correlated difficulty in orienting of attention. In fact, orienting difficulties are often one of the earliest signs of the disorder. Recently, normal persons who had one or two copies of the ε4 allele of the apolipoprotein E gene were shown to have increased difficulty in orienting attention and in adjusting the spatial scale of attention, but they had no difficulty in maintaining the alert state.

The anterior cingulate and lateral frontal cortex are target areas of the ventral tegmental dopamine system. The association of the anterior cingulate with high-level attentional control may seem rather odd because this is clearly a phylogenetically old area of the brain. However, there are reports of large projection cells that are unique to layer 5 of the anterior cingulate and that seem to have evolved recently because they are found only in humans and higher primates. Moreover, these cells also undergo late development, in accordance with the finding that executive control systems develop strongly during later childhood.

All of the dopamine receptors are expressed in layer 5 of the cingulate. Several replicated human genetic studies have demonstrated an association of one of the dopamine receptor genes D4 (DRD4) located on chromosome 11p15.5 and an attentional disorder common in childhood (attention-deficit/hyperactivity disorder; ADHD). Approximately 50% of ADHD cases have a seven-repeat allele, whereas only approximately 20% of ethnically matched control subjects have a seven-repeat allele. However, a direct comparison of children with ADHD who either have or do not have the seven-repeat allele suggests that attentional abnormalities are more common in those children without the allele. It appears likely that there are multiple pathways to ADHD, some that involve attentional networks and others that may involve behavioral but not attentional deficits. Adult subjects who suffer from ADHD have been studied in conflict tasks. Although they perform only slightly worse than normal persons, they appear to activate an entirely different network of brain areas than do normal persons. Whereas normals activate the anterior cingulate, the ADHD adults seem to rely on the anterior insula, which is usually associated with responses in more routine tasks not involving conflict.

ATTENTIONAL STATES

Alert State

Diurnal reductions in attention normally occur during the hours of maximum sleepiness, 2:00–7:00 AM, when body temperature is at a nadir, and enhanced performance is usually seen in the evening when body temperature peaks. During sleep, voluntary attention is often considered to be markedly attenuated or absent. However, there is evidence that certain attentional as well as preattentional mechanisms remain intact. Dreaming is usually divorced from a sense of controlled awareness, but purported accounts of lucid dreaming (i.e., dreaming while knowing that one is dreaming) suggest that some control mechanisms may be available during sleep. Other common anecdotes include the incorporation of ambient sound into the dream content as well as the idea of sensitivity to one's own name or child's cry.

One way to investigate information processing in sleep involves recordings of electrical signals from the brain (electroencephalograph, EEG). By averaging the brain's event related potentials (ERPs) to stimuli, it is possible to examine the processing capability of the sleeping brain.

One component frequently examined is the mismatch negativity (MMN). The MMN is an electrophysiological manifestation of involuntary preattentive processing in response to auditory oddball stimuli. In a typical MMN paradigm, a "deviant" auditory stimulus is sporadically distributed within a sequence of "standard" auditory stimuli. The MMN is evident in the difference waveform resulting from the subtraction of the ERP elicited by the standard stimulus from that elicited by the novel auditory stimuli (the deviants). The difference waveform, occurring even without attention, normally peaks between 100 and 250 msec from the onset of the deviant event (depending on the dimension of deviance and its magnitude). The MMN is presumably associated with a mechanism that compares the current auditory input to the memory traces formed by previous auditory inputs and signals the occurrence of a mismatch.

In adults, MMN tends to decline during drowsiness; whether it persists into adult human sleep is still debated. However, other EEG components do reflect the brain's reaction to novelty. Although in the developed brain active midbrain inhibition blocks cortical activity, there is reason to believe that the sleeping infant brain is not as capable of blocking and inhibiting information efficiently. Indeed, MMN is obtainable from newborns and young infants.

Another special cognitive state sometimes confused with sleep is hypnosis. Hypnosis has been used clinically for hundreds of years and is primarily a phenomenon involving attentive receptive concentration. Clinicians practicing hypnosis suggest that when one is in a hypnotic state, attentional and perceptual changes may occur that would not have occurred had one been in a more usual state of awareness. In a responsive subject, hypnotic perceptual alteration is accompanied by reproducible changes in brain action. For example, the activity of the anterior cingulate to painful stimuli can be modulated by hypnotic suggestion. Most children are highly hypnotizable and are more easily induced into the hypnotic state. The overall data on hypnotism support the claim that it is a psychological state with distinct neural correlates and not just a consequence of role-playing or social compliance. Neuroimaging data suggest that hypnosis can modulate visual system responses to colored stimuli. There is also preliminary evidence that hypnosis can change the semantic interference from a word when subjects are required to respond to its ink color (Stroop effect).

Individual Differences

Normal individuals differ in the efficiency of each of the attentional networks. One way of exploring these differences is by use of an Attention Network Test (ANT) designed to evaluate alerting, orienting, and executive attention. This test can be performed by children, adults, and animals because it does not rely on language. Efficiency of the alerting network is examined by changes in reaction time (RT) resulting from a warning signal. Efficiency of orienting is examined by changes in RT that accompany cues indicating where the target will occur. The efficiency of the executive network is examined by requiring the subject to respond by pressing a key indicating the direction of a central arrow surrounded by congruent, incongruent, or neutral flankers. A study of 40 normal adult subjects showed that the ANT produces reliable single-subject estimates of alerting, orienting, and executive function and also that the efficiency of these three networks is uncorrelated. This procedure may prove to be convenient and useful in evaluating attentional abnormalities associated with cases of brain injury, stroke, schizophrenia, and attention-deficit disorder, and may provide a useful repeated measure in studies designed to improve attention in patients and developmental populations.

Self-report scales have also been used to study individual differences in attentional components. One higher level factor called effortful control involves the ability to voluntarily shift and focus attention and inhibit non-attended information. Effortful control as reported by the subject seems to relate most closely to the executive attention network. Twin studies have suggested that the difference between people in effortful control is highly heritable. People high in effortful control also report themselves as relatively low in negative emotion. This is one source of evidence supporting the idea that executive attention is important for control of both cognition and emotion.

Development

Dramatic changes occur in the brain during the early life of the person. In the first few years of life, there is a great increase in synaptic density, which becomes much higher than adult levels and is pruned back later in development. These cellular changes are accompanied by changes in the attentional control networks discussed previously.

During the first year of life, there is a strong development of the orienting network. The abilities to control fixation, to disengage for a visual stimulus, and to move attention in anticipation of a new event all undergo rapid development. These events appear to relate to maturation of basal ganglia and parietal networks during this period.

Later, there is a dramatic development of the ability to control conflict, which appears to involve the executive attention network. Tasks that involve conflict between stimulus elements in inhibiting predominant responses undergo strong development between 2 and 4 years of age. These changes affect the child's everyday life activity, as is evident to caregivers. One way to demonstrate this is to ask parents to report on their children's temperament by using behaviorally anchored-based questions. For example, the parents are asked such questions as: (i) When engaged in play with his or her favorite toy, how often did your child play for 5 minutes during the last 2 weeks? and (ii) When told "no," how often did your child stop the activity quickly? The scales can then be combined into a factor called effortful control. This score measures individual differences in the ability of children to regulate their behavior as observed by the parents.

Children who respond to conflict tasks with high accuracy also receive higher ratings from parents in effortful control. These children also show better ability to delay gratification in tasks designed to probe this ability. They also show higher empathy for others and are less likely to cheat when given the opportunity to do so. These results suggest that toddlers are acquiring a brain system that serves to regulate their behavior in important ways in their everyday lives.

Pathology

The executive attention network is particularly vulnerable to the effects of both frontal lesions and various forms of mental illness. This vulnerability results in a neuropsychological condition called dysexecutive syndrome, in which behavior is often unregulated and includes inappropriate responses. Performance on tests involving the ability to make decisions guided by long-term consequences and the ability to inhibit inappropriate responses are impaired following closed head injury, stroke, or degenerative disorders of frontal structures.

Schizophrenics exhibit difficulty in controlling their thoughts and behaviors consistent with the dysexecutive syndrome. Neuroimaging data indicate that the neural abnormality in schizophrenia starts in the left globus pallidus and gradually produces a dysregulation of both the anterior cingulate and the dorsolateral prefrontal cortex. There is a vast body of research suggesting that these structures are involved in the control processes of executive attention. Indeed, when healthy volunteers engage in a verbal auditory shadowing task known to challenge executive attention capacities, an orienting abnormality is evident that is similar to one observed in schizophrenic patients. In acute schizophrenia, a marked loss of frontotemporal language is found. These factors make it plausible that poor regulation of executive attention mechanisms is an important part of schizophrenia. At autopsy, the brains of schizophrenics appear to contain very specific abnormalities of the cingulate, consonant with the importance of this region in the disorder. It is important to keep in mind that executive attention may be involved in the initiation of attentional shifts, and thus impairment of executive attention could influence parietal regions, resulting in orienting deficits.

REHABILITATION

Because attention is very vulnerable to effects of brain damage, is closely related to issues of volition, and can influence many other cognitive processes, it should be an important candidate for therapy. Three kinds of therapy have been applied to attentional networks: pharmacological, removing competition, and practice. There has been relatively little effort, however, to ascertain the effectiveness and mechanism of each of these therapies.

Pharmacology

As described previously, each of the three networks has strong connections to a particular neurochemical modulator. For example, lesions and pharmacological studies suggest that orienting of attention appears to be influenced by the brain cholinergic system. There are reports that nicotine, whether administered by smoking or directly, can improve attention. The close relation between smoking and schizophrenia has sometimes been considered to be a form of self-medication. Stimulant drugs such as methylphenidate that influence both norepinephrine and dopamine transmission have been shown to be successful in reducing the symptoms of attention deficit disorder.

Competition

Brain injuries often result in imbalances between the two hemispheres because they produce lesions in one hemisphere. One striking example occurs in neglect of the spatial world discussed previously. As a consequence of the lesion, perception of a stimulus on the side opposite the lesion is impaired, but perception of a stimulus on the side of the lesion may be enhanced above normal levels. Evidence for this supranormal sensitivity to stimuli on the side of the lesion comes from studies in which neglect patients outperformed control subjects in the detection of an ipsilesional stimulus.

The idea of hemispheric competition has been applied to rehabilitation studies, with the notion that inhibitory competition from undamaged circuits may impede recovery of function. In one study, patients with neglect of the left side of space due to right parietal lesions had a patch placed over the right eye. Patching improved performance, presumably by increasing the influence of information in the neglected field on the right superior colliculus. Although the procedure did reduce neglect, recovery was incomplete, was short lived, and did not generalize to other tasks.

In other rehabilitation studies, patients with right parietal lesions ameliorated their neglect by moving their left hand in the left hemispace. The benefit lasted several weeks after training and generalized to everyday function. It is important to note that bilateral activation abolished the benefit, suggesting that competition from the healthy hemisphere had detrimental effects on the rehabilitation of the lesioned hemisphere. The mechanism by which using a contralesional limb ameliorates neglect remains unknown.

Practice

It is now known that rehabilitation of the damaged brain can foster reconnection of damaged neural circuits. Animal models have suggested that specific practice may be important in fostering changes in the damaged area. Neuroimaging studies suggest several possible mechanisms, such as strong activation of tissue surrounding the damage, involvement of the same brain area in the opposite hemisphere, or the use of circuitry not previously involved in the task. Reports of each of these changes and of the role of experience have supported the use of therapies that involve practice in performing the damaged function.

A number of therapeutic methods involve practice with attention. These have often been used in cases of traumatic brain injury, in which the patients may be quite young and face debilitating damage to attentional networks. For example, attention process therapy involves practice with auditory tapes and includes exercises designed to aid alertness, improve orienting, and allow better selection of relevant information. Other methods may be much more general—for example, providing knowledge about the brain or training in the management of memory or keeping goals in mind while carrying out a practical task. There is evidence that these improve the specific function practiced, but the extent of generalization to related tasks and to everyday life activities is often limited.

Functional imaging seems to provide an important tool for evaluating therapeutic methods. Imaging provides an opportunity to see whether and exactly how the therapy influences specific circuits. This provides an intermediate level of analysis between the therapy and actual behavior that may allow a better opportunity to evaluate the effects of various forms of therapy and improve their design.

SUMMARY

The advent of neuroimaging of the human brain has allowed attention to be viewed as an organ system with its own specific anatomy. This approach makes possible detailed examination of the cellular, synaptic, and genetic bases of normal attentional networks. It serves to link attention to the study of brain states that change with the level of arousal from wake to deep sleep and with development from infancy to adulthood. This approach provides a basis for considering the many pathologies of attention due to insults to the adult brain or developmental difficulties.

—Jin Fan, Amir Raz, and Michael I. Posner

***See also*–Alertness; Attention; Attention-Deficit/ Hyperactivity Disorder (ADHD); Dreaming; Hypnotics; Sleep, Overview; Wakefulness**

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Attention-Deficit/ Hyperactivity Disorder (ADHD)

Encyclopedia of the Neurological Sciences

ATTENTION-DEFICIT/HYPERACTIVITY DISORDER (ADHD) is a syndrome of childhood constituting developmentally inappropriate, impairing, and cross-situational manifestations of inattention/disorganization, impulsivity, and motoric overactivity that cannot be better accounted for by known neurological disease or injury or by environmental trauma or deprivation. Since the advent of compulsory education in the 19th century, certain children's noteworthy problems of focusing attention and refraining from extraneous and disorganized motor behavior have become salient to society. During much of the 20th century, such appellations as minimal brain damage, minimal brain dysfunction, and hyperkinesis or hyperactivity were invoked as diagnostic terms to describe such deficits and problems. In 1980, the terminology shifted to attention deficit disorder, consistent with research pointing to problems in sustained attention and maintenance of arousal as the underlying deficits. The current nosological term, ADHD, as used in the American Psychiatric Association's *Diagnostic and Statistical Manual of Mental Disorders*, fourth edition, reflects the belief that difficulties in both attentional processing and hyperactive/impulsive behavior characterize most individuals who meet criteria for this diagnostic category. Research on the genetics, neurobiological underpinnings, and psychosocial correlates of ADHD has mushroomed in the past two decades.

ADHD received much attention in the latter part of the 20th century as scientific, clinical, and public awareness of this condition surged and as prescription rates for psychotropic medications (particularly stimulants) steadily increased. On one side are critics who contend that ADHD is a convenient psychiatric label used by society (i) to "medicalize" children's restlessness and inattention, which might be better explained by dysfunctional families, faulty schools, or societal pressures for academic success, and (ii) to legitimize pharmacological treatment for such problems. On the other side are scientists and clinicians who assert that ADHD is a real condition, with diagnostic validity and underlying neurobiological reality, for which