**Review**

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# Definition and Neurophysiological Structure of Attention

## Dikkatin Tanımı ve Nörofizyolojik Yapısı

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## ABSTRACT

This study attempts to define the subject of attention, which is at the forefront of cognitive skills that are required for daily life. This review aims to determine attention and understand its neurophysiological structure, as well as to elucidate the distinctions in terms of orientation, detection, and alertness functions in more detail. In addition, along with the explanation of attention-related disorders and their symptoms, suggestions that can be used in treatment and rehabilitation processes have been presented, and an individual, social, and technological perspective has been provided for the studies to be carried out in the future. Attention, defined in the simplest sense as the ability to focus on a location, object, or message, is a cognitive process necessary for cognitive functions such as perception, learning, memory, decision-making, and reasoning skills. The subfunctions of attention, orientation, detection, and alertness have been defined. Cortex areas related to attention and different aspects of attention have been reviewed, supported by neuropsychological study findings related to attention. Based on the findings obtained from the studies, evidence indicates that attention has a neurophysiological structure that spreads over very different areas of the brain. In particular, an increase in parietal cortex activity in tasks related to attention is among the common findings of the studies. In addition, functional differences have been revealed between the right and left hemispheres during attention processing. In addition, studies on developmental, neurocognitive, and mood disorders in which attention function is impaired have been reviewed.

**Keywords:** Attention, neurophysiology, ADHD, autism, delirium, dementia, major depressive disorder, generalized anxiety disorder

## ÖZ

Bu çalışmada günlük yaşam için gerekli bilişsel becerilerin başında gelen dikkat konusunun tanımı yapılmaya çalışılmıştır. Derlemenin amacı dikkatin tanımının yapılması ve nörofizyolojik yapısının anlaşılması yanında; yönelim, farkındalık ve alarma geçme işlevleri açısından ayrışmanın daha detaylı ortaya konulmasıdır. Bunun yanında dikkat ile ilişkili bozuklukların ve belirtilerinin açıklanması ile beraber, tedavi ve rehabilitasyon süreçlerinde kullanılabilecek öneriler sunulmuş, ilerleyen dönemlerde yapılacak çalışmalara bireysel, sosyal ve teknolojik bir bakış açısı sağlanmaya çalışılmıştır. En basit anlamda bir konuma, nesneye ya da mesaja odaklanma becerisi olarak tanımlanan dikkat; algı, öğrenme, bellek, karar verme, muhakeme yapma becerileri gibi bilişsel işlevler için gerekli bir süreçtir. Dikkatin alt işlevleri olan yönelim, farkındalık ve alarma geçme işlevleri tanımlanmıştır. Dikkat ile ilişkili nöropsikolojik çalışma bulgularıyla desteklenerek dikkat ve dikkatin farklı yönleriyle ilişkili korteks alanları derlenmiştir. Çalışmalardan elde edilen bulgulara dayanarak dikkatin beynin çok farklı alanlarına yayılmış bir nörofizyolojik yapısı olduğu kanıtlanmıştır. Özellikle dikkat ile ilişkili görevlerde parietal korteks aktivitesindeki artış çalışmaların ortak bulguları arasındadır. Ayrıca dikkatin işlenmesi konusunda sağ ve sol hemisfer arasında fonksiyonel farklılıklar ortaya konmuştur. Bunun yanında dikkat işlevinin bozulduğu gelişimsel, nörokognitif ve duygudurum bozukluklarına ilişkin çalışmalar derlenmiştir.

**Anahtar sözcükler:** Dikkat, nörofizyoloji, DEHB, otizm, deliryum, demans, majör depresif bozukluk, yaygın anksiyete bozukluğu

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# Introduction

Scientific interest in the subject of attention dates back to the beginning of experimental psychology, to the work of William James in 1890 (Posner and Petersen 1990). The attention system is similar to other sensory and motor systems. It is in relation to other functions of the brain, but maintains its integrity. It is performed by networks formed by specific anatomical areas. The functions of attention, which are orientation, detection, and alertness, have been placed within a wide range of attention-related studies, yet they have typically been examined in individual areas. It is aimed to emphasize the scarcity of studies examining these functions in a holistic manner, together with attention and its types, or attention disorders. It is thought that if attention disorders are examined by separating them into these subfunctions, more efficient and holistic results can be obtained in rehabilitation and treatment approaches.

In the simplest way, attention can be defined as the ability to focus on a specific object or location (Goldstein 2013). Attention is classified in different ways. Focusing attention on a location, message, or object is defined as selective attention; whereas focusing on more than two locations at the same time is called divided attention (Goldstein 2013). In the first studies on attention, the idea of a filter was observed to be more prominent. In this field, the dual-listening study conducted by Cherry (1953) is one of the most well-known studies in the field. In this study, participants were required to listen to two different messages from two ears and to focus on the message coming from one ear while ignoring the other. Then, the participants repeated the message coming from the ear they focused on. When they were questioned about the message coming from the ignored ear, the participants could not give a clear answer about it. However, it was found that they gave some answers about the physical characteristics of the voice. For example, they were able to distinguish whether the voice was a woman's or a man's voice. The results of this study were interpreted as a filter in attention, and the messages that could pass through the filter reached the attention stage (Chery 1953). Cherry showed with this study that people can only pay attention to one message. This study made an important contribution to subsequent studies in the field of attention in terms of procedure. Various versions of the dual listening method were used in the studies conducted afterwards.

Following the findings of this study, Broadbent (1958) presented a model that he called the bottleneck theory. In this model, after the message enters the sensory memory, it reaches the filter stage. The messages that can pass through the relevant filter are transmitted to the detector in the next stage, where all incoming messages are processed and the meaning of the message is determined (Broadbent 1958). This model is one of the first flow models in the field of attention. Broadbent's bottleneck model is among the models defined as early selection models in attention (Goldstein 2013). In early selection models, a filter is usually activated at an earlier stage during the flow of information, based on the physical properties of the stimulus.

Another example of early selection models is Treisman's (1964) Attenuation Theory of Attention. In this model, Treisman (1964) also mentions the use of a filter, but this filter functions as an attenuator. Messages that are being attended to can pass through the filter easily, whereas messages from the unattended ear can pass through in a weakened form. At this stage, a semantically strong message like the person's own name can still pass through the filter and reach the attention stage, even if it comes from the unattended ear. Different from Broadbent's model, Treisman proposed that selection occurs in two stages (Goldstein 2013). While Broadbent used the concept of a filter, Treisman preferred the term attenuator. Both Broadbent's and Treisman's models are considered early selection models, as they assume that selection occurs at the initial stages of attention (Smith and Kosslyn 2014).

Both models are regarded as pioneers of early selection theories. Early selection models are deficient in some aspects based on subsequent research (Goldstein 2013, Smith and Kosslyn 2014). A well-known study by Gray and Wedderburn (1960) provided evidence supporting this criticism. In their experiment, participants heard the message "Dear 7 Aunt" in one ear while simultaneously hearing "9 Jane 6" in the other. The results showed that participants reported hearing "Dear Aunt Jane". It was found that information from the unattended ear had passed through the attention filter (Gray and Wedderburn 1960).

In another study, MacKay (1973) played a sentence to participants in one ear that contained a word that could have more than one meaning. The sentence "They were throwing stones at me all the time" was given to the participants. "Throwing stones" was chosen as a phrase that could have both a literal meaning and a metaphorical one. At the same time, a single word related to one of those meanings was presented to the unattended ear. These words were presented as either "rock" (literal) or "insult" (metaphorical), and based on which one they had heard, participants were divided into two groups. In the test phase, participants were shown two different sentences (MacKay 1973). These sentences were chosen from examples such as "In yesterday's demonstration, the protesters were throwing rocks at the police." and "Yesterday, he was throwing rocks at his friend, saying that he was cogging dice at backgammon." When the participants who heard "rock" from the unattended ear were asked to choose which of the two sentences they saw in the test phase was similar to the sentence they heard, the rate of choosing the first sentence was higher (MacKay 1973). The other group heard the word "insult" from the unattended ear. This group tended to select the second sentence as more similar to the one they had heard earlier. These results have been interpreted as attention being related to a selection in the late stages rather than the early stages of information processing (MacKay 1973). Early selection involves the differentiation of a stimulus at the initial stages of processing based on its physical features, such as color, location, or orientation. In contrast, late selection refers to the processing of a stimulus based on its physical, functional, or semantic characteristics to determine whether it belongs to a specific target group (Alperin et al. 2013).

Whether attention operates through early or late selection has been examined in various studies over time, and the findings suggest that there is no single definitive answer (Goldstein 2013). The selection stage depends on the message on which attention is focused or the nature of the task in question. The requirements of the task the person is engaged in have been described as the factor that determines whether attention-related selection will be made early or late (Bozkurt 2024). There are studies in the literature have provided evidence that early and late selection processes in terms of attention occur at different neural levels (Drisdelle and Jolicoeur 2018).

Another topic that has been examined in relation to attention is the subject of cognitive capacity (Bozkurt 2024). The resources we use to perform any task are a product of our cognitive capacity. The amount of resources we use to complete a task is affected by cognitive load (Goldstein 2013). In tasks with low cognitive load, our cognitive capacity will not be strained much, and in this case, a small portion of cognitive resources will be used. In tasks with high cognitive load, cognitive capacity will be strained, and a larger portion of resources will be occupied with the task. Additionally, we are often occupied with more than one task in daily life. Listening to the radio while driving, talking to a friend while walking on a bumpy road, or following a series on the screen while cooking are examples of multitasking. Whether the tasks are low or high in cognitive load, it is also important whether the task we are trying to complete is a primary or a secondary task (Bozkurt 2024). In addition, the relationship between the ratio of resources allocated to the primary task and the ability to avoid irrelevant stimuli also has an effect on the distribution of attention in terms of resources. One prominent example of this is the Stroop effect (Stroop 1935). In the classic version of the Stroop test, participants are instructed to name the color of the printed color names. Participants' response speed and error rate are measured. If the text and color were congruent, participants made fewer errors and respond faster. If the text and the color are incongruent, the irrelevant stimulus causes an interference effect, and participants show prolonged reaction times and increased error rates (Goldstein 2013).

Attention skill, defined in the simplest sense as the ability to focus on a specific object or location (Goldstein 2013), will be discussed in detail in this article. The main purpose of this review is to define the attention function, explain the basic theories related to attention, and present which structures in the nervous system that are responsible for attention control in line with neurophysiological evidence. In addition, it is aimed to emphasize the distinction made in terms of orientation, detection, and alertness functions. Finally, it is aimed to explain the disorders related to attention and their clinical symptoms, to offer suggestions that can be used in treatment and rehabilitation processes, and to try to provide an individual, social, and technological perspective for the studies to be carried out in the future.

# Subfunctions of Attention

## Orientation

In order to understand attention, it is necessary to understand the subsystems of attention. These are defined as orientation, detection, and alertness. Posner and Peterson (1990) identified these three components as three functions related to attention. These three functions are subsystems that are independent of each other but work in relation to each other. Orientation is the function responsible for directing attentional resources to a specific sensory stimulus and excluding other stimuli from attention (Simard 2001). When attention can be directed to a specific stimulus, processes such as recognition and awareness are activated. It has been emphasized that orienting attention has a positive effect when the stimulus to which attention is directed is expected by the organism, but it may have a negative effect when the stimulus is unexpected (Simard 2001). Directing attention to a certain area, object, or stimulus has been studied mostly with the visual modality because our knowledge about the visual system is greater than other systems. Moreover, a large portion of the mental functions related to attention are engaged with stimuli within the visual modality. In a study conducted with monkeys, it was observed that when the monkey directed its attention to a specific spatial location, the firing rate of neurons increased, and this activation occurred in the posterior parietal lobe (Mountcastle 1978). Posner and Petersen (1990) emphasized the importance of both overt and covert attention processes, as well as eye movements, in the orientation of attention. The increase in neuronal firing observed in Mountcastle's (1978) study can be considered as evidence for the significance of working with stimuli in the visual modality and the critical role of eye movements in attentional processes.

Activation was found in more than one area of the brain related to the direction of attention. Furthermore, findings from imaging studies provide evidence that there are different pathways in the brain are involved in visual attention. Activation was observed in both the pulvinar nucleus of the thalamus and the superior colliculus of the tectum, indicating the activity of more than one pathway (Petersen et al. 1987). In studies with humans, similar activation was observed in the parietal cortex (Robertson et al. 1988).

Attention, like other topics in neuropsychology, has also been studied to understand differences between hemispheres. The reason for examining differences between hemispheres in terms of attention is to understand the processes required for attentional shifts in the contralateral direction. In one study, subjects were asked to find uppercase letters among lowercase letters and were presented with two different frequency stimuli, high and low spatial frequencies (Robertson and Delis 1986). While low spatial frequency presentation is associated with global processing, high spatial frequency presentation is associated with local processing. Low spatial frequency is associated with the ability to process the entire visually presented stimulus. Performing this function requires directing attention to the entire stimulus. Since high spatial frequency is associated with the ability to process visual stimuli locally, it means focusing attention on local features of the stimulus rather than the entire stimulus in terms of orientation. It has been shown that the right hemisphere is dominant in the case of global processing involving low spatial-frequency information, and the left hemisphere is dominant in the case of local processing involving high spatial-frequency information (Robertson and Delis 1986). Similar to the study by Robertson et al. (1988), it was found that right hemisphere patients could copy lower-case letters but could not comprehend the general shape, while left hemisphere patients drew the opposite picture, comprehending the general shape but could not copy lower-case letters (Robertson and Delis 1986). Conducting studies by forming separate groups of patients with right and left hemisphere damage and comparing the findings between these two groups is crucial for demonstrating the existence of a functional dissociation. The fact that patients with right hemisphere damage are unable to perform global processing but do not exhibit problems with local processing, and conversely, that patients with left hemisphere damage have difficulties with local processing while global processing remains intact, serves as strong evidence for this double dissociation.

The results of these studies found that both hemispheres were associated with attention in the contralateral direction. There are theories that specialization between hemispheres develops over time

and accelerates with the acquisition of literacy. Although there is no certainty about the effect of literacy, there are findings that the degree of lateralization is different between literate and illiterate patients (Lecours et al. 1988). In another study, it was found that the attention system is associated with the dorsal pathway, starting from the V1 visual area and ending in the parietal lobe, and that the anatomy of the general attention system can be associated with this pathway (Posner and Petersen 1990).

When findings are examined, orientation, one of the subfunctions of attention, is a function controlled by multiple brain regions and pathways. It has been studied mostly with visual stimuli. There was a dual separation between the left and right hemispheres in terms of global and local processing of stimuli. The orientation of attention is important in terms of other subfunctions.

## Detection

The second subfunction of the attention phenomenon, detection, is defined as noticing and responding to a specific stimulus after being directed to it. It has been emphasized that the connections between the posterior parietal lobe and the lateral medial frontal lobe are vital for detection (Goldman-Rakic 1988). Orientation to multiple locations or modalities does not create inhibition compared to orientation to a single modality, unless a specific target emerges. The appearance of the relevant stimulus is crucial. This finding serves as evidence that the function of detection is distinct from the orientation and alarm functions of attention.

Triesman and colleagues (1988) used the term "mental spotlight" for detection. According to this theory, each stimulus is initially separated into its constituent features. These features are then combined in different ways while being processed in parallel. According to Triesman, the areas where these combinations occur are the points where the "spotlights" are located, and this is where attention becomes engaged.

Posner et al. (1978) examined the relationship between attention orientation and detection. The direction in which orienting to a point increases detention and change the speed of response to a stimulus has been the subject of research. In the experiment, there is a sign in the middle of the screen that needs to be focused on. Then, a clue is given about the direction of the target stimulus to be seen on the left or right side of the screen. The clue points to the left or right side of the screen. If the target stimulus appeared on the same side as the cue, it was called a valid trial, and if it appeared on the opposite side, it was called an invalid trial. The participant's task was to press the designated key as quickly as possible when the target stimulus appeared after the cue. The findings revealed that participants responded faster in the valid trial conditions (Posner et al. 1978). It was found that detection increased and reaction time was significantly lower in the target stimulus condition that appeared on the same side as the cue than in the invalid trial condition. The findings of the study proved that the subfunctions of attention, orientation, and detection are independent but jointly functioning processes (Posner et al. 1978).

Based on the results, it can be argued that the ability to notice and respond to stimuli is primarily related to orientation function. In order for an individual to be able to pay attention to any stimulus and to perceive it consciously, they need to direct their attention to it. Stimuli to which attention is directed create greater awareness and shorter reaction times. A shorter reaction time is also related to the third subfunction, alertness.

## Alertness

The final cognitive stage of attention, and the most important function in an individual sense, is its ability to alert a person. This alert state can result in a faster response, but it can also lead to a higher error rate. This is because the person uses lower-quality information as a result of having to reach a faster response decision while in an alert state. The state of alertness affects the time it takes to respond to a stimulus. High alertness causes the response to be based on lower-quality information. As a result, response time may decrease, but the rate of incorrect responses increases.

The right hemisphere is responsible for establishing and maintaining alertness (Heilman et al. 1985). These findings also explain neglect in individuals with right hemisphere lesions. In other supporting studies, right hemisphere lesions cause problems with alertness (Heilman et al. 1985). In addition, alertness is related to the norepinephrine system in the locus coeruleus structure (Posner and Petersen 1990). It has been proven that norepinephrine cells play a role in changes in the alarm state. A decrease in norepinephrine levels was observed in right hemisphere lesions. This result provides further evidence that the right hemisphere is responsible for establishing alertness.

When the physiological dimension of attention processes is examined, there are studies that prove that the attention process is distributed across the cortex. It has been proven that orientation, detection, and alertness are controlled by separate regions in the brain. In a study with fMRI data conducted by Shulman et al. (1999), measurements were taken from the participants in two different situations, one in which they had to pay attention to stimuli on the screen that were in a certain orientation, or the other in which they had to passively watch the image. The results show that the activation caused by stimuli in a certain orientation and the activation that occurred in the passive viewing situation occurred in different brain regions (Shulman et al. 1999). These findings, combined with the results from the preceding studies above, can be considered as evidence that attention is a function controlled by different brain areas.

The attention process carried out with the contribution of different areas as a result of a distributed processing in the brain is defined as the ability to focus on the task we are interested in, the message contained in the task, or an object. Attention is an essential part of our daily functions. In cases where attention is impaired or interrupted, impairment can be seen in many stages, from performing simple tasks to completing complex operations. Moreover, disorders that will cause inadequacy not only in simple or complex single tasks but also in many developmental areas are associated with impaired attention. Understanding the functions of orientation, detection, and alertness will help to provide richer suggestions in the understanding and rehabilitation of disorders related to attention. Examining an attention disorder by separating it into its subfunctions can contribute to the production of more planned solutions in treatment processes. The definitions of the three subfunctions of attention and the associated cortical areas are summarized in Table 1.

**Table 1. Comparison of orientation, detection, and alertness functions**

| Subfunction of Attention | Related Cortex Regions | Explanation |
|---|---|---|
| Orientation | Posterior parietal lobe (Mountcastle 1978)<br>Pulvinar nucleus in thalamus (Petersen et al. 1987)<br>Superior colliculus in tektum (Petersen et al. 1987) | Directing attention to a specific stimulus, excluding other stimuli |
| Detection | Posterior parietal lobe (Goldman-Rakic 1988)<br>Lateral-medial frontal lobe (Goldman-Rakic 1988) | Perception and awareness of the stimulus |
| Alertness | Right hemisphere (Posner and Petersen 1990)<br>Locus coeruleus (Posner and Petersen 1990) | Rapid response to stimuli |

## Attention Disorders

It has been argued that most disorders requiring high levels of cognitive processing are related to attention. These conditions include neglect syndrome, schizophrenia, closed head injuries, and attention deficit hyperactivity disorder (Posner and Petersen 1990). The finding that the anterior attention system in the left hemisphere fails to establish a normal inhibition pattern in schizophrenia supports these theories (Posner and Petersen 1990).

### Attention Deficit Hyperactivity Disorder (ADHD)

Attention Deficit Hyperactivity Disorder (ADHD) is one of the most common disorders associated with impairments in the area of attention. According to data from the General Directorate of Public Health (2019), the diagnosis of ADHD varies between 3% and 7% among school-aged children. ADHD is observed

three times more frequently in boys than in girls. Among the applications to Child and Adolescent Mental Health departments in hospitals, ADHD ranks first. Common problems in ADHD include difficulty concentrating, trouble working on a task, and an inability to stay still. It is usually noted when children reach school age. ADHD is a disorder rooted in genetic factors (Aydın et al. 2006, Çetin and Işık 2018).

In the literature, brain structures of patients diagnosed with ADHD have been examined, but no lateralized abnormality has been identified (Castellanos et al. 2002). In some studies, the symptoms of this disorder are defined as control functions that determine goal-directed behavior and enable the individual to ignore irrelevant stimuli, and are referred to as executive functions (Houghton 2006). ADHD leads to clinical impairments in executive functions in both adults and children, affecting individuals in terms of orienting, detection, and alertness. Individuals diagnosed with ADHD often struggle to fully carry out the ability to orient toward task-related stimuli when required to focus on a task. Children diagnosed with ADHD frequently benefit from rehabilitation services in specialized centers. During attention exercises, these children are observed to have difficulty directing their focus to relevant stimuli as required by the instructions. In situations where the child is expected to focus on the relevant stimulus and ignore the irrelevant one, they are often unable to perform this skill effectively. The inability to direct attention to the relevant stimulus makes it difficult to develop awareness of the stimulus and to respond to it. Considering this, it would be beneficial for studies involving children and adults diagnosed with ADHD to initially focus on directing attention toward relevant stimuli. In attention exercises used during rehabilitation, activities that guide attention to relevant stimuli can be structured to progress from simple to more complex stimuli. For example, exercises such as identifying the stimulus that matches the relevant one, detecting the stimulus/stimuli that differ from the target one, and directing attention to differences between two stimuli are effective. Identifying the matching stimuli by directing attention to the relevant stimulus significantly improves the function of orientation. Exercises that involve identifying different stimuli strengthen the subfunction of detection. Activities that involve identifying target stimuli among complex stimuli can also be applied. These exercises should be organized in a sequence from simple to complex, containing both relevant and irrelevant stimuli, so that detecting the target stimuli is easier in the initial stages, and the child becomes more successful in directing attention to relevant stimuli. For instance, in a worksheet filled with pictures of fruits, the task may be to find the target fruits in the shortest time possible. Once these exercises are completed without errors and in a shorter time, the child can progress to more complex exercises with more objects. Individuals who show improvement at these stages also begin to progress in terms of transitioning to a state of alertness. Thus, their response speed to relevant stimuli increases, and the error rate decreases.

Attention is not a process that emerges only when individuals are engaged in a specific task. It is a continuously active process in daily life. In social situations, attention plays a crucial role in processing information obtained from stimuli. During every day social interactions, we process cues such as body language and facial expressions in order to understand and recognize the emotions of others and respond accordingly. In this context, attention provides us with valuable clues. Tracking the eye movements of others is an important cue in processing this information. In a study where participants were shown images of eyes looking in different directions, they shifted their own gaze in the same direction as the presented eye movements (Kingstone et al. 2003).

## Autism

Studies have suggested that individuals who experience difficulties in social communication may also have impaired attention skills. Regarding this context, research has been conducted with individuals with autism. Autism is a developmental disorder that primarily affects social functioning. It was first described by Leo Kanner in 1943. Individuals with autism often do not make eye contact with others. individuals with autism experience difficulties in many areas of social development that require attention skills. Fujisawa et al. (2014) examined the relationship between visual attention, which is necessary for processing social information, and oxytocin levels. In this study, which compared findings between children diagnosed with autism and typically developing children, eye movements were recorded using an eye-tracking device, and oxytocin levels were measured in saliva samples. In both groups, visual attention required for processing

social information was related to oxytocin levels. Although a positive relationship was found between duration of focus and oxytocin levels in typically developing children, no such relationship was observed in children with autism. This finding is consistent with the observation that children with autism have lower visual attention skills than typically developing children.

Children diagnosed with autism had deficiencies in non-verbal communication skills and attention abilities (Mundy et al. 1986). In this sense, the concept of joint attention, which is the type of attention that influences social development in individuals with autism, has been examined. Joint attention is defined as the ability to share attention between a person and an object in a social setting (Adamson and McArthur 1995). Deficiencies in attention-related skills also limit the ability of individuals with autism to perceive and express emotions (Saymaz 2008). Based on the findings of a case study discussed in Saymaz's (2008) research, it can be stated that autism symptoms cause clinical impairments in language development. In a study by Joseph and colleagues (2005), children with autism scored significantly lower than the control group in assessments testing executive functions. The same study (Joseph et al. 2005) also found no relationship between language skill levels and executive functions in the autism group. Results were interpreted as stemming from children with autism not utilizing language skills in the service of executive functions.

Imaging studies conducted on individuals with autism have shown decreased amygdala activation, a structure within the limbic system, during facial recognition tests (Hadjikhani et al. 2007). Based on the results of this study, it can be concluded that impairments in recognizing facial expressions of others among individuals with autism may be related to the brain's physiological structure, and this deficiency may lead to an inability to effectively manage the attention processes required in social environments.

Behavioral approaches have proven effective in the treatment of autism, which is the most common example of attention disorders that cause impairments in social development. The lack of eye contact observed in individuals with autism is related to a deficiency in directing attention. Therefore, improving the ability of individuals to establish eye contact can help enhance their success in attention orientation. Efforts to gradually increase eye contact that is very brief in early phases, through exercises, have shown positive outcomes in clinical settings. In interventions with children, using reinforcement to encourage eye contact can positively influence the orientation phase of attention. In rehabilitation settings, after identifying the child's area of interest, presenting relevant stimuli, even if only for a short time, followed by reinforcement using a preferred reward such as a favorite food, toy, or sticker, is a widely used method. This activity helps establish eye contact and ensures that the visual attention created is directed toward the relevant stimulus. This, in turn, enhances the detection subfunction of attention in individuals with autism. Additionally, research findings support the notion that individuals with autism experience deficiencies in joint attention. Joint attention can manifest in different areas in individuals with autism. Play skills are one of the most prominent of these areas. Behavioral interventions conducted at an early age can effectively promote development. With the proven impact of early diagnosis and intervention, programs aimed at improving play skills in children diagnosed with autism have increased joint attention. Play skills help the child share attention between the objects used during play and the person they are playing with, thus contributing to the development of joint attention abilities. Learning how to initiate play, engage in reciprocal play, and take turns during play can enhance the orientation, awareness, and alert phases of attention in children with autism.

## Neurocognitive Disorders

Disorders exhibiting impaired attention function are not limited to developmental areas. Neurocognitive disorders are another category in which attention function is affected. Delirium, a neurocognitive disorder, has been described since ancient times, although its diagnostic criteria have only become clearer in recent years. Before 1980, it was generally defined as a disorder of overall brain function. With the publication of the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (APA 2013), the criteria were revised to include attention impairment. Before the DSM-5, attention problems were more commonly associated with consciousness, but with the DSM-5 criteria, the term "attention impairment" replaced "disturbance of consciousness" (European Delirium Association and American Delirium Society 2014).

### Delirium

In delirium, there is a fundamental impairment in the individual's cognitive function. There are deficits in the ability to direct, sustain, and focus attention, along with declines in functions such as orientation, awareness, and perception (Özer et al. 2022). While attention impairments are considered one of the core symptoms of delirium, these symptoms are divided into two main categories as cognitive and non-cognitive (Grover et al. 2021). There are many studies in the literature to understand the basis of attention-related impairment. In the study by Grover and colleagues (2021), measurements obtained using the Cognitive Test for Delirium (CTD) revealed that high levels of attention deficits were linked to advanced impairments across all other areas of cognition. When evaluating non-cognitive symptoms, attention was found to play a role in all symptoms except for delusions. These findings provide evidence that attention impairment is a core symptom of delirium. Other studies in the literature using different tests support these findings (Rajlakshmi et al. 2013).

### Dementia

Dementia, another neurocognitive disorder, is a problem that is mostly associated with memory impairments, as well as a disease in which attention function declines. In patients with dementia, the decline in attention function leads to difficulties in daily life skills, communication problems, and the progression of dementia symptoms (Yamaguchi and Yamaguchi 2024). Unlike delirium, dementia, which has a slow onset and progression, is a disease characterized by memory impairments. Similar to delirium, attention and concentration disorders are observed. Levine et al. (2023) found that being diagnosed with ADHD in adults increased the risk factor for dementia. In this study, a longitudinal study was conducted with individuals born within a certain time period, and the risk of dementia in old age was examined. It was recorded that individuals diagnosed with ADHD were at approximately 3 times higher risk than those who were not diagnosed. It is known that in other types of dementia other than Alzheimer's type dementia, memory and executive function disorders, especially in the early stages, are due to a decline in attention skills (Yener and Evlice 2022). It has been reported that dementia patients experience difficulty in focusing or fluctuations in focusing attention (Kounti et al. 2006). These patients experience fluctuations in attention, cannot continue talking because their distractibility increases during activities such as speaking, and have difficulty concentrating.

## Mood Disorders

In addition to neurocognitive disorders, mood disorders are another group in which attention function is affected. Among mood disorders, major depressive disorder is one of the most widely studied disorders with a high frequency of diagnosis in the general population. DSM-5 lists criteria such as depressed mood, decreased energy, decreased interest and desire, and impaired sleep and appetite, as well as difficulty in concentration among the symptoms for the diagnosis of major depression (Kafes 2021). Symptoms such as concentration difficulties, inability to focus thoughts, and difficulty in making decisions by focusing attention have been reported in depressed patients (Markela-Lerenc et al. 2006). Among the cognitive impairments observed in depression, memory impairments, as well as attention and concentration impairments, are frequently included in the literature (Özten 2019). Kertzman et al. (2010) found that attention performance measured with the Stroop test was lower in the patient group in a study examining selective attention function in patients with major depressive disorder. In addition, when the results were examined in detail, it was noted that the decrease in Stroop test performance in the major depression group was not only due to the deterioration of selective attention skills but could be due to the decline in basic cognitive functions (Kertzman et al. 2010). The researchers emphasized that these findings may be related to the version of the Stroop test used in the study. When we examine the literature, we often see that different tests or different versions of the same test are used to measure attention. This situation is evaluated as a limitation of the studies and is emphasized by the researchers in the context of issues that need to be considered in future studies.

In another study conducted with individuals diagnosed with major depression, the d2 test was used to measure attention (Schultchen et al. 2021). According to the results of this study, the patient group had

significantly lower attention test scores than the control group. In this test, where target stimuli in the test had to be marked, individuals diagnosed with depression gave significantly lower correct answers and were less able to detect target stimuli. When the findings obtained from the study were examined, it was interpreted that having a higher level of depression leads to a lower attention score (Schultchen et al. 2021). Attention function is impaired not only in individuals diagnosed with major depressive disorder and bipolar disorder. The findings of this study support the fact that individuals diagnosed with both major depression and bipolar disorder have problems in the field of sustained attention compared to healthy individuals (Gallagher 2020).

There are studies in the literature that have examined in detail how attention affects depressive disorders. The direction of the relationship between depression and attention was examined in a study by Mac Giollabhui et al. (2019). The first hypothesis tested was that decreased attention skills cause depressive episodes. Secondly, the hypothesis that attention deficits occur because of depression was tested. When the results were examined, it was concluded that there was a more complex relationship between the two variables. The ability to direct attention decreased before the onset of depression (Mac Giollabhui et al. 2019). However, the relationship between attention and depression was not limited to depressive episodes only. It is understood that high depressive symptoms caused deterioration in selective attention and attention directing at times other than depressive episodes. These findings were interpreted as a reciprocal relationship between attention and depression, and it was emphasized that they should be examined in detail in future studies (Mac Giollabhui et al. 2019).

### Anxiety Disorders

The function of attention is also negatively affected in anxiety disorders as well as depressive disorders. In the DSM-5 diagnostic criteria for generalized anxiety disorder, difficulty concentrating is listed among the symptoms (Gündüz 2019). In the study conducted by Hallion et al. (2018), difficulty in concentration was found to be significantly high in 90% of individuals diagnosed with generalized anxiety disorder. A strength of this study is that it was conducted with a diagnosed patient group and that clinician-administered assessments were used instead of self-report methods. Therefore, the high prevalence of concentration difficulties in individuals diagnosed with anxiety cannot be attributed to measurement errors.

Within anxiety disorders, the relationship between different types of anxiety and attention has been examined. Anxiety has been examined under two different categories, trait anxiety and state anxiety (Lazarus 1991). State anxiety increases the perceived threat level in the face of any situation or in relation to a stimulus. Trait anxiety can be explained as a person's tendency to continuously direct their attention toward potential sources of threat (Pacheco-Unguetti et al. 2010). Pacheco-Unguetti et al. (2010) aimed to separate the attentional biases associated with trait anxiety and state anxiety. Because of the experiments conducted, it was found that anxiety significantly affected structures related to attention. In addition, it was recorded that anxiety had a higher disruptive effect on giving the necessary responses to complete the task, and that the participants had more difficulty in doing so, in participants who scored high in terms of the trait anxiety variable. Among the results obtained was that state anxiety affected more orientation and alertness (Pacheco-Unguetti et al. 2010). When the findings are examined in general, it can be concluded that both types of anxiety affect attention skills. In studies examining the relationship between attention functions and anxiety disorders, it has been emphasized that targeting attentional impairments and attentional biases can effectively improve treatment processes (Yiend et al. 2015).

## Discussion

The definition of attention, a key cognitive function, and its associated neurophysiological findings hold an indisputable place in the literature. Moreover, conditions in which the function of attention is impaired are examined among various topics in numerous studies within the relevant literature (Mountcastle 1978, Petersen et al. 1987, Goldman-Rakic 1988, Posner and Petersen 1990).

ADHD and autism have been addressed separately and in detail from other attention disorders within the scope of this study. The reason for the detailed examination of these two disorders and the inclusion of

examples from rehabilitation and treatment approaches is the effort to show that attention is a cognitive function that affects the individual personally and also causes impairments in social development, thereby influencing interpersonal communication and interaction. When the literature is reviewed, attention is often studied under separate subjects as a topic that affects either individual or social domains. However, as shown within the scope of this review, considering both individual and social effects together may offer broader benefits. There is a lack of studies in the literature that examine individual and social effects together and explain how their interaction functions in terms of attention. The studies discussed in this review article prove the scarcity of studies that study individual and social effects together. Considering attention as a mechanism that helps us individually perform tasks we undertake in daily life, or as a mechanism that provides the joint attention necessary for social development, makes it impossible to consider the development of individuals as a whole. Fulfilling both our individual and social functions are intertwined situations, and attention is necessary and important for both areas. Studies emphasizing deficiencies in joint attention in autism (Adamson and McArthur 1995) or deficiencies in visual attention skills (Fujisawa et al. 2014) are indicators of this necessity. The difficulties experienced by individuals in daily life skills in disorders such as dementia and delirium affect not only themselves individually but also their social environment (Yamaguchi and Yamaguchi 2024).

This review study, which aims to draw attention to the fact that future studies should not only address attention in a singular context but should continue with a dual approach that will include individual and social areas, offers an original approach. It is aimed to emphasize this deficiency in the field. In this way, both perspectives in the studies will be diversified, and more efficient results will be obtained in clinical settings. Focusing on singular aspects of attention separately prevents the emergence of a holistic approach. Conducting behavioral studies with imaging studies will lead to discovering common grounds and better interpretation of the findings. Thus, the development of new models for early diagnosis and intervention in clinical groups will be paved. In subjects addressed in the clinical field, examining attention by reducing it to its subfunctions may contribute to the development of new rehabilitation techniques.

In recent years, with the advancement of technology, studies investigating the effects of media-related multitasking on attention have frequently taken place in the field. There are studies indicating that multitasking creates a general state of inattention and causes impulsivity (Rosen et al. 2015). individuals' ability to switch between tasks decreases and their attention is distracted more quickly in multitasking. Similar findings have been obtained in different studies (Ophir et al. 2009, Cain and Mitroff 2011). Based on these studies, it can be emphasized that attention functions should be addressed in a multidimensional structure in future studies, taking into account the requirements of daily life and changes in technology, as well as considering attention in terms of individual and social skills.

## Conclusion

This review study was designed to summarize the definition of attention and the historical development of the studies, to explain the neuropsychology of attention with physiological studies in particular, and to emphasize the types of problems that impairments and deficiencies in attention can cause in a personal sense. This study aims to create a basis for future studies. Based on the points emphasized in this review, the field can be further supported by imaging and behavioral studies on the physiology of attention. The examination of the attention processes of healthy individuals will help to better understand clinical cases and to plan rehabilitation and treatment processes more efficiently. In addition, integrating future studies on different topics in terms of individual-social development areas will cause the findings to yield more meaningful results.

Attention skills, which have components such as orientation, detection, and alertness, have been studied from the 19th century to the present. Different types such as divided attention and selective attention, have been examined. The neuropsychological data and imaging studies in all of these studies attempted to reveal the physiology of attention. When we look at the literature, there is activation of similar areas in attention, but a spread of activation is seen throughout the cortex. Different dimensions of attention are processed in different areas of the cortex. Disturbances in attention can occur in many clinical conditions.

ADHD is one of the most frequently studied subjects. In addition to developmental disorders, impairments in attention function are observed in neurocognitive disorders and mood disorders. Moreover, attention is not only the ability to focus on locations, objects, or messages individually. It also has an important function in terms of social development. In this context, impairments in attention affect social development negatively.

The current review has some limitations. First, the study was created by scanning studies in two databases. In addition, more comprehensive explanations were made on the three subfunctions of attention; titles such as selective attention and divided attention were given more limited space. Scanning more databases and examining other titles related to attention in detail can be presented as suggestions for future studies.

In conclusion, the present review aims to bring together theoretical studies in the field of attention in order to contribute to solving current issues and to support the restructuring of future approaches, thereby addressing a gap in the literature. In this regard, future research should include more behavioral studies being supported by neuroimaging findings. Additionally, examining both the individual and social dimensions of attentional functions together may lead to more comprehensive outcomes, ultimately enhancing the effectiveness of treatment and rehabilitation processes. Furthermore, when this holistic approach is integrated with recent technological developments that examine the effects of such advances on cognitive functions like attention, it becomes possible to develop new approaches that consider the changing demands of the era and compensate for its negative aspects.

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