Chapter 6
Attention/Concentration: The Distractible Patient

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Abstract Attention and concentration are simple concepts on the surface but become complex when asked to assess or differentiate among capacities. While, at its most basic, attention refers to an organisms ability to recognize and respond to changes in its environment. The concept of attention when applied in neuropsychology represents a range of behavior which is dependent on functional integrity of many anatomical regions. The range of behavior includes everything from autonomic and reflexive auditory and visual orientation to sound and movement, to the ability to process several stimuli simultaneously or alternate back and forth from competing stimuli (see Kolb B, Whishaw, 2009 for review). While a universally accepted definition of attention and concentration would be broad and potentially unusable, the models of attention typically have common features including orienting, selecting stimuli and maintenance for a necessary time or successful completion of a task. These factors are represented in Fig. 6.1. Attention is typically viewed as a sequence of processes that occur in several different regions of the brain, which are involved with the acquisition and sustaining of attention. Attention is organized hierarchically, usually modality-specific at its origin and then multi-modality or multi-cortically mediated as in rapid alternation or switching of attention or maintenance of concentration.

In addition to attention, concentration refers to two elements: the capacity to sustain attention on relevant stimuli and the capacity to ignore irrelevant competing stimuli. Again, while simple, the concept of concentration is objectively difficult to differentiate in an orthogonal manner, several models of attention and concentration have been proposed and the interested reader is referred to Posner (1990) for elaboration.

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Key Points and Chapter Summary

- Attentional capacity is a prerequisite skill for accurate assessment of more complex neuropsychological functions
- Damage to the frontal lobes is most detrimental to attentional skills, but damage in any part of the brain can compromise attention
- Attention should be assessed at many levels including:
  - Voluntary attention
  - Focused attention
  - Divided attention
  - Sustained attention (concentration)
  - Alternating attention

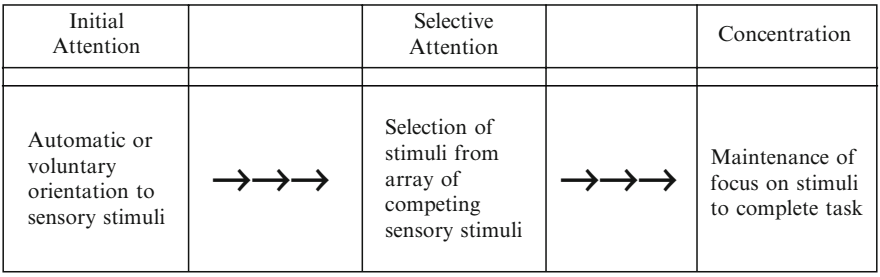

Fig. 6.1 Common elements in cognitive models of attention and concentration

Anatomy of Attention/Concentration

Attention and concentration is multiply determined from an anatomical perspective and involves many regions of the brain. Broadly speaking, attention and concentration deficits can arise from compromise in virtually any region of the brain; however, certain regions contribute different aspects to the attentional process. Table 6.1 outlines anatomical areas involved in different aspects of attention. For additional review of neuroanatomic correlates of attention, see Chap. 3, this volume (see also Kolb and Whishaw 2009; Lezak et al. 2004 for a thorough review of functional neuroanatomy for attention and concentration).

Table 6.1 Localization and lateralization of attentional deficits

Area	Attentional function
Superior colliculus	Regulates automatic orientation to visual stimuli
Inferior colliculus	Regulates automatic orientation to auditory stimuli
Ascending reticular activating system	Provides activating stimulation to cortex to initiate and maintain arousal necessary for initial and sustained attention
Thalamus	Lesions can produce contralateral inattention, or interfere with transmission of sensory input necessary for sustained or alternated attention
Limbic system (amygadala, cingulate gyrus and hippocampus)	Determines saliency of increasing stimuli, provides emotional tone thus facilitating attention and memory, involved with stimuli detection and appropriate alternation of attentional focus
Parietal lobes	Cross-modality hemispatial attention, with right parietal dominance for hemispace attention
Pre-frontal cortex	Responsible for voluntary initiation and sustaining attention, rapid alternation of attentional focus and shifting of attention
Dorsolateral frontal cortex	Initiation of attentional focus
Orbital frontal cortex	Sustaining of attentional focus

Attention Problems: A Behavioral Guide

Below, we provide a behavioral description of some common types of attention problems followed by a possible diagnostic or syndromic explanation for the observed attention deficits. It is important to note that attention problems may not be apparent in one-on-one situations and/or in highly structured settings where distracting stimuli are minimized and the environment and task are novel. Common symptoms of attention deficits and hyperactivity and impulsivity as listed by the DSM-IV are summarized in Table 6.2.

Table 6.2 Common symptoms of attention deficits, hyperactivity and impulsivity as listed by the DSM-IV

Neuropsychological deficit	Clinical presentation/symptoms
Attention	For DSM-IV diagnostic criteria, must have six (6) or more of the symptoms below for six (6) months in duration of severity that is maladaptive and inconsistent with the patient's developmental level • Avoids engaging in tasks that require sustained mental effort • Does not listen when spoken to directly • Does not follow through on instructions • Has difficulty sustaining attention in activities • Fails to give close attention to details • Has difficulty organizing tasks • Loses things necessary for activities • Is easily distracted by extraneous stimuli • Is forgetful in daily activities

(continued)

Table 6.2 (continued)

Neuropsychological deficit	Clinical presentation/symptoms
Hyperactivity and impulsivity	For DSM-IV diagnosis of hyperactivity/impulsivity type (or combined type) ADHD, patient must have six (6) or more of the following symptoms persisting for at least six (6) months in duration of severity that is maladaptive and inconsistent with the patient's developmental level. Hyperactivity • Acts as if "driven by a motor." • Has difficulty playing quietly • Is fidgety • Leaves seat when expected to remain seated • Runs about in situations in which it is inappropriate • Talks excessively Impulsivity • Blurts out answers before questions have been completed • Has difficulty taking turns • Interrupts or intrudes on others

A. Problems in attention without hyperactivity

Patients often present as being easily distractible and may have difficulty with compliance to complete some testing due to attention problems. Patients may be distracted by efforts to examine visual fields with confrontation, and will have difficulty maintaining a task if the examiner is making noise or moving around. While common in the general population, these patients frequently report difficulty completing projects they start and start another project before finishing the current project. Patients may also complain of memory problems such as, forgetting to do school or work projects. However, the forgetfulness often reflects a secondary effect of varying attention on consolidation of memory rather than a direct memory failure. These individuals often appear disorganized and inefficient or scattered due to the effect of their attentional difficulties in gathering the necessary prerequisite materials or completing tasks. While overt hyperactivity and impulsivity may not be present, these patients often appear fidgety, restless, or anxious.

B. Problems primarily with impulsivity and/or hyperactivity

Patients often present with a history of rash decisions and impulsive behaviors, that can often threaten their safety. These patients are clearly overactive relative to their peers and are often perceived as disruptive, non-compliant and unruly. They are also often perceived by peers as intrusive or annoying. Patients may complain of difficulty maintaining vigilance (focus) on tasks across environments (home, school, and/or work). Patients often have difficulty keeping still, and will fidget in their chairs or when trying to stand still. Younger patients may exhibit symptoms of conduct disorder and/or mood symptoms of anxiety or depressive symptoms. These patients may describe themselves as "class clowns" and may over-use alcohol and/or drugs. They are often avoidant of situations that require restricted movement or sustained attention (i.e., long travel, classrooms/lectures/meetings).

C. Problems in attention with impulsivity/hyperactive

Patients present with a combination of inattentiveness and impulsivity and hyperactivity. Patients present with being easily distracted, and go from one project to another without finishing the first. Patients also exhibit high energy levels and make rash and impulsive decisions. They often have difficulty learning from past mistakes and appear to impulsively make the same judgment errors repeatedly, despite good ability to verbalize alternative or correct responses and often display true remorse subsequent to their repeated mistakes. Like patients with primarily hyperactive-based attention problems, patients with both attention and hyperactivity/impulsivity may describe themselves as "class clowns" and may over-use alcohol and/or drugs as coping strategies.

D. Problems in maintaining vigilance

Patients having trouble maintaining vigilance may readily engage in a task and indicate an interest in completing the task. Span of attention (e.g., digit span) can be entirely intact, potentially even above average. However, for tasks taking longer times to complete, these patients lose interest in the task and become distracted. Patients typically begin to fidget and can daydream. Other novel stimuli present in the area will frequently distract a patient to move or stop engaging in the task. Patients with deficits in vigilance often avoid and/or complain about engaging in repetitive tasks.

Patients with deficits in vigilance often develop compensatory behaviors and fidget by playing with writing instruments, doodling, shifting position frequently (sitting or standing), and may "tap" their foot or fingers.

While appearing to be entirely inattentive, often when these patients are asked about recent events or details, they can usually respond correctly. Child patients with problems in vigilance deficits are often able to respond correctly to questions posed to them about what had recently transpired in the classroom, despite seemingly attending to doodling, talking to neighbors, and/or fidgeting in their desks.

E. Adult presenting with primary attention problems

The adult patient presenting to the neuropsychology clinic for predominate attention problems poses a significant challenge to the diagnosis and treatment of attention deficits. The diagnosis of Attention Deficit Disorder and Attention Deficit with Hyperactivity Disorder (ADD/ADHD) retrospectively requires a careful and detailed analysis of when symptoms of attention and/or impulsivity/hyperactivity problems began. DSM-IV criteria require onset of attention problems before the age of 7 years old. Onset of attention problems and/or hyperactivity/impulsivity in adulthood (after age 18) generally precludes a diagnosis of ADHD. While changes in attentional capacity are both common in the general population and expected with age, they may be a secondary symptom of developing neurologic or psychiatric disease. Attentional difficulties are a very common symptom across multiple neurologic and psychiatric disorders and thus it is critical that an acute cause be ruled out. In adult patients complaining of attention and/or hyperactivity/impulsivity symptoms, the diagnosis is neurological disease or psychiatric mood disorder until proven otherwise.

Assessment of Attention

The clinical assessment of attention ranges from tasks requiring simple attentional capacities to complex attentional functions involving selection, sustaining and alternating attention as well as inhibiting distraction or avoiding unwanted attentional switching to automatic or overlearned processes (i.e., reading or semantic processing rather than color naming or stating the case a word is printed in). Assessment of attention typically involves assessment of attentional capacity including, *focused attention, sustained attention, divided attention and rapid alternating attention*. In addition, assessment of attention frequently includes an evaluation of ability to inhibit automatic or overlearned responses. Assessment proceeds from the simplest tasks of attentional capacity to more complex tasks of focused, sustained, divided, and rapid attentional alternation. A brief summary is provided below, and bedside assessment examples are discussed in more detail below.

- Simple attentional capacity is a prerequisite skill which must be considered both in the assessment of more complex attentional factors in addition to other higher order cognitive skills (memory, language, visual-spatial reasoning, abstraction, etc.) that are assessed later in the neuropsychological evaluation. Digit span forward is an example of this ability in which patients are asked to repeat a series or random numbers.
- Focused attention (selective attention) refers to the ability to "tune out" or attend to chosen (consciously targeted information) stimuli while simultaneously ignoring other stimuli that are judged less important (i.e., not becoming distracted by competing stimuli). Examples of this are the Wechsler Intelligence tests digit symbol/coding and symbol search tasks and cancelation tasks. Among researchers, there is debate as to whether there is a difference between focused and sustained attention.
- Sustained attention (or vigilance) is the ability to maintain attention to stimuli over an extended period of time, even when stimuli may not be constant. Some would consider sustained attention as *concentration*. Examples include the various continuous performance tests in which attention must be sustained on a computer screen looking for a specified target over an extended time.
- Divided attention (some consider this to reflect working memory) refers to the ability to process more than one (multiple) stimuli (information) at the same time or maintain involvement in more than one task at a time (keeping information from multiple stimuli or tasks "on line" and respond appropriately to several operations of a task simultaneously). An example of this is mental arithmetic and letter–number sequencing tasks.
- Rapid alternating attention refers to the ability to rapidly shift attentional ability between stimuli or tasks. This type of attention is more difficult to evaluate without psychometric instruments. Examples include the Wechsler Intelligence tests digit symbol/coding subtest and symbol search subtest. These tests require rapid alternation of attentional focus, usually for short periods of time (ex. 90 seconds).

Table 6.3 Factors which can negatively effect assessment of attention

Factor	Assessment
Establish sensory thresholds	Assure adequate auditory, visual and tactile sensory thresholds, provide compensation if necessary (i.e., amplifier, large print, etc.)
Medication	Rule out sedative, hypnotic, analgesic, anxiolytic or other medication that affects attention (i.e., antihistamines).
	Examine dose schedules to minimize negative post dose effect.
	Examine medication and dose changes that may indicate magnified effect due to ineffectual habituation.
Fatigue	Examine the individual's activity level on the day of assessment; ask about changes in sleep/wake cycle and quality of rest on previous evening.
	Note the age and general health condition of the individual; examine individual level of fatigue as testing progresses, and note time of day the assessment of attention is occurring.
Environmental factors	Note auditory and visual distractions.
	Note presence of others or any change in environmental stimuli and the individual's response to these changes.

Before discussing the assessment of attention, several factors should be considered which could produce detrimental effects on immediate attention and distort the assessment of attention. These factors include the general medical condition of the patient, with acute patients and those immediately post-procedure likely to display attentional deficits that are varying and transient. Medication can also have a detrimental effect, and it is critical to be aware of the medication the patient is taking, the dosing schedule of medication that potentially affects attention and any recent change in medication, dose or dosing schedule. It is also important to assess the patient's level of fatigue, the extent of previous activity on the day of assessment and to account for the potentially fatigue-inducing effect of your current assessment. In noting fatigue, it is important to consider the time of day in which the assessment occurs, as in many individuals (especially the young and elderly) fatigue effects occur rapidly as the day progresses. An assessment of the environment is also necessary to rule out any extraneous distractions prior to assessing attention. Table 6.3 provides a checklist of pre-testing factors that can affect measured attentional skills.

Methods to Assess Attention and Concentration

As previously discussed, attention varies in complexity from simple to complex attentional abilities. Simple components of attention can be assessed in the interview both informally and formally. Attention should be assessed through observation by noting such behaviors as reciprocal conversation skill, time on task, response time and susceptibility to distraction or environmental change. Assuming that these

behaviors are noted to be within normal limits, assessment of attention should progress from simple attention to auditory and visual tasks to more demanding tasks requiring sustained attention, rapid shifting of attention and dual processing of information. Many of these tasks can be administered at the bedside for patient screening or brief assessment while other components of attention are better evaluated in a controlled testing environment. This chapter will focus on brief/bedside evaluation of attention and concentration, but for more structured and elaborate attentional assessment the interested reader is referred to Lezak et al. (2004).

Brief/Bedside Assessment of Attention

Auditory Attention Span. Forward digit span involves the presentation of random single-digit numbers (0–9) to the patient at one per second (e.g., 6 – 4 – 9 – 7 – 2). The numbers are repeated by the patient and assessed for accuracy. While education does have an impact on performance, age appears to have a minimal effect on digit-span forward (Lezak et al. 2004). The range of repetition of digits forward is traditionally considered to be 7 with an approximate standard deviation of 2 (e.g., correctly repeating 5–9 digits forward is considered normal). Test presentation data and descriptions of performance are presented in Table 6.4. For those patients older than 65, a reduction of 1 digit is appropriate (e.g., 4–8 digits forward). Individuals who have speech production problems can be presented with a page with numbers arranged from 0 to 9 and test stimuli either presented aurally or by pointing to numbers. Similar performance levels should be expected as with aural presentation and verbal response.

Reverse digit span is a slightly more difficulty task requiring patients to listen to digits presented at a rate of one per second (or view as in the case of visually presented stimuli) and then report the sequence of numbers in reverse order. This task is more demanding in that it not only requires short-term attention, but the storage and manipulation of this information prior to repetition of the digits. This task has been

Table 6.4 Digit span forward and reverse[a]

Digits	Forward	Reverse
2 – 6	Severely impaired	Moderately impaired
9 – 3 – 1	Moderately impaired	Mildly impaired
5 – 7 – 4 – 8	Mildly impaired	Borderline
3 – 9 – 6 – 2 – 5	Borderline	Low normal
8 – 3 – 1 – 2 – 9 – 4	Low normal	Normal
7 – 6 – 4 – 1 – 3 – 5 – 2	Normal	High normal
3 – 9 – 4 – 6 – 8 – 2 – 5 – 1	High normal	High performance
5 – 6 – 9 – 2 – 8 – 3 – 5 – 1 – 7	High performance	Superior

[a]For patients age 65 or older, add one digit to obtained performance to derive normative descriptor

Rule of thumb: Bedside Assessment of Attention

- Adequate and sustained arousal is a prerequisite for assessment of attention
- Attentional deficits produce a pattern of variable performance across neuropsychological assessment
- Attention Assessment should include:
  - Sustained attention/Vigilance
  - Attention under distraction
  - Divided attention
  - Rapid alternation of attention focus

shown to be much more revealing as to the effects of acute and chronic cortical compromise. In a normal population, the average person should perform one digit less in digits backward than forward (i.e., 6±2). Test data are presented in Table 6.4.

Many other attention span tasks are available that include assessing forward and reverse span including letter span and visual span, and the interested reader is referred to Lezak et al. (2004) for a description of these tests.

Assessment of Vigilance

Vigilance, or the ability to sustain attention voluntarily, is also critical for successful performance on neuropsychological tests and a prerequisite skill in making meaningful interpretation of subsequent neuropsychological test data. It is especially important to assess vigilance periodically in patients who are acutely injured or otherwise believed to experience fluctuations in attentional capacity.

The most direct way to assess vigilance is to ask the patient to perform a task that requires sustaining attention. Vigilance should be sustainable for at least 60–90 seconds without interruption. In the interview, a patient can be asked to point to a series of objects in the room either by mimicking the examiner or by following verbal commands. Such commands can be repeated to ensure that vigilance can be sustained for 60–90 seconds. Such commands or mimicking can include pointing to ceiling, floor, walls, windows, furniture or personal objects in the room. The individual could also be asked to count to 100 or recite the alphabet or read aloud for 60 seconds. The critical element is that the task involves over learned stimuli which require minimal cognitive processing.

More formal bedside assessment of vigilance can be conducted using a letter or digit vigilance task (see Table 6.5 for example). Such tasks require the patient to listen to a series of numbers or letters and respond only to a target letter or number by raising a finger or tapping a table. In such tasks, each number or letter is read at a rate of one per second and performance is evaluated based on omissions errors

Table 6.5 Letter and number vigilance assessment tasks[a]

Digits	Letters
5 3 9 1 5 5 6 7 4 1 8 2 5 6 5	A C R P A A M D Q S D T A B A
5 5 8 3 1 6 4 4 2 7 1 9 4 5 1	A A Z P T M N N E F G B S A L
5 8 6 3 9 5 5 5 2 7 6 1 5 4 2	A S P L R A A A G M C D A D B
2 7 6 5 4 9 3 8 6 4 8 2 5 1 4	B G F A D S T P Z R F T A C F

[a]Digits and letters should be read at one per second. Errors should be noted as commission (c) omission (o) or perseveration (p). Total errors exceeding three indicate impairment. After a patient understands directions, no further assistance is provided during testing

(failing to detect a target), commission errors (falsely reporting a target as presented) and perseverations of response. These tests typically have a one-to-four response items-to-distracter ratio, and minimal total errors are expected in normally functioning patients aged 6 years old and older. Patients with greater than three total errors should be considered to be impaired. Test stimuli are presented in Table 6.5 for both letter and digit vigilance tasks (Target letter A and number 5 in this example). While the assessment of attention should be conducted at the bedside or during interview, assessment of more complex attention and a quantitative assessment of attentional capacities is best done in a formal assessment setting which can control environmental factors and make comparisons to standardized data. The interested reader is referred to Lezak et al. (2004) for a thorough review of attention assessment measures. Common measures to assess for vigilance include continuous performance tests, which require the patient to respond to various stimuli on the screen while not responding to others.

References and Suggested Further Reading

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