Attention: The Focus of Consciousness 8

Case Study
A resident physician finishes his last night shift at the end of a week of night calls. It is 5:00 a.m. and the last few hours have been particularly straining because of several unstable patients. The resident is very tired but conscientiously decides to do rounds on his patients one more time before getting some rest. While evaluating a patient whose hemodynamic status has recently worsened, he is emergently called to another patient who has been inadvertently extubated during positioning. When the resident arrives at the bedside, the patient is being mask ventilated by a nurse, and the oxygen saturation is 85 %. The physician takes over the ventilation and asks the nurse to prepare for reintubation. Because the patient is agitated and resists mask ventilation, the resident decides to give him a bolus of fentanyl and midazolam from the infusion pump. Immediately after the injection, the patient becomes severely tachycardic and hypertensive. The heart rate is 180 bpm and the blood pressure is 260/150 mmHg. A quick glance at the infusion pump labels makes the resident realize that he has mistakenly delivered a bolus of epinephrine instead of fentanyl. Upon recognition of the error, the patient's hemodynamic response is rapidly brought under control with boluses of nitroglycerin. His vital functions return to normal soon after. The patient is then uneventfully intubated.

After 1 week of night shift in an ICU, a fatigued physician was faced with an emergency. The call for help reached him in a moment when his attention was focused on another problem. Tired and still immersed in thought, he had to switch tasks and manage an emergency situation where he had to concentrate on mask ventilation and simultaneously deal with an agitated patient and prepare for reintubation. In this context, he wanted to give a bolus of an analgosedative drug to the patient manually and unintentionally manipulated the wrong infusion pump and applied a high dose of a catecholamine. Due to an immediate intervention with a vasodilating drug, further patient harm due to an excessive increase in heart rate and arterial blood pressure was prevented.

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8.1 The Control of Action: Attention, Vigilance, and Concentration

Human thinking, perception, and action can be consciously controlled and influenced. Conscious control is vital for problem solving and for actions that require precision and that potentially impact the patient's short- and long-term well-being. The relevant central resource, the process by which we focus our awareness, is called *attention*. It enables us to be completely present in a certain task. Attention, however, is also a vulnerable and limited resource. If it decreases or, as in the case study, is substandard due to fatigue, then people often suffer a loss of control over their behavior. Mistakes are more readily committed. Furthermore, attention is a precious commodity because there are limitations on how much attentional capacity we have.

Human factors research has proposed (a) phasic and tonic activation, permanent attention, and vigilance as *characteristics of attention* and (b) tiredness, fatigue, and monotony as *disturbance of attention*.

8.1.1 Attention

Due to a moment of inattention, an intensive care physician injected a bolus of a wrong drug. He did not notice the mistake until the monitor alarm made him aware of a dangerously high blood pressure and heart rate. Although he was focusing his attention on the emergency situation, one part of his actions escaped his attention, namely, the injection of the drug. How then should we conceptualize "attention?" "Everyone knows what attention is," psychologist William James stated as early as 1890. "It is the taking possession by the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought. Focalization, concentration of consciousness are of its essence. It implies withdrawal from some things in order to deal effectively with other" (James 1890). Despite this early and understandable explanation, there is no clear agreement on definition to the present day (e.g., Eysenck and Keane 2000; Styles 2006). Instead, several metaphors are used to describe certain aspects of attention (Zimbardo and Gerrig 2007). The three most distinct metaphors are those of a spotlight, a filter, and a bottleneck.

8.1.1.1 Metaphors of Attention

The *spotlight* metaphor conceptualizes: *Not everything that is present in the situation is consciously perceived by humans*. We can only look at, listen to, and reflect upon that which is within the focus of attention. The "spotlight attention" is intimately connected with consciousness; however, information that is not within the focus of attention is not lost; it still can enter perception, be processed, and then become apparent as emotions. This happens in a cryptic form because emotions are flash-like, holistic summaries of situational assessments and do not explain themselves (Chap. 4).

The metaphor of a *filter* emphasizes the fact that *not everything that humans perceive enters consciousness* (Chap. 5). The most popular conceptualization of this theory is Broadbent's metaphor of a bottleneck (Broadbent 1958): Because

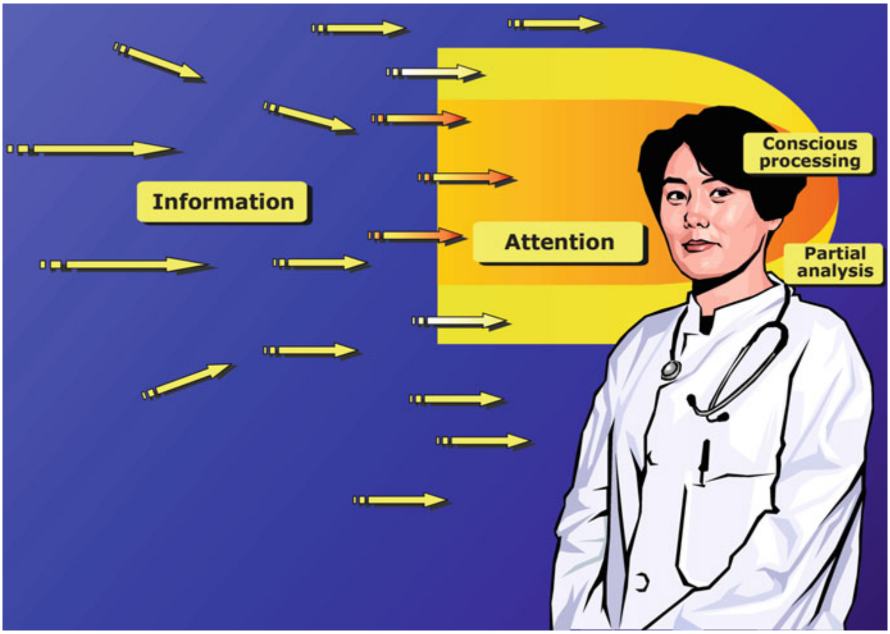

Fig. 8.1 Modified bottleneck metaphor of attention: As attention is a limited resource ("the bottleneck"), every piece of information has to be processed on a conscious level or it will be lost; however, some information, although not perceived consciously, will be partially analyzed

attention is a limited resource, every piece of information that is not consecutively processed on a conscious level, and hence passes through the *bottleneck*, is lost. A modified version of the bottleneck theory is empirically supported by neurophysiological findings: Although the conscious processing of information depends on attention, other sensory inputs, even if they are not consciously perceived, will be partially analyzed (Fig. 8.1). Partial analysis is accomplished through neuronal networks other than the cortex. A neuronal network connection can perceive unconsciously received data with respect to relevance and fit them into existing schemata (Ramachandran and Blakeslee 1999). If a perception is judged to be "relevant," an involuntary orientation toward the source of the sensory stimulus occurs (*orientation response*; Sokolov 1963). The monitor alarm caused by a violation of the blood pressure limit is such a source of a sensory stimulus that caused a reorientation of the resident's attention. For him, the sound of the alarm was a relevant perception that fit into an existing schema and directed him to turn his attention to data outside the focus of his immediate attention.

8.1.1.2 Physiology of Attention

The physiological correlate for attention is the activation of the central nervous system. According to the quality of activation, two basic forms of attention can be discerned: a *tonic* and a *phasic* arousal.

Tonic arousal describes the wakefulness of a person. This arousal is not accessible by conscious control. It is regulated by the circadian sleep-wake rhythm and impaired by sleep deprivation. The tonic arousal of the resident was low when the emergency occurred.

Phasic arousal describes the increase in central nervous system (CNS) activation that follows a stimulus (e.g., alarm) signaling imminent danger. The physiological consequence of phasic arousal is a sympathoadrenergic reaction with a concomitant increase in heart rate and blood pressure, dilated pupils, and increase in skin resistance. When the resident perceives danger for his patient via the BP alarm, his attention undergoes a phasic activation.

In contrast to attention being unconsciously focused by central nervous activation, other aspects of attention, namely, vigilance, selection, and sharing, can at least partly be controlled consciously.

8.1.2 Vigilance

Vigilance is the ability to remain alert and watchful for extended periods of time and to react appropriately to occasional stimuli. The first to conduct research into neurophysiological properties of vigilance was the famous neurologist, Sir Henry Head. He proposed at the beginning of the last century that vigilance is "the extent to which the activities of a particular portion of the central nervous system exhibit at any moment signs of integrative and purposive adaptation" (Head 1923). During World War II, the Royal Air Force recruited psychologist Norman Mackworth to study the efficiency of radar operators. Triggered by the field-generated experience that airborne radar and sonar operators on antisubmarine patrol missed weak signals on their displays particularly toward the end of a watch, Mackworth sought to determine by systematic study why and when this phenomenon occurred. He found that the accuracy of signal detections declined by about 15 % after only 30 min and then showed a more gradual decline over the remainder of the watch period. This quintessential finding of detection performance, described as vigilance decline over time, is also known as the *vigilance decrement* (Mackworth 1948; Mackworth 1970). His explanation, which was followed by most cognitive psychologists, was that vigilance decrement was caused by the mentally undemanding and understimulating nature of the tasks operators had to perform. From this traditional point of view, vigilance tasks were benign assignments that did not require much from the observer. However, more recent research has proven conventional wisdom to be wrong. Modern studies provide powerful converging evidence showing that vigilance assignments impose substantial demands on the information-processing resources of observers and are therefore associated with a considerable level of subjective workload and stress (Warm et al. 2008). The findings of high information-processing demand during vigilance tasks support the view that attention is the limiting resource and that the workload imposed by vigilance tasks drains our information-processing resources. Thus, instead of "being a bore," extended vigilance tasks actually impose a high cognitive demand.

Interest in vigilance has increased in high-risk enterprises because of the prevalence of automation. Technological advancements have shifted the roles of workers from active controllers to that of system supervisors who serve in a fail-safe capacity in which they need only react when problems arise. In some respect the task description of a "system supervisor" is true for many domains in acute medical care. Whereas the beginning of anesthesiology, to name one example, was characterized by a strong clinical interaction between patient and physician or nurse, this has changed during recent decades. Observation of monitors and vital sign displays has replaced the "hand on the pulse," and the number of displays, alarms, and waveforms on high-end monitors has risen from approximately four in 1970 to as many as 23 in 2000 (Beatty 2000).

Because many pathophysiological changes often develop over an extended period of time, patients tend to decompensate gradually. Thus, an early awareness of impending changes is of paramount importance. The vigilant observation of patient status and monitors is an important task for healthcare providers in acute and emergency healthcare settings. In light of this fact, and with an eye toward a little sense of humor, several anesthesia societies from around the world have accommodated by integrating *vigilance* into their society's maxim ("vigila et ventila"; stay vigilant and ventilate).

Performance decrements during lengthy vigilance tasks manifest as decreases in reaction time and a drop in visual or auditory alarm detection probability (Krueger 1994). During lengthy surgeries, vigilance decrements can become a problem for surgical residents who may have to perform monotonous tasks or for anesthesia providers who must continuously monitor patient vital signs, assess the possible impact of a variety of parameters and physical changes, and administer drugs. Vigilance is one of the key characteristics in the successful prevention of critical situations (Howard and Gaba 1997). Performance shaping factors that increase (e.g., stress) or reduce (e.g., fatigue) the level of activation will impair vigilance.

8.1.3 Concentration

Concentration is the long-term focus of attention on a specific, consciously selected segment of reality (Zimbardo and Gerrig 2007). Concentration depends on the ability to pay *selective attention* by which disturbing stimuli are blocked out and a conscious selection of relevant stimuli is made. To fully concentrate on one aspect of reality, the actual motive to concentrate and focus attention over long period has to be guarded from concurrent motives that strive for activation (Chap. 4). In addition, concentration demands that we increase the threshold for perceiving irrelevant stimuli that could distract us. Concentration requires both the inhibition of irrelevant stimuli *and* unwanted motives to continue maintaining a chosen focus.

8.1.4 Divided Attention

The term "divided attention" is used if someone has to accomplish two or more tasks at the same time (Eysenck and Keane 2000). Most people are unable to consciously process data in a parallel manner. They can only execute several tasks if only one of them demands conscious thinking and all the others can be processed automatically

(Schneider and Shiffrin 1977). The intensive care physician from the case study is no exception to this rule. His attention is focused on successful mask ventilation and the preparation for reintubating the patient. The bolus application of the assumed analgosedative drug, however, is done automatically without looking closely at the infusion pump. If a task such as the bolus application is executed automatically, then attention will only turn toward the automatism at certain "control points" to check the correct execution. For the remaining time, the physician's attention is focused on mask ventilation and the planned intubation. These tasks demand conscious thinking. However, because the intensive care physician is tired, these tasks demand more of his attention than usual. As a consequence, he misses "control points" of the drug administration and depends on the automatism of manipulating the pump to be executed without a sufficient amount of conscious control.

Dealing with several tasks simultaneously without a loss in efficiency is more likely possible if different sensory modalities are involved. The physician can more easily give orders and at the same time listen to the signal of the pulse oximeter. Analytic thinking, in contrast, requires his full concentration and therefore shielding of his attention from all other tasks.

The necessity to divide attention between multiple concurrent tasks is not only an inherent characteristic for certain medical emergencies but is also characteristic of the task environment of acute medical care provision as a whole. The skill of trying to divide attention is made even more difficult because healthcare professionals are often "interrupt driven" (Antoniadis et al. 2014) in their task performance and have to manage many "break-in tasks" (Chisholm et al. 2000). Attentional control mechanisms and divided attention are also relevant if previously formed intentions are executed during an appropriate but delayed "window of opportunity" (*prospective memory*; Harrison et al. 2014; West et al. 2011; Smith 2003 Chapter 4). Prospective memory cues are detected via monitoring processes, in which people expend attentional resources either by keeping the intention activated while performing ongoing activity or by searching the environment for the prospective memory cue. Such cues can be:

- *Time based* (e.g., "at 1:00 p.m. I have a meeting with the executive director")
- *Event based* (e.g., "the next time I meet my colleague, I will ask him whether he got the broken stretcher repaired")
- *Action based* (e.g., "as soon as I'm finished dictating the medical report, I will have another look at the newly admitted patient in room 014")

A transformation of time-based cues into event-based cues (e.g., by setting an alarm on one's mobile phone) helps to make the prospective memory more independent of limited attentional capacity.

8.1.5 Attentional Capacity: A "Bucket Theory"

The necessity of dividing attention between different tasks is always there in healthcare. So, could we do some training to enlarge our attentional capacity? Research done with pilots (Wickens 1984) in order to design effective aircraft cockpits shows that we are dealing with a certain amount of attention that a human has and can share between different tasks. This view of attentional capacity propounds a “bucket theory of attention” because every person has a certain amount of attentional capacity. It cannot be enlarged at will, but it can be managed differently.

There are different theoretical approaches to attentional capacity in psychology. Most authors think of attention as a central bank of resources that is available for all tasks requiring mental effort. A competing model is that of multiple specialized resources, specific to a modality (e.g., seeing, hearing). Both models, however, agree that the overall capacity of attention is limited.

This view has a lot to do with performance in teams and explains why it is important for a person managing a medical incident (e.g., code leader) to keep her hands off the patient, to not “do” anything but just “think.” That way the precious resource of “attentional capacity” is being used for an important role. Clinicians often have been so overtrained to perform certain tasks; they often think these tasks do not require much of their attention. But this is incorrect. For example, we might find an anesthesiologist squeezing a bag valve mask while trying to run a code. Even though the anesthesiologist may not be aware that squeezing the bag is taking away from his attention, some amount of attentional capacity is being used. The better alternative would be to step back, think, and spend 100 % of the attentional capacity on running the event.

8.2 Open for News: Background Control and the Horizon of Expectations

An essential precondition for many tasks in acute and emergency healthcare is the ability to completely focus on the actual intention. Because certain tasks require great precision and skill, the current activity may require most of our attention. However, concentration on one task should never become absolute; otherwise, it could become impossible to detect opportunities for other good intentions or imminent complications and dangers. Background control is the mechanism by which our cognitive system tries to avoid this pitfall (Dörner 1999). The term, *background control*, describes the phenomenon wherein people tend to scan their environment on a regular basis for relevant and new clues. This is done by allowing attention to take a broad view of the situation and then having it return to its primary task.

Background control happens without conscious planning. If a task is very important or when the stress level rises, background control is reduced or completely abolished. Background control is also influenced by the feeling of competence. If someone feels incompetent, they may either start to control their environment less to prevent threatening events from being discovered (called “encapsulating”), or they may start to scan quite frequently, which appears to be volatile, inconsistent, and unfocused behavior.

The extent to which people attend to background control depends on the safety of the environment, the difficulty of the current task, and one’s expectations about the progress of events (“horizon of expectations”; Fig. 8.2). The horizon of expectations is a prognosis about the expected; it extrapolates present circumstances to predict the future. In the case study, the physician’s horizon of expectations

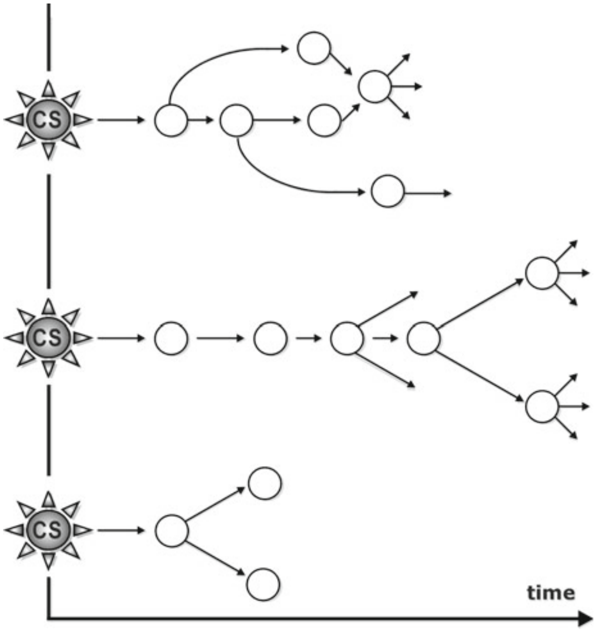

Fig. 8.2 Horizon of expectations (After Dörner 1999). Every critical situation (*CS*) is extrapolated into the future. *Circles* represent events and the arrows alternative actions or developments. The further away from the present an event is, the more options are thinkable and expectations become increasingly imprecise

consisted of continuing the unproblematic preparation for reintubation. The moment the horizon of expectations broke (because of the increase in the patient's heart rate and arterial blood pressure alarm), he was surprised and possibly even frightened. Attention was immediately focused toward the infusion pumps (orientation response), and then he reflected on the situation: What happened? Why are things not going as expected?

The horizon of expectations is a necessary component for the regulation of attention. Expected events take less of our attentional capacity. Occasional attention controls are enough to refresh and verify the situational picture. Events, however, that cannot be predicted with certainty have to be tracked more closely. The greater the uncertainty about expectations concerning the future (uncertain horizon of expectations), the more often people have to control and attend to the background.

8.3 Situation Awareness

Human factors research has shown the importance of situation awareness (SA) as a central factor for error reduction within complex technical systems. Situation awareness is usually defined as "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and a projection of their status in the near future" (Endsley 1995; Fig. 8.3). "Knowing what is going on so you can figure out what to do" is a catchy summary for situation awareness (Adam 1993). Situation awareness is especially important in work domains where a

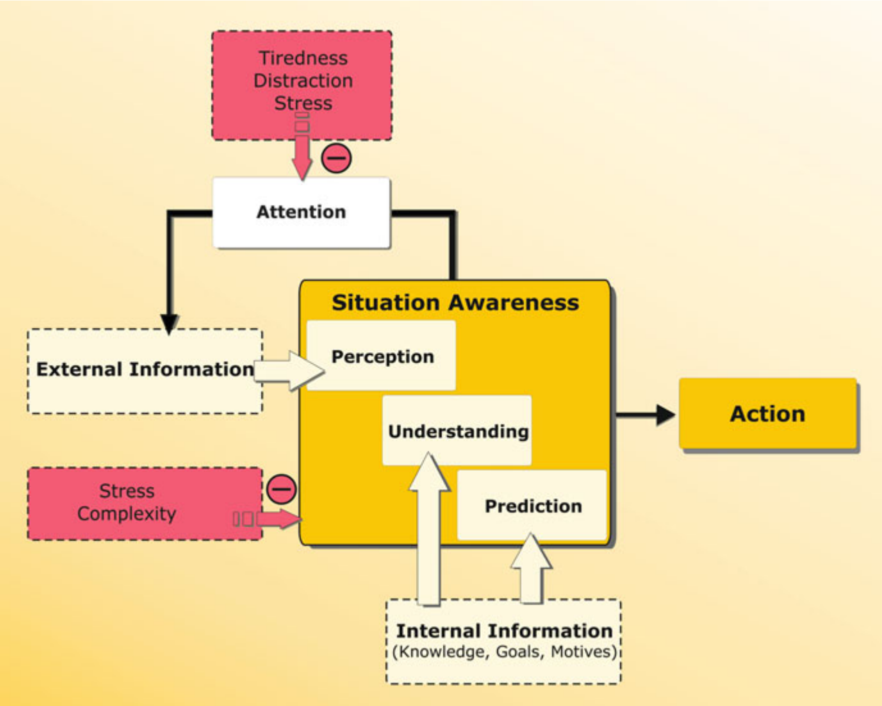

Fig. 8.3 Situation awareness involves being aware of what is happening in the vicinity, comprehending the relevance of aspects within the current situation, and predicting the future status of the situation. Tiredness, distraction, stress, and complexity of the situation impair the formation of adequate situation awareness

highly dynamic environment generates high information flow and poor decisions can lead to serious consequences.

One result of research into situation awareness is that people have to be oriented to the entirety of their environment to be able to control it (Endsley 1995, 2000, 2004; Carskadon-Banbury and Tremblay 2004; Stanton 2010). A crucial prerequisite for good situation awareness is metacognition, the concept that individuals are able to reflect on their own thought processes, to stand apart, and to "think about their thinking." Metacognition builds situation awareness by allowing the healthcare provider to ask the following questions (e.g., Endsley 1995):

- What is the big picture? What is happening and which items determine the present situation?
- What do the current actual events signify?
- In which directions could the situation evolve?

To develop and maintain situation awareness, people first have to construct an image of the current situation by detecting objects, parameters, and events that might be relevant for this situation. To update and maintain a high degree of situation awareness, two processes have to be in operation:

- The situational image has to be updated regularly. This is done by the above-described process of background control. For the buildup of situation awareness, this control has to be done consciously by allocating some of our attention to updating.
- The perceived elements have to be assessed with respect to their relevance. A good assessment demands clarity about the goals of the particular situation because relevance can only be determined in reference to goals.

The ability of clinicians to gain situation awareness can be enhanced by the design of a work space and by the way necessary information is presented. If the cognitive system of the user and behavioral processes are taken into account, such as intelligent design for monitors, alarms, and integration of graphic displays, design factors can support and enhance situation awareness (e.g., Drews and Westenskow 2006; Edworthy and Hellier 2006; Michels et al. 1997).

Situation awareness, like other attentional processes, is susceptible to distraction, disruption, tiredness, high workload, and stress. Stress in particular seems to have a strong negative impact on perception and comprehension of the elements in the environment and on the prediction of future status (Sneddon et al. 2013). Moreover, the complexity of a situation and task renders the formation of adequate situation awareness difficult.

Just as individuals have situation awareness, members of a team will possess situation awareness required for their respective responsibilities as well as information requirements relevant to all team members. Research refers to situation awareness in team operations as "shared situation awareness" or "team situation awareness." One of the main tasks in team formation and function is the creation of such shared situational awareness, of a shared mental model of the situation. Developing shared mental models for a problem creates a context for making decisions that uses the cognitive resources of the entire team (Stout et al. 1997; Vidal and Roberts 2014). Such shared knowledge enables each person to carry out his or her role in a timely and coordinated fashion, helping the team to function as a single unit with little negotiation of what to do and when to do it (Sorensen and Stanton 2013; Chap. 11). On the other hand, a lack of shared knowledge correlates with team errors (overview in Schmutz and Manser 2013).

8.4 Disturbances of Attention

Conscious control of actions can be impaired by many factors. Some disorders, somatic as well as psychiatric (e.g., depression, schizophrenia), change the regulation of attention. Furthermore, some people habitually show an insufficient regulation of attention (*cognitive failure;* Broadbent et al. 1982). These disturbances appear to be relatively stable personality traits and are not covered in this chapter. In the context of this chapter acute alterations in attention due to tiredness, fatigue, monotony, and "encapsulation" are examined. These impairments are common problems in caring for patients in the acute care environment, decrease general performance, and may cause mistakes.

8.4.1 Can I Stay in the Game?: Fatigue

The term *fatigue* describes the diminished ability to perform both cognitive and physical tasks that require mental or muscular work. Fatigue is a protective physiological function signaling that the margin of effective performance has been reached. Fatigue appears as a reversible reduction in the physical and mental performance and is accompanied by feelings of physical exhaustion (muscular fatigue) and by the subjective feeling of tiredness (mental fatigue). In contrast to monotony, the effects of fatigue can only be compensated for by rest, not by a change in activity. Fatigue has various effects on physiological outcomes and on mental and behavioral performance (Zimbardo and Gerrig 2007; Dinges 1995; Rosekind 1995), among others:

- Alertness, attention, and vigilance are reduced. People are able to sustain concentration on a task for a shorter than usual period of time.
- Reduced motor performance (fine motor skills and eye-hand coordination) and a decreased effectiveness of motor tasks (speed and accuracy are reduced).
- Slowed reaction time and decision-making. In order to reduce effort, rule-based decisions are preferred over knowledge-based decision-making (principle of economy; Chap. 6).
- Impaired memory function manifested as a reduced ability to learn and to recall items.
- Motivational alteration of the thinking process: People become careless in the formation of opinion, increasingly tolerant of their own mistakes, and prone to hasty decisions.
- Change in social behavior with disrupted communications, uncontrolled affects, and a reduced inclination to share information with team members.
- Alterations in visual perception ranging from changes in the sensitivity threshold to perceptual anomalies (e.g., illusions, hallucinations) in the case of prolonged severe sleep deprivation. In addition, the degree of resolution of perception can decrease, which may lead to important details being missed.
- Somatic symptoms emerge and appear as an increase in heart rate, shallow breathing, a reduction in muscle tone, and an increase in oxygen consumption. These symptoms emerge even if the level of physical work remains stable.

Fatigue and its recovery follow exponential curves, albeit reciprocally: The decrement in psychomotor performance begins slowly and becomes more manifest the longer a mental or physical strain is sustained. In contrast, the recreational effect of a break is strongest in the first minutes of the break. Then the rate of recovery decreases. Therefore, many short breaks are more effective than a single long one.

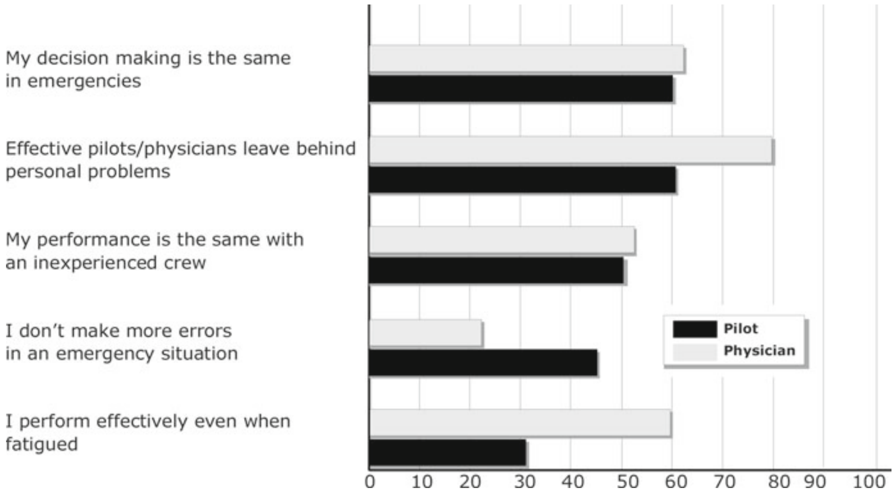

Fig. 8.4 Percentage of physicians and pilots who had an unrealistic attitude toward their performance limits. Two of three physicians denied any detrimental effect of fatigue on their performance (From Helmreich and Merritt 1998)

There is a significant discrepancy between subjective reports of fatigue and alertness and objective measures of physiological status (Howard et al. 2002). The feeling of tiredness is perceived much later than the actual decline in the physical performance or mental capability. Physicians seem to be especially prone to this kind of misjudgment. In contrast to other professional groups (e.g., pilots, nurses), physicians often believe that they can perform flawlessly even when fatigued (Fig. 8.4; Flin et al. 2003; Helmreich and Merritt 1998).

Because the feeling of tiredness is an unreliable indicator of actual fatigue, people often react to this feeling only when their performance has already decreased. This is one of the reasons why breaks are often taken too late. Recovery then takes more time than when breaks are taken early and regularly. With respect to patient safety, it is important to obtain ample and timely breaks.

8.4.2 I'd Rather Be in Bed: Sleepiness and Sleep

Fatigue demands rest. It is caused by physical and cognitive work or by prolonged stressful situations. Sleepiness is caused by the need to sleep and prompts people to go to bed and thus to recover. In sleep medicine, however, the terms *fatigue* and *sleepiness* are often used interchangeably. More precisely, fatigue is referred to as "on-the-job sleepiness" or "daytime sleepiness" (Caldwell et al. 2008; Monk 1991). Sleepiness, in the strict sense, is part of the natural sleep-wake cycle that is synchronized to a circadian rhythm of approximately 24 h. This circadian rhythm's timekeeper is located in the suprachiasmatic nucleus

(SCN) of the human brain. The rhythm is biphasic with a state of increased sleep tendency at night and during early afternoon (circadian lulls) and periods of maximal wakefulness during late morning and late evening. Light is the major factor that ties this rhythm to activity during the day and sleep at night. Additionally, various physiologic variables and hormones either rise or fall at various times throughout the 24-h period.

Sleep deprivation occurs when an individual does not obtain the quantity of sleep needed to restore their central nervous system to a fully rested state. Sleep deprivation can occur on a long- or short-term basis. Chronically reduced sleep (e.g., restricted to less than 5 h per day) creates a cumulative "sleep debt" that will impair physiological and cognitive performance within a week (Dinges et al. 1997). The concept of sleep debt has been crucial for countering the notion that healthcare professionals can accommodate to less sleep through constant sleep deprivation in conjunction with adequate motivation and professionalism (e.g., by expecting novices to work 36 h every other day with only one night in between; Caldwell et al. 2008). Tiredness is nature's toll, unswayable by pride or professionalism. With increasing age, the need for sleep does not decrease; on the contrary, the amount of slow-wave sleep phases decreases, the probability for nocturnal awakening rises, and sleep becomes less restorative.

Impact of Sleep Debt

Sleep debt manifests well before a week of disrupted sleep. One single night of sleep deprivation is sufficient to impair performance comparable to the effect of ethanol ingestion. One night's loss of sleep can cause performance-impairing and memory decrement effects that are equally potent to alcohol and significantly more potent in its sedative effect. Two hours of sleep loss has an equivalent sedative effect to the ingestion of three 12-oz (360 ml) servings of beer. A sleep loss of 8 h corresponds to the effect of consuming ten 12-oz beers (Roehrs et al. 2003). In a study, following 17 h of wakefulness, the performance on psychomotor tests was comparable to the effect of a blood alcohol concentration of 0.5‰. After 24 h of sustained wakefulness, psychomotor ability further decreases to performance comparable to that of a person with a blood alcohol concentration of 1.0‰ (Dawson and Reid 1997; see also Arnedt et al. 2005; Ware et al. 2006; Van Dongen et al. 2003). Moreover, sleep-deprived house staff has a higher risk of sleep-related driving accidents when driving home after a night shift. This finding led to the recommendation that management should provide "post-call" sleeping facilities for all personal working night shifts (AAGBI 2013).

Despite the general effect of sleep deprivation on performance, some individuals are more fatigue resistant than others. There seems to be a relationship with their chronotype (or "circadian type," "diurnal preference"). People who prefer to be active early in the day ("morningness") are often more affected by sleep deprivation than people who are most alert in the late evening hours ("eveningness"). Thus, personal characteristics of being "larks" or "owls" seem to affect psychomotor performance in the work environment (Caldwell et al. 2008).

Night Shift

On-the-job sleepiness is a constant threat to safe performance in healthcare because many healthcare professionals work nonstandard schedules and consistently fail to obtain sufficient sleep. Recently, 70 % of residents working in the ICU demonstrated a severe degree of sleepiness despite reductions in work hours (Reddy et al. 2009). Individuals are at increased risk for on-the-job sleepiness if they:

- Have to work long hours in a given shift
- Have to work long shifts for several consecutive days
- Have unpredictable or irregular shift schedules
- Did not obtain sufficient sleep immediately prior to the work shift
- Suffer from cumulative sleep debt

Several studies have shown that working the night shift increases the likelihood of accidents with every consecutive night (Knauth 1995; Spencer et al. 2006). Night services and on-call duties make clinicians susceptible to error (Landrigan et al. 2004; see Howard et al. 2002; Samkoff and Jacques 1991 for overview). Research on the performance of surgeons (Taffinder et al. 1998; Grantcharov et al. 2001), anesthesiologists (Howard et al. 2002), and residents (Barger et al. 2006) following sleep deprivation corroborated the notion that the incidence of errors increases as a function of sleepiness. Although there is no clear correlation between sleepiness and direct harm to patients, surveys support this notion. For instance, in an interview study with anesthesiologists, more than half of the group was able to remember one or more clinical errors they had committed as a direct result of extreme sleepiness (Gaba et al. 1994; Gravenstein et al. 1990). Similar results have been reported from other clinical areas (Baldwin and Daugherty 2004).

In recent years, attempts have been made to mitigate the adverse effects of shift work on the circadian rhythm by designing ergonomic shift systems (overview in: Flin et al. 2008; Nelson 2007). Elements of such worker-friendly shifts are:

- Forward shift rotation: Scheduling shifts on consecutive days so that they advance forward through a 24-h day is preferable (e.g., first shift in the morning, second in the afternoon, third as night shift).
- Shift changeover: Providing 24 h of coverage using shifts of 10-, 8-, and 6-h duration is more sleep-friendly than scheduling three 8-h work periods.
- Scheduling on-call duties no more frequently than one in every five nights.
- Napping for short periods: Naps during nighttime hours can minimize changes in circadian rhythms (Smith-Coggins et al. 2006). Given the difficulty of introducing naps in most clinicians' night shifts (e.g., emergency department), it would mandate at least double clinician coverage to increase napping opportunities.

One problem with sleep deprivation seems to be that subjects can be physiologically sleepy, even near pathological levels, without being aware of their progressively impaired alertness and increasing cognitive deficits. In an experimental setup, every second subject believed that they had stayed awake during the entire study period while EEG/EOG measurements showed they had fallen asleep (Howard et al. 1995). Besides having a major impact on the ability to perform adequately, sleepiness also interferes with personal lives during training programs (e.g., residency programs), leaving many personal and social activities and meaningful personal pleasures deferred (Papp et al. 2004).

Another source of errors during nighttime is *sleep inertia*. Sleep inertia describes the fact that an abrupt awakening from deep sleep (e.g., when a pager beeps) is characterized by a decline in motor performance and a subjective feeling of grogginess. Reaction time performance is directly related to sleep stage at awakening, e.g., persons awakened during the deepest sleep have the slowest reaction times. Furthermore sleep inertia has a strong motivational impact as it urges people to return to sleeping. Although the effects of endogenous epinephrine in an emergency can partially counter sleep inertia, recovery to full orientation can take up to 20 precious minutes. Until then healthcare providers give less than optimal care during crisis management. Sleep inertia studies show there is no easy solution to the problem of waking up “impaired.” Both working through the night and sleeping when being on call can lead to errors.

Disruptive circadian rhythm is the cost individuals have to pay for shift work and on-call duty. For this reason, many healthcare professionals try to treat their lack of synchronization by using alertness-enhancing or sleep-promoting substances. Caffeine is the most common alertness-enhancing drug. Caffeine increases vigilance and improves performance in sleep-deprived individuals, especially if they normally do not consume high doses of caffeine. It has no serious side effects but can interfere with daytime recovery sleep if it is taken toward the end of the night shift. Modafinil has been shown to significantly attenuate fatigue-related performance decrements throughout 40 h of continuous wakefulness. It has low abuse potential but its long duration makes it difficult to synchronize its effect with the 24-h circadian rhythm. Amphetamines (e.g., dextroamphetamine) have the greatest potential for abuse and should therefore not be used by healthcare providers to treat fatigue resulting from sleep deprivation. In a recent nationwide survey, 6 % of anesthesia residents admitted to taking “something other than caffeine” to stay awake while on call (Hanlon et al. 2009).

One might expect that the lack of rest incurred by working night shifts would facilitate daytime sleep. But because the circadian rhythm is disrupted, many people have trouble sleeping when their natural circadian rhythm tells them it is time to be awake. Thus, clinicians often use substances to assist obtaining much needed sleep. Among the most commonly used substances promoting sleep are melatonin, an endogenous hormone that varies in a 24-h cycle and signals “biological night,” and zolpidem, a nonbenzodiazepine hypnotic. Older sleep medications (e.g., benzodiazepines) should be avoided because they carry a high potential for abuse. The use of pharmacological sleep aids by clinicians is widespread. For example, 20–30 % of emergency physicians reported regular use of sleep-facilitating substances (e.g., alcohol, antihistamines, sleep adjuncts, and benzodiazepines) to help them sleep around a night shift (Bailey and Alexandrov 2005; Handel et al. 2006).

To solve these problems associated with sleep deprivation and performance decrements, it is likely that healthcare professionals, especially the ones who must make high-stakes decisions under time-limited conditions, will need to assert their right to lead healthy lives themselves. The long-term cumulative effects of sleep deprivation hastens the onset of professional burnout and limits the number of years that highly trained individuals can practice their craft (Nelson 2007).

8.4.3 Much Ado About Nothing: "Alarm Fatigue"

Acute patient care is unthinkable without patient monitoring systems used to continuously monitor vital signs and to quickly detect critical and life-threatening conditions. Although modern alarm systems fulfill this requirement, problems in their real-world clinical application diminish their usability: Artifacts of moving patients (e.g., ambulance vehicle, intensive care) and surgical manipulation (e.g., electrocautery) as well as too narrowly set alarm thresholds create a high percentage of clinically irrelevant alarms. Studies have indicated that the presence of false-positive alarms ranges from 80 to 99 % (overview in Borowski et al. 2011). The high number of false-positive device alarms leads to a desensitization of caregivers, which results in inadequate or even complete lack of responses to alarms. The problem of excessive alarms resulting in alarm fatigue is sometimes called "cry wolf effect" (Bretznitz 1984; Schmid et al. 2011). The dimension of the problem may be illustrated by the fact that within a 4-year period the US Food and Drug Administration (FDA) Manufacturer and User Facility Device Experience database (MAUDE) received 566 reports of patient deaths that were related to disabled, silenced, or ignored device alarms (FDA 2011). Strictly speaking, alarm fatigue is not caused by disturbance of attention but results from motivational protection of attention. Whenever something repeatedly demands attention and proves to be false, it will lose its importance. Once audible alarm sounds lose their relevance, the horizon of expectations changes: An orientation reaction toward the alarm source does not take place, and caregivers continue to pursue their current task. Ergonomics and human factors engineering has identified several ways of improving currently used alarm systems (Borowski et al. 2011):

- "Softer" alarm melodies instead of single piercing alarms
- Vibrotactile alarms allowing silent notification of a responsible provider
- Networking of alarm devices
- Algorithms that reduce the number of false alarms (e.g., alarm delays, online signal extraction, etc.)
- Intelligent alarm systems (e.g., context-aware alarms, alarms based on root cause analysis, diagnostic alarms)
- Improvement in the knowledge of healthcare providers regarding the function of the alarm system (e.g., user-friendly manuals, self-explanatory systems, and adequate training)

8.4.4 Nothing to Do: Monotony

Monotony is a state of reduced mental and physical activity (Ulich 2001). This condition arises when people are in an environment with few relevant stimuli and have to frequently repeat uniform tasks that demand their attention. These tasks cannot be automated, but they do not demand hard thinking either. In contrast to fatigue (which demands recovery), monotony disappears as soon as the task is altered: "seconds of terror" dispel "hours of boredom." Monotony is best addressed by a change in tasks. Listening to music or undertaking physical exercise can mitigate monotony. Monotony is not usually a big problem in the context of acute and emergency healthcare. Tasks such as monitoring and surveillance may be boring, but they do not create monotony; instead, they demand vigilance.

8.4.5 Tightly Focused: Too Much Concentration and Missing Background Control

Up to now we have described how too little arousal impairs attention. But the contrary can be true as well: Excessive concentration on a task can interfere with an appropriate distribution of attention. If people are too preoccupied with a task, then the occasional scanning of the environment for relevant information (background control) will be significantly reduced. We then are no longer open for other relevant clues and are less likely to notice when another problem emerges that may become important. This is like wearing blinders (Chap. 9 on the influence of stress).

8.5 Tips for Clinical Practice

- Take the effects of fatigue seriously. The feeling of wakefulness can be deceptive. Do not wait until you feel tired before getting some rest. Take scheduled breaks.
- If you are unable to work safely, you should take measures to rest or go home.
- If you work in a team, you can avoid fatigue by relieving each other from time to time.
- Before you appoint a task to someone, make sure that the person is paying attention.
- Ensure that important actions can be performed without interruption.

8.6 "Attention" in a Nutshell

- Attention is the conscious focus of perception and thinking on an object.
- When attention is being focused, information can enter consciousness via a second, indirect way: the preconscious processing and test for relevance that is experienced as emotion.
- Relevant stimuli lead to an automatic orientation of attention.

- Vigilance is the ability to maintain attention for extended periods of time and to react to rare and accidentally occurring stimuli.
- Concentration is the extended focus of attention on a specific, consciously selected segment of reality. Concentration includes selective attention, guarding from concurrent motives, and an increase in the perception threshold.
- The "horizon of expectations" is a (subconscious) forecast about the expected; it is an extrapolation of the present into the future.
- Situation awareness is the ability to perceive and assess a situation and anticipate its future development: "Knowing what is going on so you can figure out what to do and what will likely happen when you do it."
- Situation awareness, like other attentional processes, is susceptible to distraction, disruption, tiredness, high workload, and stress.
- Fatigue is a reversible reduction in performance. Its effect can only be remedied by rest, not by a change in activity.
- Fatigue is a protective physiological response that cannot be overcome by motivation, training, or willpower.
- Tiredness is caused by the need to sleep and is a natural function of our circadian rhythm.
- Tiredness is a physiological process. It is nature's toll, unswayable by pride or professionalism.
- Feeling fatigued does not exactly correlate with the actual physiological impairment of fatigue, i.e., people often subjectively experience fatigue after fatigue has already set in and performance has already decreased.
- People cannot reliably self-judge their level of fatigue-related impairment.
- Sleep deprivation occurs when an individual does not obtain the quantity of sleep needed to restore their central nervous system activity to a fully rested state.
- After 24 h of continuous wakefulness, the psychomotor ability of a subject decreases to a performance comparable to that of a person with a blood alcohol concentration of 1 %.
- Physicians are prone to misjudgment about their achievement potential. They often believe themselves to be unimpaired even when fatigued.
- Monotony is a state of reduced mental and physical activity.
- There are wide individual differences in fatigue susceptibility.
- There is no one-size-fits-all "magic bullet" (other than adequate sleep) that can counter the effects of inadequate sleep for every person in every situation.
- There are valid counter-fatigue and sleep strategies that will enhance safety and productivity when correctly applied.

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