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# From Absence to Presence: Blurred Consciousness and Sleep States

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## Abstract

*The ability to be aware of and interact with the external environment is a basic evolutionary requirement of all organisms. Technology's impact on human cognitive functioning has significantly impacted this capacity, suggesting a need to rethink presence. This paper describes conceptualizations related to the consciousness of presence from a sleep-wake research perspective.*

**Keywords---** Absence, Presence, Sleep, Alertness, Performance, Microsleep

## 1. Introduction

Alertness, task- readiness, immersion and presence are various terms used in the medical and human factors literature to describe human interaction with both real and simulated environments. The ability to be aware of and interact with the external environment is a basic evolutionary requirement of all organisms. Technology's impact on human cognitive functioning has significantly impacted this capacity, suggesting a need to rethink presence. This paper describes conceptualizations related to the consciousness of presence from a sleep-wake research perspective.

In an increasingly interconnected global economy where workload and productivity have shifted towards cognitive as opposed to physical labour, research is now focusing more than ever on the impact of sleepiness and fatigue during desired wake time, and insomnia during desired sleep time. Similarly, scholastic/academic motivation and performance deficits are being noted in children and adolescents, in part due to the increased 24/7 availability of technology and entertainment options, usually at the expense of sufficient sleep. To underscore this trend, during the past year, the first ever World Sleep Day was organized by the World Association of Sleep Medicine with the theme "Sleep well, live fully awake".

Aside from any philosophical considerations about the role of sleep states in presence, it should be noted that breaks in presence due to sleep-related causes are of significant real-world relevance. Today more than ever, fatigue and sleepiness contribute to human error, diminished workplace productivity and accidents in technology- heavy, industrialized societies in terms of human, environmental, and economic impacts [1, 2, 3]. With the widespread use of automation, this trend of blurred

division of wakefulness and sleep will continue to escalate in the future, particularly as more people conduct vigilance-based activities, including transportation safety, at times other than traditional daytime work hours [4]. Inquests into serious incidents such as Chernobyl, the grounding of the Exxon Valdez, and the Challenger Disaster have all placed at least partial blame on deficits in alertness due to sleep-related factors [3, 5, 6]. Motor vehicle accidents (MVAs) due to impaired vigilance are a major preventable cause of morbidity and mortality in North America [7, 8, 9], with recent research suggesting that sleep-related neurocognitive dysfunction can be as impairing as alcohol intoxication [7, 8, 9, 10]. Thus there is a clear relevance to understanding neural correlates underlying fatigue- and sleep-related performance changes, both in an assessment and treatment paradigm. At this time no well-established, reliable screening instruments exist to assist in the decision-making process of assessing driving and workplace safety. Development of such tests would therefore be relevant from a public health perspective.

## 2. Current Concepts in Sleep Consciousness

Sleep research can be conceptualized as measuring presence in terms of changes in neurophysiologic function in combination with changes in subjective level consciousness and motor function. Polysomnography (PSG) has been used to study psychophysiological aspects of changes in conscious states, describing three states of consciousness: wakefulness, non-REM sleep and REM sleep [11]. PSG consists of continuous and simultaneous recording of the following core parameters:

- electroencephalogram (EEG) recording of brain activity;
- electro-oculogram (EOG) recording of eye movements;
- electromyogram (EMG) recording of muscle activity.

Through use of PSG recording techniques sleep researchers have been able to define three distinct and separate continually shifting states of consciousness that sleeping humans experience (Figure 1):

1. waking consciousness, characterized by a high frequency, low-amplitude EEG activity and normal muscle tone.
2. nonREM (NREM) sleep, divided into four stages and characterized by a progressive slowing of EEG frequencies and increase in amplitude, relaxed EMG muscle tone and slow rolling to absent eye movements.

3. REM or “paradoxical” sleep, characterized

by a mixed-frequency low-amplitude EEG pattern akin to stage I sleep (which is often thought of as the transition between relaxed wakefulness and sleep proper), rapid eye movements and atonia (an absence of neuromuscular activity).

REM sleep, it is worth noting, is distinguished from NREM sleep through its relatively active EEG pattern, despite a high arousal threshold characteristic of sleep (hence the term “paradoxical sleep”) and from a wakeful state by the presence of muscle atonia which prevents the activation of motor response systems in the face of cortical activation (a useful evolutionary adaptation that prevents us from physically acting out our dreams). In this sense, vivid dreaming experienced during REM sleep can be classified as perhaps the most archetypal of organic and self-generated virtual environments.

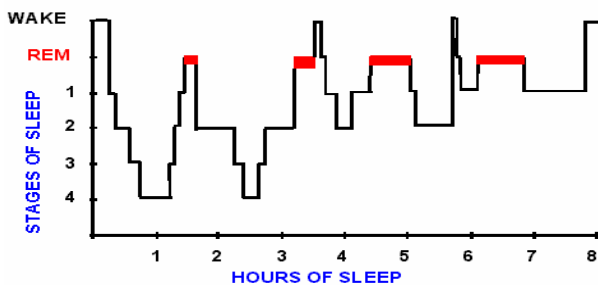


Figure 1 Hypnogram in a healthy individual, showing the dynamic nature of sleep stages, with dream-rich REM episodes (indicated by thick bars) recurring between non-REM sleep periods of varying depth at regular intervals

While these states were previously thought to be relatively distinct from one another, it is now believed that dynamic oscillations between consciousness states can occur. For example, an individual may lapse from waking consciousness into temporary microsleep episodes (non-REM sleep), or REM sleep in the case of narcolepsy. Increasingly immersive simulated environments make it tempting to suggest that virtual reality might be acknowledged as a fourth “synthetic” state of consciousness that will increasingly compete with “organic” states of consciousness (Figure 2). In this scenario, mental attention directed at media-based immersive human-computer interactions (HCI) shifts to and from cognitive resources directed towards non-mediated human–environment interactions. This trend has yet to be extensively studied by sleep researchers, although there is increasing recognition in the medical literature that extensive use of computer-based tasks may adversely affect sleep health [12, 13]. If sleep is conceptualized as an “offline” continuation of information-processing of daytime events and perceptions, the continuum with “online” and other artificially mediated experiences deserves consideration.

In HCI tasks, there is a spectrum of immersion ranging from *presence* (completely engaged) to *absence* (completely disengaged) [14]. It has been proposed that there

may well be an electrophysiological correlate of absence, as defined by intrusions of sleep consciousness while engaged in a task. Thus the term *absence*, historically used by neurologists to define characteristic sleeplike EEG activity in certain types of nonmotor seizures, could also be applied to the study of presence in the context of HCI, even when lacking characteristics of frank epileptiform activity [15], if resulting in the subjective experience of “disconnect” from the environment. As an individual is decreasingly engaged in a perceptual experience, he or she will retreat into a state of absence that is both a psychological/ perceptual experience and a neurophysiologic state. Rather than expecting a continuous experience, both in terms of perceptual and motor output flow, factors such as circadian fluctuations, fatigue and actual intrusion of sleep into waking consciousness are relevant to be aware of in assessments and treatments using virtual-environment or immersive simulation-based tasks.

	Sensory Experience	External Sensory Input	Motor output neuromuscular	
Awake	+	+	+	Organic
Non-REM	-	-	-	Organic
REM	+	-	-	Organic
VR*	+	+	+	Synthetic

Figure 2 Conceptualizing presence in virtual reality as a “synthetic” state of consciousness

3. Clinical Relevance of Presence Research

Currently, there is a convergence of research conceptualizations in the domains of sleep and attention, and this may in part relate to the 24-7 phenomena described in the introduction. For example, insomnia is seen as a 24-hour phenomenon in which there is nocturnal frontocortical hyperactivity, and consequent daytime frontocortical hypoactivity, resulting in fatigue and poor performance on daytime tasks [16]. Analogously, a relatively novel insight into attention deficit disorder (ADD) has been that sleep disturbances due to brief arousals from sleep (which may occur due to respiratory or movement events, but most commonly occur spontaneously) cause fragmentation of sleep during the night, resulting in reduced daytime alertness, and symptoms of ADD [17].

Multimodal studies including simulator performance and neurophysiologic monitoring provide two streams of data

regarding presence on an immersive task. Research in my laboratory has focused on measurement of episodes of “microsleep” episodes during driving simulation in healthy subjects as well as subjects with sleep deprivation, clinical sleep disorders, and recovering from anaesthesia [18]. This has allowed a methodology to demonstrate intrusions of sleep consciousness into wakefulness, which is relevant to transportation safety. A specific safety consequence of lapses of attention or microsleep can be the potential occurrence of operator impairment, causing transport safety risks. Results of the series of studies were recently summarized in *Cyberpsychology and Behavior* [14].

## Summary/Conclusions

In assessing presence, “what is not there” can be as important as “what is there”. As the use of simulation assessment and treatment protocols continues to be developed, care must be taken to consider the underlying factors that could play a role in limiting immersion and engagement. The role of the spectrum of absence to presence has been chiefly discussed from a sleep medicine perspective. This paper has attempted to briefly highlight the question of what neurocognitive processes driven by sleep states might explain performance impairment in a driving simulation paradigm, although this phenomenon could also be used in other types of simulations, particularly ones involving situation awareness and continuous task monitoring. Phenomena including circadian variation in alertness and sleepiness, microsleep episodes, and task fatigue/disengagement are all relevant factors in the multifaceted spectrum of absence to presence. The use of multimodal assessments, combining subjective self-ratings of sleepiness, alertness and fatigue, multiple simulator performance variables and neurophysiologic monitoring provides a more complete assessment, though an excessively large number of assessment variables can complicate data analysis.

While actual intrusion of sleep-related EEG activity is probably easier to detect than subtle shifts in neural networks due to shifts in affective, attentional or motivational state, appreciating the fluctuating and non-continuous nature of the states of absence and presence can form the basis of better understanding variations in performance on simulated tasks. Furthermore, the issue of insight into impairment is interesting; if an individual subjectively feels that they are performing well on a task, yet there is a mismatch in terms of simulator performance, it might be advisable to consider the role of factors such as fatigue and sleepiness, particularly on prolonged task exposure.

An intriguing future question is whether increasingly immersive simulation experiences are likely to have a more powerful influence on human behaviour through a process of videohypertansference, with episodes of absence, sleep and dreaming acting as unconscious conduits for this sleep-dependent-learning to occur [19, 20, 21]. Even while in a temporary state of absence, subconscious integration of the

immersive experience may continue to occur, as perceptual and emotional experiences are eventually integrated into behavioural changes.

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