



Universiteit
Leiden
The Netherlands

Sleep-related hallucinations

Waters, F.; Ling, I.; Azimi, S.; Blom, J.D.

Citation

Waters, F., Ling, I., Azimi, S., & Blom, J. D. (2023). Sleep-related hallucinations. *Sleep Medicine Clinics*, 1-15. doi:10.1016/j.jsmc.2023.10.008

Version: Publisher's Version

License: [Licensed under Article 25fa Copyright Act/Law \(Amendment Taverne\)](#)

Downloaded from: <https://hdl.handle.net/1887/3714613>

Note: To cite this publication please use the final published version (if applicable).

Sleep-Related Hallucinations

Flavie Waters, MSc, MPsych, PhD^{a,b,*}, Ivan Ling, MBBS, FRACP^{c,d}, Somayyeh Azimi, PhD^{a,e}, Jan Dirk Blom, MD, PhD^{f,g,h}

KEYWORDS

- Classification • Hallucinations • Dream-like experiences • Hypnagogic • Hypnopompic • Hypnagogia

KEY POINTS

- Sleep-related hallucinations (SRH) refer to a diagnostic category within the ICSD-3 group of “Other Parasomnias” that comprises two symptoms: hypnagogic and hypnopompic hallucinations (HHH) and complex nocturnal visual hallucinations (CNVH).
- Some individuals may also experience clinical hallucinations during the day that are unassociated with SRS.
- HHH are extremely common and generally benign in the general population. They are also a nonspecific symptom for any sleep disorders, or psychiatric, medical, and neurologic conditions.
- Little information exists about CNVH, though their resemblance to visual hallucinations in Charles Bonnet syndrome and other neurologic conditions suggest that they reflect a marker for psychopathology.
- A categorical approach to assessment reliant solely on the presence of SRH is not helpful as a diagnostic aid as SRH frequently co-occur with other sleep disorders and medical conditions.

INTRODUCTION

There has been a long-standing historical interest in the relationship between sleep and hallucinations. The American psychiatrist William Charles Dement (1928–2020) went so far as to suggest that “*there can be little question that dreams qualify as hallucinations.*”¹ This notion contrasts with the engrained distinction between sleep and waking states, but many researchers are intrigued by the possibility of a continuum.^{2–4} In the second and third editions of the International Classification of Sleep Disorders (ICSD, 2005⁵; 2014;⁶ 2023⁷), hallucinatory

phenomena that occur in the context of sleep are included as a diagnostic group called sleep-related hallucinations (SRH). SRH refer to a class of hallucinations that occur at sleep onset or on awakening from sleep and are reported on after the transition to a waking state has occurred.

In the ICSD,⁵ SRH are classed within the broader group of parasomnia disorders. They solely include two hallucinatory events, comprising (1) hypnagogic and hypnopompic hallucinations (“HHH,” also referred to collectively as hypnagogia) occurring in the drowsy state at the time of falling asleep or waking in the morning, respectively and (2) complex

^a Clinical Research Centre, Graylands Hospital, North Metropolitan Health Service Mental Health, Brockway Road, John XXIII Avenue, Mount Claremont, Perth, Western Australia 6009, Australia; ^b School of Psychological Science, The University of Western Australia, Crawley, Western Australia, Australia; ^c West Australian Sleep Disorders Research Institute, Perth, Australia; ^d Department of Pulmonary Physiology & Sleep Medicine, Sir Charles Gairdner Hospital, 5th Floor, G-block, Nedlands, Western Australia 6009, Australia; ^e School of Human Sciences, University of Western Australia, Crawley, Western Australia, Australia; ^f Parnassia Psychiatric Institute, Kiwistraat 43, The Hague 2552 DH, the Netherlands; ^g Faculty of Social and Behavioural Sciences, Leiden University, Leiden, the Netherlands; ^h Department of Psychiatry, University Medical Center Groningen, Groningen, the Netherlands

* Corresponding author.

E-mail addresses: flavie.waters@health.wa.gov.au; Flavie.waters@uwa.edu.au

nocturnal visual hallucinations (CNVH), following a sudden awakening during the night. The latter occurs mostly in the setting of visual and neurologic disorders. Some individuals may have hallucinations during the day, which are not associated with these sleep-related events.

The similarities between sleep-related events and “daytime” hallucinations have received much scrutiny, but a lot remains unknown about this new relatively category called “SRH.” In any case, they can reveal fascinating insights into the activities of the sleeping brain that are not readily available to our conscious awareness. In addition, they can shed light on other types of hallucination, notably visual hallucinations occurring in the context of Charles Bonnet syndrome (deafferentation phenomena) and release phenomena.

The objective of this review is to facilitate an understanding of SRH. To achieve this, it will address the history, background, and descriptions of SRH and discuss the continuity between SRH and other conditions. Similarities and differences to daytime clinical hallucinations are outside of our scope (for a detailed discussion, see Ref³).

HISTORY AND BACKGROUND

Although sleep has been a topic of philosophic and prescientific investigation since the time of Aristotle (384–322 BC) and beyond (Aristotle, 1984), the modern study of sleep only truly began with the application of the electroencephalogram (EEG) and eye movement detection techniques to the sleeping brain. These techniques revealed that human consciousness commutes between three naturally occurring and reversible neurophysiological and behavioral states called wakefulness, rapid eye movement (REM) sleep, and non-rapid eye movement (NREM) sleep.² These states are continuous and cyclical and quantifiable by the degree of complexity in which neurons interact within the central nervous system.⁸ Far from being passive, these states of consciousness all involve active brain functions, although connectivity with prefrontal cortex and executive functions distinguishes wakefulness from NREM and REM.

Mental events occurring during sleep have a physiologic basis that can be recorded. For example, dreaming during sleep coincides with cyclically recurring periods of EEG-recorded sleep states and eye movements.⁹ Although sleep electrophysiology progresses in a relatively uniform way across individuals, elements of REM and NREM sleep are not mutually exclusive. In some individuals, REM and NREM may dissociate and/or recombine to create undesirable experiences during sleep, which are termed “parasomnias.”^{10–12}

The first reference to hallucinations in sleep diagnostic manuals can be traced back to the initial edition of the ICSD (1990¹³) and its subsequent revision, the ICSD-R (2001¹⁴), under the category of Terrifying Hypnagogic Hallucinations. These were described as intensely frightening hallucinatory phenomena occurring only at sleep onset and a type of nightmare that interrupts the process of falling asleep and leads to a sudden return to full wakefulness.¹⁵ These phenomena may be accompanied by a realistic awareness of the presence of someone or something, often causing a profound sense of fear or dread (Table 1). In these earlier versions of the ICSD,^{13,14} they were described as extremely rare, and their clinical significance was rated using criteria based on severity (mild, moderate, severe) and duration (acute, subacute, chronic).

Subsequent versions of ICSD (–2,⁵ –3,⁶ and 3 TR⁷) featured the newly identified group of SRH within the broader diagnostic cluster of the parasomnias. Thus, from 2005 onward, SRH have been defined as “Hallucinatory experiences that occur at sleep onset or on awakening from sleep,” thereby expanding on the previous diagnostic category of Terrifying Hypnagogic Hallucinations. They can occur in the absence of other symptoms or disorders (“idiopathic type”) or as a symptom of another sleep disorder. The specification for clinical significance states that this experience must be recurrent and that infrequent hallucinations of this type may be within the limits of normal sleep–wake transition.

DESCRIPTION AND CLASSIFICATION

ICSD-3 criteria of SRH include (1) a complaint of recurrent hallucinations that are experienced just before sleep onset or on awakening; (2) prominently in the visual modality, and (3) the disturbance is not better explained by another sleep, mental, or medical disorder, medication, or substance use.^{6,7}

SRH refer to two separate experiences: HHH and CNVH.

The first published descriptions of hypnagogic hallucinations in the general population can be traced back to almost 180 years ago to French neurologist and psychiatrist Jules-Gabriel François Baillarger (1809–1890).¹⁶ By contrast, descriptions of CNVH are very recent.^{17,18}

Since Alfred Maury’s (1817–1892) observation in 1865⁴ of a continuum in form and content with daytime hallucinations, the classification systems for all clinical and clinical subtypes of hallucinations have sought to chart their sensory modality, contents, form, and duration.^{19,20}

Table 1
Characteristics of sleep-related hallucinations in different sleep disorders categories and other conditions

	Time of the Night	Content that is Intense, Vivid and with an Array of Simple and Complex Forms	Negative Affective Content (Fright, Anxiety, Dread, Threatening)	Detailed Memory Recall	Type of Wakening	Clear Separation of Sleep and Wake States	Co-occurs with Other Parasomnias
Hallucinations in sleep disorders within the "Other Parasomnia" category							
Hypnagogic hallucinations ³⁰	Sleep onset, usually first third of the night (from NREM sleep, or from sleep onset REM period)	Sometimes Gradual progression from simple to complex multimodal with auditory component as sleep approaches REM	Rarely	Immediate recall if awoken but rapidly forgotten	Brief arousal from sleep may be followed by a return to sleep or progression to wake	Sometimes difficult to differentiate from sleep-onset dreams	Yes
Hypnopompic hallucinations ³⁰	On waking, usually in the 2nd half (out of a period of REM)	Sometimes complex, especially if occurring out of period of REM	Rarely	Immediate recall if awoken but rapidly forgotten	Brief arousal from sleep may be followed by a return to sleep or progression to wake	Sometimes difficult to differentiate from dreams	Yes
Terrifying hypnagogic hallucinations	Sleep onset Sudden awakening	Yes, similar to nightmares	Yes	Yes: immediate recall, and prominently remembered	Sudden and abrupt arousal With autonomic hyperactivity	No separation: Persist into wake state "Double consciousness" simultaneous recall of dreams and external environment	Yes
Complex nocturnal visual hallucinations ⁴⁹	During the night: Sudden awakening	Yes, complex visual images, sometimes superimposed on the environment	Yes	Yes: immediate recall, and prominently remembered	Sudden and abrupt arousal With autonomic hyperactivity	No separation: Persist into wake state Identified as separate from dreams	Yes

(continued on next page)

Table 1
(continued)

	Time of the Night	Content that is Intense, Vivid and with an Array of Simple and Complex Forms	Negative Affective Content (Fright, Anxiety, Dread, Threatening)	Detailed Memory Recall	Type of Wakening	Clear Separation of Sleep and Wake States	Co-occurs with Other Parasomnias
Exploding head syndrome (other parasomnias) ⁸⁸	Sleep onset or when waking up	Simple auditory hallucination of an abrupt loud noise, sometimes accompanied by a simple visual hallucination (noise, light)	Yes	Yes	Abrupt arousal	Recognized as dreams	n/a
Hallucinations in REM-related parasomnias and NREM disorders of arousal							
Nightmare Disorders (REM-related parasomnias)	Anytime during the night, often in the 2nd half and REM sleep	Yes: as vivid but less intense than sleep terrors	Yes	Yes	Full awakening With autonomic hyperactivity	Recognized as dreams Do not persist into wake state	Yes
Recurrent sleep paralysis (REM-related parasomnias) ⁴⁷	Anytime, but often early in the night, from sleep-onset REM	Multisensory with auditory, somatic, olfactory senses. Feelings suffocation	Yes		Awakening with feeling of suffocation	Recognized as dreams	n/a
Sleep terrors (NREM disorders of arousal)	SWS, often in the early hours	Yes	Yes	Poorly recalled unless awakened during the episode	Sudden and abrupt arousal from NREM (fearful and with high autonomic hyporeactivity)	Recognized as dreams	n/a
Hallucinations in narcolepsy							
Hypnopompic and hypnagogic hallucinations in the setting of narcolepsy ⁷⁶	Can occur at any time during the night.	Intense, vivid, brief, and dream-like. Multisensory, visual, auditory and tactile, vivid	Yes	Yes	No awakening (hypnagogic) Normal awakening (hypnopompic)	Hallucinations may intrude into wakefulness and may be experienced in semiconscious state.	n/a

Sleep disorders associated with a medical condition

Sleep-related epilepsy	Any, often during N2	Multisensory; may involve somaesthetic (all sensory and somatic dimensions), auditory or visual depends on the localization of the epilepsy. Usually brief, simple, but may be complex if parietal and temporal association areas are involved.	Sometimes	Unusual	Yes	Yes	n/a
------------------------	----------------------	--	-----------	---------	-----	-----	-----

Other neurologic and psychiatric disorders encountered in the differential diagnosis of sleep disorders

Visual hallucinations in the setting of alpha synucleinopathies (Lewy body disease and Parkinson's disease)	Often in the evenings or at night, with darkness or reduced vigilance.	Primarily visual unimodal hallucinations of formed hallucinations. People, animal, varying in intensity.	Sometimes	Yes		Yes	Yes
Hallucinations due to a psychotic disorder	n/a	Primarily auditory-verbal, but visual, tactile hallucinations also occur in 30% of cases	Yes	Yes	n/a	Yes	Yes
Hallucinations due to CNS injury (Peduncular Hallucinations, Charles Bonnet syndrome)	May occur at night. Vivid dreams. Occur with eyes open or closed	Primarily visual unimodal, simple or complex; Complex include detailed, complex and colourful images of people, objects or animals. Sometimes bizarre, deformed or panoramic	No	Yes	n/a	Yes	Yes

(continued on next page)

Table 1
(continued)

	Time of the Night	Content that is Intense, Vivid and with an Array of Simple and Complex Forms	Negative Affective Content (Fright, Anxiety, Dread, Threatening)	Detailed Memory Recall	Type of Wakening	Clear Separation of Sleep and Wake States	Co-occurs with Other Parasomnias
Delirium	May occur at night. Vivid dreams.	Visual hallucinations are typical, but multimodal hallucinations are also common. Prolonged duration, and involving complex formed images.	Yes	Reduced insight, confusion, and altered consciousness			
Other hallucinations encountered in the differential diagnosis of sleep disorders							
Medications and substances	Increased abnormal dreams and nightmares	Dopaminergic medication; Anticholinergic therapy; Also psychostimulants; dissociative anaesthetics and psychedelics. Contents are usually complex and varied and depends on psychoactive contents and context	Sometimes	Reduced insight, confusion, and altered consciousness	n/a	Yes	Yes
Lucid dreams	n/a	Often visual, tactile, proprioceptive; complex; sometimes superimposed on the environment	No	Yes	n/a dynamic and voluntary; switch with conscious awareness	Sometimes, strategies include the use of cues to distinguish wake from lucid dream episodes	

Methodological Approaches

Daytime hallucinations and SRH are assessed using similar methods involving subjective reports.^{21,22} In contrast to daytime experiences, however, SRH require individuals to think back retrospectively to an experience that occurred in a different state of consciousness. A common approach for assessing SRH includes epidemiologic and psychological methods such as surveys or interviews.²²

In sleep medicine, subjective reports are combined with objective methods to examine the sleep stages in which SRH occur. Study participants are typically allowed to fall asleep according to their regular sleep schedule and then awoken at a predetermined interval coinciding with the sleep stage of interest. Sleep stages can be identified by real-time EEG recordings and/or eye movement detection and using analyses of EEG patterns, power, cortical distribution, and eye/head movements.^{19,23,24} Participants are asked to report on their most recent experience before awakening. Multiple experimental sessions across one or multiple nights allow for repeated measurements for each individual.^{19,25}

Self-reports are an essential conduit to human subjective experiences. However, mental processes in the sleeping brain are locked in a different state of consciousness, and the limited interactions between the sleep and wake states call for caution. As we fall asleep, mental functions gradually shut down, and memory transfers are interrupted contributing to anterograde amnesia on awakening.²⁶ Other factors compromising recall include the time elapsed between awakening due to memory interference and degradation.²⁷ In people with medical and neurologic conditions—who have elevated rates of HHH and especially CNVH—confusion, cognitive impairment, and memory difficulties may also affect the reliability of descriptions.

Of note, it has been suggested that some sleep stages may be more directly accessible to conscious memory than others. For example, the distinct neurophysiological features of REM sleep, in which the sleeper may experience vivid dreams, are closest to the waking state so that REM dreams may be better recalled.²² Regardless, the interpretation of SRH studies should take into account the quality and accessibility of events that happened during sleep.

Hypnagogic and Hypnopompic Hallucinations

Hypnagogic hallucinations

Hypnagogic hallucinations are fleeting perceptual phenomena that occur around the moment of

falling asleep (see [Table 1](#)). They are extremely common, usually non-pathological, and perhaps universal experiences. Lifetime prevalence rates range between 2% and 75% in the general population,^{28,29} although these rates may be skewed due to differences in study design and the methodological limitations mentioned above. Results from epidemiologic surveys suggest that the prevalence follows a U-curve and is more likely to occur in younger people and older people,³⁰ whereas observations about gender effects are mixed.³¹ Reportedly, hypnagogic hallucinations occur at elevated rates in people with psychiatric disorders, such as anxiety disorders, post-traumatic stress disorder (PTSD), psychotic disorders, and mood disorders (50%–80%³⁰), and in those taking psychotropic medications.^{30,32} However, the nature of the association with mental illness and medications is poorly understood, and poor sleep quality and frequent awakening may well contribute to more opportunities for the recall of sleep-related experiences rather than truly elevated rates.

Hypnagogic hallucinations are defined as occurring at sleep onset, although precise definitions of sleep onset vary.^{33–35} Definitions typically include light sleep (“N1”), but may also refer to the second stage of NREM (“N2”),^{19,36–38} or any other sleep stage immediately preceding REM.¹⁷

Studies describe a progression in the form and content of sleep mentation as sleep progresses from N1 toward REM sleep.^{9,19,20,23} When awoken during N1, people typically provide vague and fragmentary reports of imagery, with primarily visual contents.^{19,25} As sleep progresses, thought-like imagery acquires perceptual features (auditory–somatosensory components) and unusual contents that blend into dream features. The loss of reality monitoring and voluntary control resembles the characteristics of clinical hallucinations.²³ The affective intensity and complex narrative structure of some hypnagogic events can also be difficult to differentiate from the onset of REM dreams.^{6,19}

The visual component is the most commonly emphasized and is possibly related to spontaneous activity that occurs in the occipital cortex in the transition to sleep.^{39–41} Visual images comprise 55% to 86% of hypnagogic reports^{35,42,43} and are described as kaleidoscopically changing (some of them possibly entoptic) phenomena such as geometric patterns, shapes, and light flashes.³ Other visual images may involve a broad array of events ranging from simple (lights, patterns, designs, written text, formless shapes) to complex phenomena (human faces or figures, animals or objects, scenes involving landscapes and/or people).²⁰

Hypnagogic hallucinations often feature sensations in multiple modalities, either concurrently or sequentially.²³ Auditory impressions, in 8% to 35% of hypnagogic events, can include sounds (radio, phone, doorbell, music) or voices.^{35,44–46} Bodily sensations are also frequent occurrences (in 25% to 50% of reports)^{19,29,42} and are described as a sense of touch and bodily distortions, or feelings of weightlessness, flying, or falling into an abyss. Affective contents occur in a minority of events (<5%), and examples include being caught in a fire, or being involved in an attack.³⁰ A final phenomenon is a sense of presence in the room, although this is associated more commonly with sleep paralysis.⁴⁷

Hypnopompic hallucination

Hypnopompic hallucinations accompany the departure from sleep for the duration of a few seconds to minutes¹⁵ (see **Table 1**). They typically occur in the morning, although this is not always the case. They are reported to occur less frequently than hypnagogic hallucinations (7%–13%).²⁹ Here too, frequency rates are reportedly higher in people with psychiatric disorders (15%–36%) compared with the general population.³⁰

They can arise from a period of REM sleep, with their features more closely resembling the continuation of a dream sequence than sleep-onset hypnagogic hallucinations. They are described as vividly real and intense, and sometimes involving a narrative, albeit rarely frightening (30% of cases). Individuals may be uncertain whether they represent waking or dream-related experiences (ICSD-3). A typical example is a person with whom we were conversing in a dream, who is still being seen and heard when the eyes are open and perceived as actually present in the bedroom. Examples may include relatives or acquaintances, children, and varied animals.¹⁷ The dreamer may be in the middle of a conversation, although the hallucinated people

rarely reply and disappear with the transition of awakening. Forgetting appears less rapid than with hypnagogic hallucinations, and they can linger in the mind after awakening.

Complex Nocturnal Visual Hallucinations

CNVH are differentiated from hypnagogia as occurring during the night and representing a distinct form of SRH.^{5,6} The mental imagery and perceptual forms of CNVH closely resemble normal dreams. However, the episodes are distinguished from dreams because they occur during a state resembling an intermediate state of consciousness, and they are associated with behavioral acting out. The episode also terminates with a sudden waking^{6,7} (see **Table 1**) associated with the recollection the vivid “dream like” imageries.^{18,48,49} The eyes may be open and visually tracking the object's change across space.⁴⁸ One case study describes the patient as sitting up on the bed yellow, looking around mumbling unintelligible words and/or pointing to nonexistent objects.⁴⁹ The presence of emotional content within a narrative structure may cause fright or alarm. **Fig. 1** shows a patient sitting up in bed, acting out on the hallucination by pointing and displaying facial emotional.

CNVH have so far only been reported in small case series,^{17,49} small cohorts,¹⁸ and in patients with documented sleep disorders,⁴⁸ rather than at the population level. Descriptions include complex contents such as small animals (insects, rodents), persons, or distorted forms,^{17,18} which may be superimposed on the perceptual word and disappear when the ambient illumination is increased. The contents may take varied and multicolored forms of vivid, intricate, relatively immobile images sometimes distorted in shape or size and superimposed on veridical perceptions similar to the daytime hallucinations typical of Charles Bonnet



Fig. 1. (A) During this episode, the patient sat on the bed staring at a nonexistent presence or object with a scared expression. (B) During this episode, the patient laughed and displayed positive emotions. (C) During this episode, the patient stared and pointed toward an invisible object in the room with his finger, as if hallucinating. (From Castelnovo A, Loddo G, Provini F and Manconi M. Frequent, complex and vivid dream-like/hallucinatory experiences during NREM sleep parasomnia episodes. *Sleep medicine* 2021; 82: 61–64.)

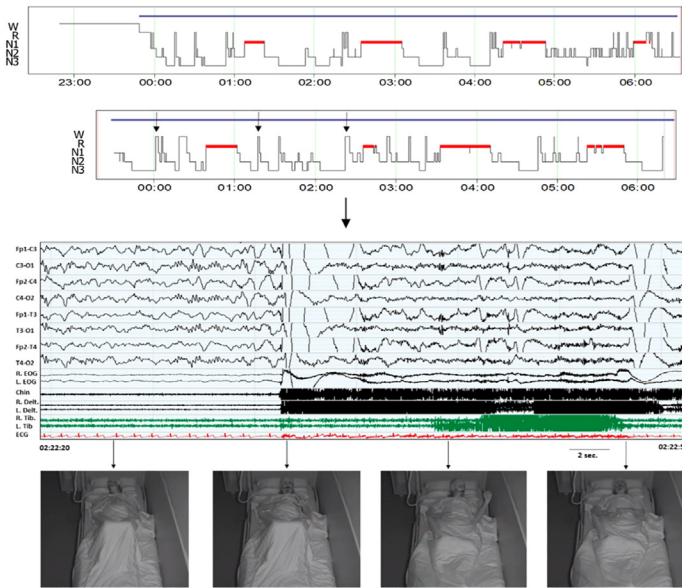


Fig. 2. Upper panel: Hypnograms of the first and second polysomnography (PSG) nights. Black arrows indicate minor NREM sleep parasomnia episodes. Sleep architecture was preserved on both nights (N1 proportion 12% and 10%, N2 = 39% and 39%, N3 = 26% and 26%, REM = 23% and 25%, sleep efficiency = 94% and 93%, REM sleep latency = 70 and 69 minute—in the first and night, respectively), but characterized by several abrupt awakenings out of NREM sleep (21 and 12 awakenings—with and arousal index (AI) of 13.6 and 11.5—in the first and second night, respectively). Central panel: 30 s-epoch of the v-PSG during a Type 1B episode, illustrating the dissociated sleep–wake state. The PSG montage included eight EEG bipolar traces from fronto-polar (Fp), temporal (T), central (C), occipital (O) leads, two electrooculograms (EOG), electromyograms from the chin, left and right deltoids (L and R

Delt), and left and right tibialis anterior muscles (L and R Tib). The EEG shows diffuse slow wave activity (N3 stage) before the activation of EMG, then a movement artifact, followed by slow waves of small amplitude in the frontal leads, mixed with higher mixed and largely artifactual frequencies in the central, temporal, and occipital leads. Lower panel: The black vertical line indicates the time of the picture shown in the bottom-right corner. In the first picture, the subject was still sleeping, and in the second picture, he opened his eyes and flexed his neck, his arms, and extended his fingers, and stared perplexedly at his hands. In the third picture, he turned his head and partially his trunk to the left and in the last picture he went back lying in the bed. The episode lasted about 20 s and the patient gradually woke up soon after it. He described having had a dream but could remember only brief sketches of it. (Adapted from Castelnovo A, Loddo G, Provini F and Manconi M. Frequent, complex and vivid dream-like/hallucinatory experiences during NREM sleep parasomnia episodes. *Sleep medicine* 2021; 82: 61–64.)

syndrome.¹⁷ CNVH have been described as rare with a frequency that can average four times a week in affected individuals.^{18,29}

Some individuals may report both HHH and CNVH at different times.¹⁷ Descriptions point to differences between CNVH and HHH in the timing during sleep and electrophysiological features. Their epidemiologic and clinical profiles also point to important differences:

- CNVH interrupt sleep, which differs from HHH which occur in the borderlands between sleep and wake.
- CNVH are characterized by a distinct EEG and behavioral patterns consisting of low-voltage, mixed-frequency signals⁴⁸ during NREM sleep^{18,50} (Fig. 2, showing CNVH during NREM REM).
- CNVH have a mean onset age of 40 years and are associated with increased age,¹⁸ whereas HHH can occur in healthy and unmedicated people in the context of normal sleep and in both younger and older people.^{29,31}
- CNVH are commonly associated with neurologic conditions and visual disorders^{18,51,52}

(although they have also been described in groups of people without diagnosed pathology⁵¹).

There are striking similarities between CNVH and daytime visual hallucinations in disorders associated with visual pathways or brain stem lesions. These include visual hallucinations in Charles Bonnet syndrome.¹⁷ Both types include visual percepts (highly detailed, colorful, and at times grotesque images of people or animals) and rapid transformations of images, although an affective component is often lacking in CBS, but not for CNVH.^{53,54} Explanations of CNVH involving visual release overlap with those of Charles Bonnet syndrome, which is attributed to lesions of the afferent visual pathway,^{53–55} both resulting in the visual cortex generating aberrant images.

CNVH also resemble visual hallucinations associated with brainstem or thalamic lesions, such as neurodegenerative disorders associated with alpha-synucleinopathies pathologies, such as Lewy body disease and Parkinson's disease,^{56–58} in which oculo-visual problems are common.^{59–61}

Visual hallucinations in Parkinson's disease also change with darkness or illumination.⁶²

Peduncular hallucinosis in brainstem disorders with midbrain and diencephalic pathology also resemble CNVH^{63,64} where the hallucinations are described as complex, vivid, and colorful and are sometimes associated with auditory content and retention of insight.⁶³

The resemblance of CNVH to the typical complex visual hallucinations of these disorders has led to suggestions of common neurophysiological substrates, with separate neural system involvement.^{52,56,65}

Although previous studies have linked complex hallucinations to "REM" dysfunctions or intrusions^{17,66–69} NREM sleep.⁵⁰ In an attempt to reconcile these mixed findings, Gnoni and colleagues⁴⁸ suggested that CNVH may involve multiple coexisting states of consciousness (wake, NREM, and REM) which have been decoupled and reassembled. It is proposed that the unique combination of co-occurring wake, NREM, and REM elements manifests as hallucinatory experiences in CNVH. Other evidence of parallel processing of multiple states includes neurobiological evidence of nighttime EEG microstates of alpha band activity that are indistinguishable from waking conscious states.⁷⁰ Micro-wake "fragments" activity, recorded during slow-wake sleep (SWS) and REM,^{71,72} are localized in the midbrain regions including the pedunculopontine nucleus^{64,73} which is a region of interest given that virtually every sensory system projects onto the brain stem. Furthermore, lesions in this area produce visual hallucinations that closely resemble CNVH.⁶³ In the next decades, technological advances can hopefully further build on this new knowledge about biological explanations of SRH.

Association with Other Sleep Disorders

Within the parasomnia cluster of ICSD-3, SRH are grouped under "Other Parasomnias." This residual category encompasses a range of unusual sleep-related conditions with diverse presentations, loose boundaries, and assorted pathophysiological bases for which there is insufficient or inadequate information to substantiate their unequivocal existence.

Other parasomnias are distinguished from NREM- and REM-related parasomnias (the two main categories of this classification), although they frequently co-occur with these other parasomnias and other sleep disorders. HHH and CNVH can occur either at the same time or on different nights as other behavioral symptoms of sleep disorders, making them difficult to identify and isolate.

Narcolepsy

SRH commonly occur in individuals with narcolepsy, which is a disorder of somnolence, with frequency rates of approximately 33% to 80%.^{74,75} Unlike CNVH which intrude on nighttime sleep, narcolepsy comprises sleep episodes intruding on daytime functions. Narcolepsy typically begins in youth between the ages of 10 to 20 years, unlike CNVH which is associated with older age.⁷⁶ In addition, narcolepsy is associated with a paralysis of the skeletal muscles, whereas CNVH is associated with sitting up or sudden movements.

Rapid eye movement-related parasomnias

Among all parasomnias, this category of parasomnias is the most commonly associated with vivid and prominent perceptual events, although their symptom presentation differs somewhat from SRH descriptions.

- In REM sleep behavior disorders, where the patient acts out dreams during REM sleep, the event ceases when the person is awoken, while CNVH tend to persist into wakefulness.⁷⁷
- Nightmares share features with both hypnagogic hallucinations and CNVH. The emotive and frightening contents resemble hypnagogic hallucinations, but nightmares are recognized as dreams and are vividly remembered. One point of difference between CNVH and nightmares is that the individual is usually fully orientated when awakened during the nightmare.⁶ The person with nightmares also usually remembers the dream content in vivid detail. Finally, nightmares also generally occur out of REM-sleep stage, whereas SRH are commonly associated with NREM.
- Sleep paralysis commonly co-occurs with SRH, especially in the context of hypersomnia or insufficient sleep (4% to 40%).^{6,47} Sleep paralysis involves the disturbing temporary inability to move voluntary muscles at sleep-wake transitions. It can be accompanied by hallucinations (25%–75% of patients, ICSD-3), including the incubus phenomenon (ie, a hallucinated figure that presses down on one's chest).⁷⁸ Apart from the visual and tactile components of this phenomenon, hallucinations in the context of sleep paralysis may have auditory, visual, and kinesthetic components, or involve the sense of a presence in the room, either concurrently or at separate times from episodes of paralysis. They have strong dream-like surreal contents, with auditory and bodily elements that are perceived to be real and ominous.^{79–81} In contrast to simple hypnagogic experiences,

the person feels awake and conscious but unable to move. Episodes of sleep paralysis elicited by awakening patients from nocturnal sleep seem to arise from REM sleep, but almost always correspond with mixed REM and waking EEG.^{82,83}

Non-rapid eye movement-related parasomnias

Disorders of arousal from NREM (eg, confusional arousals, sleepwalking, and sleep terrors)⁵⁰ can also be associated with SRH, but those events are frequently recognized as dreams which do not persist into wakefulness.

Sleep terrors commonly feature SRH, too. Sleep terrors are characterized by sudden arousal, intense fear, or panic and accompanied by autonomic and behavioral manifestations including piercing screams or cries, sitting up in bed, and attempts to “escape” from terrifying dream-like contents. The patient is usually unresponsive to external stimuli, and, if awakened, is confused and disoriented. Amnesia for the episode occurs frequently, although sometimes there are reports of fragments or very brief vivid dream images or hallucinations. They occur out of N2, often at the beginning of the night, or in slow wave sleep (SWS, N3) at any time during the night. Studies of CNVH also suggest a contribution of NREM sleep.^{48,50}

Other parasomnias

Finally, there is some overlap with other categories within the cluster of other parasomnias. Exploding head syndrome consists of a sudden loud bang, usually at sleep onset and sometimes accompanied by a flash of light. A point of difference with SRH is that it does not involve complex visual imagery and lasts only a fraction of a second. Also, exploding head syndrome has a lower prevalence than hypnagogic states.⁸⁴

SUMMARY AND DISCUSSION

Our current state of knowledge is that SRH is a diagnostic category that features in ICSD alone and solely comprises HHH and CNVH. These phenomena are thought to represent a single symptom cluster with distinctive presentations, but it is not yet clear whether they have a single underlying mechanism or perhaps different ones.

There has been an evolution in the conceptualization of SRH over time. Although SRH are interesting to study in their individual forms, there are a number of distinctive questions that remain to be answered.

1. What is the link between CNVH and Terrifying Hypnagogic Hallucination described in the ICSD-R?

CNVH closely resembles THH, except in the timing of sleep. THH occur at sleep onset, whereas CNVH can occur at any time during sleep.

Similarities between CNVH and THH are that: their contents resemble nightmares, and the accompanying emotional effect includes fear, foreboding, and threatening contents; both are associated with body movements (vocalization and screaming for THH; sitting up and eyes open with CNVH); both are associated with intact recall and may in fact represent a continuation into wakefulness; and THH have sometimes been described as a “double consciousness” simultaneous recall of dreams and external environment, which resemble descriptions of CNVH. Another common and distinctive feature of both is that they terminate with sudden awakening, and they persist into awakening. This separates them from other SRS that are associated with a brief arousal and a subsequent return to sleep.

2. Do HHH and CNVH represent the same or distinct phenomena within the SRH category:

HHH are extremely common and, mostly benign, in the normal population. The upgrading of their clinical significance from benign phenomena to the status of sleep disorders across successive ICSD versions raises questions about unsubstantiated pathologization. HHH are now labeled as sleep disorders, although they are not identified as symptoms with substantial clinical merit. Their clinical significance is identified if they are “recurrent,” and because they are common symptoms of other sleep disorders, especially parasomnias and other psychiatric conditions.

By contrast, evidence for CNVH comes from descriptions of patients with sleep disorders or medical conditions, in whom they may be a symptom of a clinical condition. CNVH are also differentiated from HHH (and other different parasomnia-related events) by the timing, complex visual contents, sudden arousal, affective contents, and good memory recall of events.

There are therefore questions about whether they represent the same or different phenomena, and they should be combined under the same category of SRH. A commonality is that many EEG studies link both to NREM.⁸⁵ However, other evidence links them to all states of consciousness, including waking, sleep onset, sleep offset, and REM sleep, and it is not clear whether they have distinct neurophysiological basis or polysomnography (PSG) features.

One possibility is that SRH can be represented along a continuum of severity, with normal variants of HHH at one end, and CNVH as a pathologic

entity at the other. If this is the case, a better explanation of the threshold of clinical significance would be useful to clinicians. A continuum of presentation, however, does not necessarily imply a continuous of mechanisms. Notwithstanding their similarity, evidence from their demographic profile and clinical course suggests different mechanisms between HHH and CNVH. CNVH are a common feature of neurologic disorders, whereas HHH occur in a non-pathological form in the majority of cases. Many questions remain about their association with other sleep disorders. Their lack of specificity to any that one sleep disorder or a specific somatic or psychiatric condition should remain at the forefront of all clinical assessments.

SUMMARY

In conclusion, perceptual phenomena which occur around and during sleep represent a fascinating topic for study as they reveal a world that is not easily accessible to our waking state. One suggestion is that they are a mirror image of each other, with the dreaming brain being an “offline” virtual reality simulation of the “online” waking world.⁸⁶ However, our knowledge of sleep states and associated perceptual phenomena is still rather limited. Methodological issues are important barriers that constrain our understanding of the nature, causes, and significance of SRH. Advances in the conceptualization of the wake versus sleep dichotomy may also help to facilitate direct comparisons between phenomena with similar clinical features.

CLINICS CARE POINTS

- Sleep-related hallucinations (SRH) have been documented in all stages of sleep (non-rapid eye movement [NREM] and rapid eye movement [REM]), in healthy individuals, and in people with a variety of general medical, neurologic, and psychiatric disorders.
- Not all hallucinations require interventions. Infrequent hallucinations may be within the limits of normal sleep–wake transitions.
- SRH can occur independently from, but are frequently associated with, other sleep disorders. The presence of other symptoms that occur concurrently with SRH may therefore be indicative of narcolepsy or other disorders.
- SRH cannot be understood in isolation, and it is inadvisable to give excessive weight to individual features of SRH.⁸⁷ The combination of features accompanying complex nocturnal visual hallucinations is an important factor that

can assist in diagnosis and help to determine whether treatment is needed.

- Future research should focus on the development of reliable assessment tools that can differentiate between different features of daytime and SRH outside of the simple wake–sleep dichotomy.

DISCLOSURE

The authors have nothing to disclose.

REFERENCES

1. Dement WC. Recent studies on the biological role of rapid eye movement sleep. *Am J Psychiatr* 1965; 122:404–8.
2. Windt JM. How deep is the rift between conscious states in sleep and wakefulness? Spontaneous experience over the sleep–wake cycle. *Philosophical Transactions of the Royal Society B* 2021;376: 20190696.
3. Waters F, Blom JD, Dang-Vu TT, et al. What is the link between hallucinations, dreams, and hypnagogic–hypnopompic experiences? *Schizophr Bull* 2016; 42:1098–109.
4. Maury A. *Le sommeil et les rêves: études psychologiques sur ces phénomènes et les divers états qui s'y rattachent*. Paris: Didier; 1878.
5. Medicine AaOs. International classification of sleep disorders. Diagnostic and coding manual 2005; 148–52.
6. American Academy of Sleep M. International classification of sleep disorders. 3rd edition. Darien, IL: American Academy of Sleep Medicine Darien, IL; 2014.
7. American Academy of Sleep M. International classification of sleep disorders ICSD-3-Text revision. 3. uberarbeitete Auflage ed. Darien, Ill. Ill: American Acad. of Sleep Medicine Darien; 2023.
8. Walter N, Hinterberger T. Determining states of consciousness in the electroencephalogram based on spectral, complexity, and criticality features. *Neuroscience of Consciousness* 2022;2022:niac008.
9. Dement W, Kleitman N. The relation of eye movements during sleep to dream activity: an objective method for the study of dreaming. *J Exp Psychol* 1957;53:339.
10. Mahowald MW, Schenck CH. NREM sleep parasomnias. *Neurol Clin* 1996;14:675–96.
11. Schenck CH, Cramer Bornemann M, Kaplish N, et al. Sleep-related (psychogenic) dissociative disorders as parasomnias associated with a psychiatric disorder: update on reported cases. *J Clin Sleep Med* 2021;17:803–10.

12. Schenck CH, Mahowald MW. REM sleep parasomnias. *Neurol Clin* 1996;14:697–720.
13. Thorpy MJ. Classification of sleep disorders. *J Clin Neurophysiol* 1990;7:67–82.
14. American Academy of Sleep M. The international classification of sleep disorders, revised : diagnostic and coding manual. Westchester (Illinois): American Academy of Sleep Medicine Westchester (Illinois); 2001.
15. Blom JD. A dictionary of hallucinations. 3rd edition. London, UK: Springer; 2023.
16. Baillarger JGF. Extrait d'un mémoire intitulé: des hallucinations, des causes qui les produisent, et des maladies qu'elles caractérisent. Paris, France: Baillelière; 1846.
17. Takata K, Inoue Y, Hazama H, et al. Night-time hypnopompic visual hallucinations related to REM sleep disorder. *Psychiatr Clin Neurosci* 1998;52:207–9.
18. Silber MH, Hansen MR, Girish M. Complex nocturnal visual hallucinations. *Sleep Med* 2005;6:363–6.
19. Foulkes D, Vogel G. Mental activity at sleep onset. *J Abnorm Psychol* 1965;70:231.
20. Mavromatis A. On shared states of consciousness and objective imagery. *J Ment Imagery* 1987; 102(1):28–41.
21. Murphy DB, Myers TI. Occurrence, measurement and experimental manipulation of visual "hallucinations". *Percept Mot Skills* 1962;15:47–54.
22. Strauch I, Meier B. In search of dreams: results of experimental dream research. Paris, France: SUNY Press; 1996.
23. Rowley JT, Stickgold R, Hobson JA. Eyelid movements and mental activity at sleep onset. *Conscious Cognit* 1998;7:67–84.
24. Diezig S, Denzer S, Achermann P, et al. EEG microstate dynamics associated with dream-like experiences during the transition to sleep. *Brain Topogr* 2022;1–13. <https://doi.org/10.1007/s10548-022-00923-y>.
25. Foulkes D, Spear PS, Symonds JD. Individual differences in mental activity at sleep onset. *J Abnorm Psychol* 1966;71:280.
26. Tivadar RI, Knight RT, Tzovara A. Automatic sensory predictions: a review of predictive mechanisms in the brain and their link to conscious processing. *Frontiers in human neuroscience* 2021;15:702520.
27. Wyatt JK, Bootzin RR, Anthony J, et al. Sleep onset is associated with retrograde and anterograde amnesia. *Sleep* 1994;17:502–11.
28. Honig A, Romme MA, Ensink BJ, et al. Auditory hallucinations: a comparison between patients and nonpatients. *J Nerv Ment Dis* 1998;186:646–51.
29. Ohayon MM. Prevalence of hallucinations and their pathological associations in the general population. *Psychiatr Res* 2000;97:153–64.
30. Ohayon MM, Priest RG, Caulet M, et al. Hypnagogic and hypnopompic hallucinations: pathological phenomena? *Br J Psychiatry* 1996;169:459–67.
31. Bless JJ, Hugdahl K, Kråkvik B, et al. In The twilight zone: an epidemiological study of sleep-related hallucinations. *Compr Psychiatr* 2021; 108:152247.
32. Pandi-Perumal SR, Kramer M. Sleep and mental illness. London, UK: Cambridge University Press; 2010.
33. Berry RB, Brooks R, Gamaldo CE, et al. The AASM manual for the scoring of sleep and associated events. rules, terminology and technical specifications, Darien, Illinois. American Academy of Sleep Medicine 2012; 176:2012.
34. Guo D, Thomas RJ, Liu Y, et al. Slow wave synchronization and sleep state transitions. *Sci Rep* 2022; 12:7467.
35. Yang C-M, Han H-Y, Yang M-H, et al. What subjective experiences determine the perception of falling asleep during sleep onset period? *Conscious Cognit* 2010; 19:1084–92.
36. Agnew H, Webb W. Measurement of sleep onset by EEG criteria. *Am J EEG Technol* 1972;12:127–34.
37. Davis H, Davis PA, Loomis A, et al. Human brain potentials during the onset of sleep. *J Neurophysiol* 1938;1: 24–38.
38. Carskadon MA, Dement WC. Normal human sleep: an overview. *Principles and practice of sleep medicine* 2005;4:13–23.
39. Goupil L, Bekinschtein T. Cognitive processing during the transition to sleep. *Arch Ital Biol* 2012;150: 140–54.
40. Horovitz SG, Fukunaga M, de Zwart JA, et al. Low frequency BOLD fluctuations during resting wakefulness and light sleep: a simultaneous EEG-fMRI study. *Hum Brain Mapp* 2008;29:671–82.
41. Kjaer TW, Law I, Wiltschjotz G, et al. Regional cerebral blood flow during light sleep—a H215O-PET study. *J Sleep Res* 2002;11:201–7.
42. Sidgwick H. Report on the census of hallucinations. In: Proceedings of the society for psychical researchXXVI. London, UK: Kegan Paul, Trench, Trübner & Co: Cambridge University Press Cambridge; 1894. p. 25–422. Part X.
43. Leaning F. An introductory study of hypnagogic phenomena. In: Paper presented at: proceedings of the society for psychical research 1925, Society for Psychical Research; Nottingham, UK.
44. Jones SR, Fernyhough C, Larøi F. A phenomenological survey of auditory verbal hallucinations in the hypnagogic and hypnopompic states. *Phenomenol Cognitive Sci* 2010;9:213–24.
45. Leroy E-B. Les visions du demi-sommeil: hallucinations hypnagogiques. Paris; 1933.
46. Hori T, Hayashi M, Morikawa T. Topographical EEG changes and the hypnagogic experience. In: Ogilvie RD, Harsh JR, editors. Sleep onset: Normal and abnormal processes. American Psychological Association; 1994. p. 237–53.

47. Cheyne JA, Rueffer SD, Newby-Clark IR. Hypnagogic and hypnopompic hallucinations during sleep paralysis: neurological and cultural construction of the night-mare. *Conscious Cognit* 1999;8:319–37.
48. Gnani V, Duncan I, Wasserman D, et al. Nocturnal visual hallucinations in patients with disorders of arousal: a novel behavioral and EEG pattern. *Croat Med J* 2022;63:438.
49. Castelnovo A, Loddo G, Provini F, et al. Frequent, complex and vivid dream-like/hallucinatory experiences during NREM sleep parasomnia episodes. *Sleep Med* 2021;82:61–4.
50. Diaz-Abad M, Sanchez AM, Kabir A, et al. A case of complex and abnormal behaviors at night: the role of the epilepsy monitoring unit in diagnosis. *Case Rep Neurol* 2020;12:18–23.
51. Lysenko L, Bhat S. Melatonin-responsive complex nocturnal visual hallucinations. *J Clin Sleep Med* 2018;14:687–91.
52. Manford M, Andermann F. Complex visual hallucinations. Clinical and neurobiological insights. *Brain* 1998;121:1819–40.
53. Madill S, Ffytche D. Charles Bonnet syndrome in patients with glaucoma and good acuity. *Br J Ophthalmol* 2005;89:785–6.
54. Santhouse A, Howard R, Ffytche D. Visual hallucinatory syndromes and the anatomy of the visual brain. *Brain* 2000;123:2055–64.
55. Ffytche DH, Catani M. Beyond localization: from hodology to function. *Phil Trans Biol Sci* 2005;360:767–79.
56. Barnes J, David A. Visual hallucinations in Parkinson's disease: a review and phenomenological survey. *J Neurol Neurosurg Psychiatr* 2001;70:727–33.
57. Eversfield CL, Orton LD. Auditory and visual hallucination prevalence in Parkinson's disease and dementia with Lewy bodies: a systematic review and meta-analysis. *Psychol Med* 2019;49:2342–53.
58. UP Mosimann, Rowan EN, Partington CE, et al. Characteristics of visual hallucinations in Parkinson disease dementia and dementia with Lewy bodies. *Am J Geriatr Psychiatry* 2006;14:153–60.
59. Armstrong R. Oculo-visual dysfunction in Parkinson's disease. *J Parkinsons Dis* 2015;5:715–26.
60. Hinkle JT, Pontone GM. Lewy body degenerations as neuropsychiatric disorders. *Psychiatr Clin* 2020;43:361–81.
61. Pang L. Hallucinations experienced by visually impaired: Charles Bonnet syndrome. *Optom Vis Sci* 2016;93:1466.
62. Fénelon G, Mahieux F, Huon R, et al. Hallucinations in Parkinson's disease: prevalence, phenomenology and risk factors. *Brain* 2000;123:733–45.
63. Benke T. Peduncular hallucinosis: a syndrome of impaired reality monitoring. *J Neurol* 2006;253:1561–71.
64. Vita MG, Batocchi AP, Dittoni S, et al. Visual hallucinations and pontine demyelination in a child: possible REM dissociation? *J Clin Sleep Med* 2008;4:588–90.
65. Bertram K, Williams DR. Visual hallucinations in the differential diagnosis of parkinsonism. *J Neurol Neurosurg Psychiatr* 2012;83:448–52.
66. Gottesmann C. The dreaming sleep stage: a new neurobiological model of schizophrenia? *Neuroscience* 2006;140:1105–15.
67. Kelly PH. Defective inhibition of dream event memory formation: a hypothesized mechanism in the onset and progression of symptoms of schizophrenia. *Brain Res Bull* 1998;46:189–97.
68. Arnulf I, Bonnet A-M, Damier P, et al. Hallucinations, REM sleep, and Parkinson's disease: a medical hypothesis. *Neurology* 2000;55:281–8.
69. Manni R, Terzaghi M, Ratti P-L, et al. Hallucinations and REM sleep behaviour disorder in Parkinson's disease: dream imagery intrusions and other hypotheses. *Conscious Cognit* 2011;20:1021–6.
70. Bréchet L, Brunet D, Perogamvros L, et al. EEG microstates of dreams. *Sci Rep* 2020;10:17069.
71. Eschenko O, Magri C, Panzeri S, et al. Noradrenergic neurons of the locus coeruleus are phase locked to cortical up-down states during sleep. *Cerebr Cortex* 2012;22:426–35.
72. Destexhe A, Hughes SW, Rudolph M, et al. Are corticothalamic 'up' states fragments of wakefulness? *Trends Neurosci* 2007;30:334–42.
73. Smith DM, Terhune DB. Pedunculo-pontine-induced cortical decoupling as the neurophysiological locus of dissociation. *Psychol Rev* 2023;130:183.
74. Szűcs A, Janszky J, Hollo A, et al. Misleading hallucinations in unrecognized narcolepsy. *Acta Psychiatr Scand* 2003;108:314–7.
75. Leu-Semenescu S, DeCock VC, Le Masson VD, et al. Hallucinations in narcolepsy with and without cataplexy: contrasts with Parkinson's disease. *Sleep Med* 2011;12:497–504.
76. Scammell TE. Narcolepsy. *N Engl J Med* 2015;373:2654–62.
77. Atassi MDS, Atassi PhD K, Sandberg MSM. Rem behavior disorder and sleep related hallucinations, a case study. *Marshall Journal of Medicine* 2021;7:4.
78. Kompanje EJO. 'The devil lay upon her and held her down' Hypnagogic hallucinations and sleep paralysis described by the Dutch physician Isbrand van Diemerbroeck (1609–1674) in 1664. *J Sleep Res* 2008;17:464–7.
79. Cheyne JA, Newby-Clark IR, Rueffer SD. Relations among hypnagogic and hypnopompic experiences associated with sleep paralysis. *J Sleep Res* 1999;8:313–7.
80. Molendijk ML, Bouachmir O, Montagne H, et al. The incubus phenomenon: prevalence, frequency and

- risk factors in psychiatric inpatients and university undergraduates. *Front Psychiatr* 2022;13:1040769.
81. Cheyne JA, Pennycook G. Sleep paralysis postepisode distress: modeling potential effects of episode characteristics, general psychological distress, beliefs, and cognitive style. *Clin Psychol Sci* 2013;1:135–48.
82. Takeuchi T, Miyasita A, Inugami M, et al. Laboratory-documented hallucination during sleep-onset REM period in a normal subject. *Percept Mot Skills* 1994;78:979–85.
83. Takeuchi T, Miyasita A, Sasaki Y, et al. Isolated sleep paralysis elicited by sleep interruption. *Sleep* 1992;15:217–25.
84. Sharpless BA. Exploding head syndrome. *Sleep Med Rev* 2014;18:489–93.
85. Hurwitz TD, Schenck CH. Parasomnias. *Foundations of Psychiatric Sleep Medicine* 2010;160:85–9.
86. Hobson JA, Friston KJ. Waking and dreaming consciousness: neurobiological and functional considerations. *Progress In Neurobiology* 2012;98:82–98.
87. Waters F, Fernyhough C. Hallucinations: a systematic review of points of similarity and difference across diagnostic classes. *Schizophr Bull* 2017;43:32–43.
88. Sharpless BA. Exploding head syndrome is common in college students. *J Sleep Res* 2015;24:447–9.