Neuroscience and Biobehavioral Reviews 167 (2024) 105919

Contents lists available at ScienceDirect

Neuroscience and Biobehavioral Reviews

journal homepage: www.elsevier.com/locate/neubiorev

# Conscious experiences during non-rapid eye movement sleep parasomnias

Anna Castelnovo [a,b,c,*], Francesca Siclari [d,e,f,**], Sara Spaggiari [a], Dolores Borth [g], Mauro Manconi [a,b,h], Isabelle Arnulf [i,j], Carlos H. Schenck [k,l]

[a] Sleep Medicine Unit, Neurocenter of Italian Switzerland, Civic Hospital (EOC) of Lugano, Lugano, Switzerland
[b] Faculty of Biomedical Sciences, Università Della Svizzera Italiana, Lugano, Switzerland
[c] University Hospital of Psychiatry and Psychotherapy, University of Bern, Switzerland
[d] The Netherlands Institute for Neuroscience, Amsterdam, the Netherlands
[e] Center for Investigation and Research on Sleep, Lausanne University Hospital (CHUV), Lausanne, Switzerland
[f] The Sense Innovation and Research Center, Lausanne and Sion, Switzerland
[g] Center for Narcolepsy and Hypersomnias, Department of Medicine, University Witten/Herdecke, Witten, Germany
[h] Department of Neurology, University Hospital, Inselspital, Bern, Switzerland
[i] Narcolepsies et Hypersomnies rares, Assistance Publique-Hôpitaux de Paris-Sorbonne (AP-HP-Sorbonne), Hôpital la Pitié-Salpètrière, Paris, France
[j] Sorbonne University, Paris Brain Institute (ICM), Inserm, CNRS, Paris, France
[k] Minnesota Regional Sleep Disorders Center, Departments of Psychiatry, Hennepin County Medical Center, USA
[l] University of Minnesota Medical School, Minneapolis, MN, USA

ARTICLE INFO

*Keywords:*
Sleepwalking
Night terrors
Confusional arousals
Dreams
Recall
EEG
Polysomnography
Consciousness

ABSTRACT

Disorders of Arousal (DOA) are non-rapid eye movement (NREM) parasomnias traditionally regarded as unconscious states. However, recent research challenges this assumption. This narrative review aims to explore the presence and qualitative features of conscious experiences in patients with DOA during their episodes. The literature indicates a higher recall of conscious experiences during DOA episodes than previously believed, estimated at about 50–60 % in adults (immediately post-episode). Data on children are limited but suggest a lower recall rate (<30 % when interviewed retrospectively). Patient reports range from brief scenic fragments to elaborate scenarios with plot development, often fraught with negative emotions and misfortunes and with considerable correspondence between subjective experiences and observed behaviors. In many of the described cases, patients appear to enact their dreams, entering a hallucinatory state where internally generated images overlay external percepts. The potential implications for clinical management, research endeavors, and legal considerations regarding nocturnal violence, along with existing limitations and controversial points, are discussed.

## 1. Introduction

Non-rapid eye movement (NREM) sleep parasomnias are a group of common disorders attributed to partial arousal from NREM sleep, typically occurring during N3 slow-wave sleep (SWS) within the initial phase of the main sleep period. Affected patients exhibit complex sleep-related behaviors, and varying degrees of autonomic activity. These phenomena are more prevalent in children (~5 %), peaking around the age of 10, but they may persist and even begin later in life (Stallman and Kohler, 2016). The main type of NREM parasomnias are Disorders of Arousal (DOA), which are defined as recurrent episodes of incomplete awakening, absent or inappropriate responsiveness, limited or no cognition or dream report and partial or complete amnesia for the episode (American Psychiatric Association, 2013; American Academy of Sleep Medicine, 2023). During DOA episodes patients may appear awake, have their eyes open, talk, scream, look around in a perplexed or frightened manner, point at non-existent objects, walk, run, leave their house, drive, eat, engage in sexual acts, and in the process can harm themselves or others (Siclari et al., 2010). They can also throw themselves out of a window and engage in other types of pseudo-suicidal or even homicidal behavior (Mahowald et al., 2003; Castelnovo et al., 2024). Specifically, DOA include three main clinical presentations known as confusional arousals (CA), sleep terrors (ST) and sleepwalking (SW) (also known as somnambulism). CAs manifest as mental confusion

* Correspondence to: via Tesserete 46, Lugano 6900, Switzerland.
** Correspondence to: The Netherlands Institute forNeuroscience, Meibergdreef 47, Amsterdam 1105 BA, the Netherlands.
*E-mail addresses:* anna.castelnovo@eoc.ch (A. Castelnovo), f.siclari@nin.knaw.nl (F. Siclari).

https://doi.org/10.1016/j.neubiorev.2024.105919
Received 5 July 2024; Received in revised form 3 October 2024; Accepted 4 October 2024
Available online 16 October 2024

and/or disoriented behavior occurring within the bed. A variant, sexsomnia or abnormal sleep-related sexual disorder (SRSD), involves inappropriately-timed (and also atypical) sexual behaviors. ST are characterized by sudden episodes of fear and terror, often beginning with alarming vocalizations and screams, accompanied by prominent autonomic arousal signs. SW involves ambulation and complex behaviors outside the bed, such as object manipulation or even driving (Schenck and Mahowald, 1995). Patients may appear awake but typically exhibit reduced responsiveness to verbal and other external clues (Schenck et al., 1989), and are variably insensitive to painful stimuli (Lopez et al., 2015). Sleep-related eating disorder (SRED) is recognized as a distinct type of non-rapid eye movement (NREM) sleep parasomnia. It is characterized by abnormal eating behaviors, where individuals prepare and consume food or drink during sleep. These behaviors can be unusual or excessive, involving the ingestion of atypical combinations of foods, non-food items, or even inedible substances (Mainieri et al., 2023).

International classification systems note the absence or limited presence of mental imagery or cognition in DOA, contrasting with dream-enacting behaviors in rapid eye movement sleep behavior disorder (RBD) (American Academy of Sleep Medicine, 2023). Thus, various neurologists and sleep physicians refrain from diagnosing DOA when patients report vivid mental activity during their episodes [personal observations]. However, a growing number of studies have shown the presence of conscious experiences during DOA episodes. This observation is in line with the demonstration of dreams occurring in all sleep stages (Foulkes, 1964; Mcnamara et al., 2010) including the traditionally "dreamless" SWS (Cavallero et al., 1992). Additionally, current neurophysiological evidence, although limited, converges to show brain activity features during DOA episodes compatible with the re-emergence of consciousness (Terzaghi M. et al., 2009; Sarasso et al., 2014; Bassetti et al., 2000; Terzaghi et al., 2012; Flamand et al., 2018; Ratti et al., 2018; Castelnovo, 2022; Cataldi et al., 2024).

The aim of this review is to synthesize the burgeoning evidence surrounding the compelling topic of conscious experiences during NREM parasomnia episodes in adults, as well as in children, analyze its ramifications concerning the need for revision of diagnostic criteria, provoke debate on this matter, examine its legal and ethical implications (e.g., cases of homicide during sleepwalking), and delve into its scientific implications (e.g., consciousness and local sleep phenomena).

## 2. Study features

The available evidence (> 40 peer reviewed articles and one published book) is based on old anecdotical reports (Yellowlees, 1878; Morris, 1951; Podolsky, 1959; Bonkalo, 1974; Oswald and Evans, 1985; Gottlieb et al., 1986; Howard and D'Orbán, 1987; Broughton et al., 1994; Schenck and Mahowald, 1995; Hartman et al., 2001; Mahowald et al., 2003; Pressman et al., 2005; Ekirch and Shneerson, 2011; Willock, 2022), case reports or case series, and some more recent systematic studies (Fisher et al., 1974; Kales, 1980a, 1980b; Oudiette et al., 2009; Uguccioni et al., 2013; Arnulf et al., 2014; Dubessy et al., 2017; Haridi et al., 2017; Baldini et al., 2019; Castelnovo et al., 2021b; Kalantari et al., 2022; Cataldi et al., 2024). In a minority of the cases, authors captured the episode along with the associated conscious correlate immediately after the patient's awakening (Kales et al., 1966; Fisher et al., 1974; Kavey and Whyte, 1993; Guilleminault et al., 1995; Pressman et al., 1995; Pilon et al., 2008; Pillmann, 2009; Oudiette et al., 2009; Bhat et al., 2012; Mwenge et. al., 2013; Uguccioni et al., 2013; Rocha and Arnulf, 2020; Cataldi et al., 2024). Most studies described the lifetime recollection of conscious experiences associated with DOA episodes. Detailed descriptions of all reviewed studies are provided in Table 1 and Supplementary Materials.

### 2.1. Recall rate of subjective conscious experiences in adult patients with DOA

Only two studies systematically investigated the actual recall rate of subjective conscious experiences during clinical DOA episodes, immediately post-occurrence. One study reported a 58 % recall rate of conscious experiences across 275 episodes from 12 subjects, all affected by ST (Fisher et al., 1974). More recently, a high-density electroencephalography (EEG) study on 75 unanimously scored DOA episodes from 18 patients revealed consistent results. Patients reported conscious experiences after 81 % of episodes, with clear recall of the experience content in 56 %, and no experience (unconsciousness) in 19 % (Cataldi et al., 2024).

Other authors documented instances of conscious experiences upon spontaneous awakening immediately following an episode during video-polysomnography (vPSG), in single case reports or in research studies with primary outcomes other than mental activity (Pressman et al., 1995; Pilon et al., 2008; Bhat et al., 2012; Rocha and Arnulf, 2020).

The majority of the studies investigated and reported high lifetime recollection of conscious experiences in adults with DOA. As the collection of conscious experiences was retrospective, the passage of time could potentially bias the memory of the mental content (Oudiette et al., 2009; Uguccioni et al., 2013; Baldini et al., 2019; Castelnovo et al., 2021b; Kalantari et al., 2022; Siclari, 2024). Nonetheless, these studies suggested that a high percentage of adult subjects (71–77 %) can recall at least one conscious experience associated with a previous nocturnal episode during clinical interviews. Notably, Castelnovo et al. found that 64 % of 25 adult DOA patients reported frequent recollection of conscious contents during episodes (more than half of the time), with one patient reporting recall in every instance. In a more recent study involving 35 adult DOA patients, the majority (94 %) could recall their conscious experiences during at least one parasomnia episode, and roughly one-third (32 %) reported always or often remembering their experiences. These higher percentages may be attributed to the selection criteria for the study, which included patients who experienced at least one DOA episode per week over the past month (Siclari, 2024).

Strong support for the data just cited comes from a series of 25 chronic DOA adult patients (14 males, 11 females; mean age, 35.5 yrs) who had presented for evaluation on account of sleep-related injuries in most cases, and their initial interviews with one of the authors (CHS) was taped recorded and transcribed, with written permission by the patients (Schenck, 2005). Conscious experiences during DOA episodes was reported by 96 % (24/25) of patients, with an imminent threat triggering many DOA episodes in 92 % (23/25) of patients. Data from some of these cases were included in a published series of 54 DOA cases with sleep-related injury (Schenck et al., 1989), along with a sleep-driving case (Schenck and Mahowald, 1995). Additional data on these cases, along with verbatim descriptions of DOA episodes and conscious experiences provided by the patients, spouses, and other family members are contained in the Supplementary Materials.

Notably, the conventional belief that dream recall and dream-enacting behavior are more prevalent in RBD compared to DOA has been challenged by findings from Uguccioni et al. They observed comparable conscious "dream-like" parasomnia-related recollection rates during the lifetime in individuals with DOA (91 %) and RBD (88 %). Moreover, in a laboratory setting, individuals with DOA exhibited higher dream recall rates the next morning (87 %) compared to those with RBD (25 %) (Uguccioni et al., 2013). Subsequently, an independent study reported a similar high recall rate of vivid "dreams" in SW (89 %) compared to RBD (80 %), with > 60 % dream/behavior concordance (Haridi et al., 2017).

Taken together, these positive findings suggest that DOA patients are often conscious during their episodes. However, it must be noted that even after interviewing adults immediately after episodes in the laboratory, a minority of cases (20 %) did not report any experience, and 25 % had the impression of experiencing something but could not

**Table 1**
Summary of reviewed articles.

| Author(s) | Date | Participants | | | Diagnosis | Objective Sleep Evaluation | Method of assessment | Results | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | N | Age (Y) | Sex | | | | Conscious experience | *Quality of conscious experience* | *Isomorphism* |
| **Yellowlees** | 1878 | 1 | 28 | M | SW | - | anedoctal | *yes (at 10 y)* | *hallucinatory* | *yes* |
| **Morris** | 1951 | 1 | Middle age | F | SW/NT | - | anecdotal | *yes* | *dreamlike* | *yes* |
| **Podolsky** | 1959 | 6 | 16-middle age | 86 % M | SW | - | anecdotal | *yes (2 cases)* | *dreamlike* | *yes* |
| **Jacobson et al.** | 1966 | 9 | 15 ± 4 | 78 % M | SW | **EEG, EMG, EOG** | after episode interview ormorning interview | *no* | - | - |
| **Kales et al.** | 1966 | 5 | 9–11(+ 27) | 75 % M(+ 1 F) | SW | **EEG, EMG, EOG** | after episode interview | *no* | - | - |
| **Fisher et al.** | 1974 | 12 (250 nights) | 26–34 (+52) | 83 % M | NT | **PSG** | after episode interview (systematic) | *yes (58 %)* | *fragmentary* | *yes* |
| **Bonkalo** | 1974 | 50 | NA | NA | CA | - | anedoctal | *yes (in 4 cases)* | *dreamlike* | *yes* |
| **Kales et al.** | 1980 | Current: 29Past: 21 | 2934 | 48 % M38 % M | SW | - | life-time interview (systematic) | *yes (48 % current, 10 % past)* | *fragmentary* | *yes* |
| **Kales et al.** | 1980 | ST: 40SW: 29 | 2829 | 53 % M48 % M | NT | - | life-time interview (systematic) | *yes (42 % NT, 48 % SW)* | *fragmentary* | *yes* |
| **Oswald & Evans** | 1985 | 3 | 14, 22, 27 | M | SW | - | anedoctal | *yes (all3 cases)* | *dreamlike* | *yes* |
| **Gottlieb** | 1985 | 1 | young adult | M | NT, past SW | - | anedoctal | *yes* | *delusional/unclear* | *yes* |
| **Howard &D′ Orban** | 1987 | 1 | 17 | M | NT | - | anedoctal | *yes* | *dreamlike* | *NA* |
| **Schenck et al.** | 1989 | 54 | 32 ± 10 | 61 % M | SW/NT | **vPSG** | life-time interview | *yes (many cases)* | *dreamlike, fragmentary or elaborated* | *NA* |
| **Kavey & Whyte** | 1993 | 2 | 34, 34 | F | SW | **vPSG** | life-time interviewafter episode interview | *yes(in one case also immediately after episode)* | *hallucinatory* | *yes* |
| **Broughton et al.** | 1994 | 1 | 23 | M | SW(sleep-driving) | **vPSG** | anecdotal | *yes* | *amnesia with "patchyrecall for isolated events"* | *no* |
| **Schenck and Mahowald** | 1995 | 1 | 43 | M | SW(ICSD−2) | **vPSG** | anecdotal | *yes* | *dreamlike* | *yes* |
| **Guilleminault et al.** | 1995 | 34 | young adults | ~50 % M | SW | **At-home PSG** | life-time interviewfamily interviewafter episode notes | *yes* | *fragmentary, vague nightmarish imagery with fear or impending threat* | *yes* |
| **Pressman et al.** | 1995 | 1 | 35 | M | NT | **vPSG** | after episode interview | *yes* | *dreamlike* | *yes* |
| **Hartman et al.** | 2001 | 22(27 % with trauma history) | 36 ± 9 | 45 % M | SW/NT(DSM-IV) | - | anecdotal | *yes (83 % trauma vs. 25 % w/o trauma)* | *vivid, dreamlikere-enactment in the trauma group* | *reported for the trauma group* |
| **Mahowald et al.** | 2003 | 5 | 20–77 | 100 % M | 2 SW2 SW/NT1 presumed SW/NT | - | anecdotal | *yes* | *dreamlike* | *yes* |
| **Mahowald et al.** | 2005 | 1 | 28 | M | SW | - | family interviewanedoctal | *yes (at 12 y)* | *dreamlike* | *yes* |
| **Pressman et al.** | 2005 | 1 unknown M | | | NT, presumed SW | - | anecdotal | *yes* | *dreamlike, hallucinatory* | *yes* |
| **Pilon et al.** | 2008 | NCG: 10CG: 10 | 26 ± 525 ± 3 | 40 % M30 % M | SW(ICSD−2) | **vPSG** | after episode interview in 4 cases | *yes* | *dreamlike, hallucinatory* | *yes* |
| **Pillmann** | 2009 | 1 | 26 | M | SW(ICSD−2) | **vPSG** | anectotal, post-episode recall (not concomitant to the vPSG) | *yes* | *dreamlike* | *yes* |
| **Oudiette et al.** | 2009 | 38 | 26 ± 7 | 46 % M | SW/NT (ICSD−2) | **vPSG** | life-time interviewmorning interview(systematic) | *yes (71 %)* | *dreamlike* | *yes* |

(*continued on next page*)

**Table 1** (*continued*)

| Author(s) | Date | Participants | | | Diagnosis | Objective Sleep Evaluation | Method of assessment | Results | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Ekirch & Shneerson** | 2011 | 8 | 17–33 | 75 % M | SW | - | anecdotal | *yes* | *dreamlike* | *yes* |
| **Oudiette et al.** | 2011 | 19 | 34 ± 15 | 32 % M | SW(ICSD−2) | **vPSG** | morning interview (systematic) | *yes* | *dreamlike* | *re-enactment of the task* |
| **Bhat et al.** | 2012 | 1 | 27 | M | SW, NT, CA | **vPSG** | life-time interviewafter episode interview (concomitant with vPSG) | *yes* | *dreamlike* | *yes* |
| **Mwenge et al.** | 2013 | 1 | 33 | F | SW, NT | **vPSG+ home-videos** | life-time interviewmorning interview(concomitant home-videos, not with vPSG) | *yes* | *dreamlike* | *yes* |
| **Uguccioni et al.** | 2013 | DOA: 32RBD: 24 | 31 ± 869 ± 9 | 50 % M79 % M | SW NTRBD (ICSD −2) | **vPSG** | life-time interviewafter episode interview ormorning interview(systematic) | *yes* | *dream-like* | *yes* |
| **Arnulf et al.** | 2014 | 73 | 32 ± 10 | 51 % M | SW, NT15 % SRSD23 % SRED(ICSD−2) | **vPSG** | life-time interview via RBD1Q and and RBDSQ questionnaires(systematic) | *yes (53 %)* | *nightmarish with vital threat* | *yes* |
| **Szucs et al.** | 2014 | 9 | 27 ± 6 | 89 % M | SW, NT (ICSD−2) | **vPSG** | life-time interview | *yes* | *frightening, ''claustrophobic'' dreams* | *yes* |
| **Haridi et al.** | 2017 | SW: 62RBD: 64YC: 59OC: 66 | 32 ± 1069 ± 832 ± 967 ± 8 | 47 % M69 % M49 % M65 %M | SW, NT (ICSD−3) | **vPSG** | life-time interview (systematic) | *yes* | *vivid dreams* | *yes* |
| **Dubessy et al.** | 2017 | 17 | 17–76 | 71 % M | SRSD | **vPSG** | life-time interview (systematic) | *yes (18 %)* | *Non-erotic, banal, or even stressful sleep mentation* | *no* |
| **Baldini et al.** | 2019 | 45 | 33 ± 17 | 56 % M | SW, NT, CA (ICSD−3) | **vPSG** | life-time interview (systematic) | *yes (77 %)* | *dream-like with frightening, distress content* | *yes* |
| **Rocha & Arnulf** | 2020 | 1 | 37 | F | SW, NT, CA | **vPSG** | life-time interviewafter episode interviewmorning interview | *yes* | *dream-like* | *yes* |
| **Gnoni et al.** | 2020 | 3 | 33, 35, 59 | 67 % M | CA | **vPSG** | retrospective analysis of clinical records | *yes* | *depersonalization, somatic and visual hallucinations, Cotard delusions* | *yes* |
| **Castelnovo et al. (a)** | 2021 | 1 | 28 | M | SW, CA | **vPSG+ home-videos** | life-time interviewdiary reports | *yes* | *exceptionally complex, long and frequent dreamlike hallucinatory* | *yes* |
| **Castelnovo et al. (b)** | 2021 | Adults: 25Children:20 | 30 ± 610 ± 3 | 40 % M: 70 % M | SW, NT, CA (ICSD−3) (DSM−5) | **vPSG** | life-time interviewfamily interview(systematic) | *Adults (yes 76 %)Children (yes 20 %)* | *dreamlike, hallucinatory* | *yes* |
| **Gnoni et al.** | 2022 | 30 out of 370 (target group) | 33 ± 6 | 30 % M | SW, ST, CA | **vPSG** | retrospective analysis of clinical vPSG records, morning interview | *yes (target group)* | *complex nocturnal visual hallucinations* | *yes* |
| **Willock** | 2022 | 2 | 20NA | 100 % M | SW | - | anecdotal | *yes* | *dreamlike* | *yes* |
| **Kalantari et al.** | 2022 | 188 | 33 ± 10 | 39 % M | SW, NT | **vPSG** | life-time interview (systematic) | *yes (adulthood>adolescence>childhood)* | *NA* | *NA* |
| **Cataldi et al.** | 2024 | 22 | 27 ± 5 | 36 % M | NT, CA | **EEG, EOG, EMG, Video** | after episode interview (systematic) | *yes(56 % full recall,81 % mental recall without content)* | *dreamlike or hallucinatory* | *yes* |
| **Siclari** | 2024 | 35 | 29 ± 8 | 46 % M | ST, NT, CA | **EEG, EOG, EMG, Video** | life-time interview | *yes (94 %)* | *Illusions, hallucinations, dreams* | *yes* |

Abbreviations: CA: confusion arousal, CG: control group, EEG: Electroencephalography, EMG: Electromyography, EOG: Electrooculography, MSLT. Multiple Sleep Latency Test, NA: not available, NT: Night Terrors, NVG: non- violent group, NCG: non control group, OC: old control, RBD: REM Sleep Behavior Disorder, RBD1Q: Single-Question Screen for REM Sleep Behavior Disorder, RBDSQ: REM sleep behavior disorder screening questionnaire, SW: Sleep Walking, VG: violent group, V-PSG: Video Polysomnography, YC: young control. The term "systematic" refers to studies that systematically conducted semi-structured interviews to assess subjective recall in DOA as the primary outcome of the study.

remember the content (Cataldi et al., 2024). In several instances, patients can regain consciousness while carrying out a particular activity or screaming, without any intention in mind, and roughly a third of patients retrospectively report frequently or always experiencing such episodes (Siclari, 2024).

### 2.2. Recall rate in children

Despite the higher frequency of clinical episodes during childhood, only a few papers have reported data on conscious experiences during DOA episodes in this age group. Two older studies based on on a limited number of subjects (4 and 7 children respectively) reported complete amnesia for incidents in the sleep laboratory when children awakened spontaneously immediately afterwards or in the morning (Jacobson et al., 1966; Kales et al., 1966). Oswald and Evans also reported of a 14-year-old boy, who stabbed his cousin, but who denied any memory for the event (Oswald and Evans, 1985).

In instances where conscious “dream-like” recall did occur, the content resembled the observed activity. In the same paper, Oswald and Evans anecdotally described the DOA episodes of a 27-year-old man, who at the age of 10 threw a butter dish out of the window believing it was a bomb (Oswald and Evans, 1985). Podolsky mentioned the case of a 16-year-old girl with night terrors who dreamed that burglars had intruded her home and shot dead her dad and her 6-year-old brother (Podolsky, 1959). Howard and D′Orban documented the case of a 17-year-old guy who dreamed that he was being attacked by shadowy figures in an unfamiliar house and stabbed his friend 20 times (Howard and D’Orbán, 1987). Mahowald et al. (Mahowald et al., 2005) presented a clinical vignette illustrating a potential case of parasomnia-related homicide, where the suspect had a history of sleepwalking since childhood, and frequently experienced dreams involving someone chasing him. Oudiette et al. reported on a child who climbed onto the roof while experiencing an elaborate, movie-like inner scenario. In this scenario, he and his little brother were being chased by strangers (Oudiette et al., 2009).

The only systematic study on this topic was retrospective and reported that 20 % of the interviewed children (n = 20) were able to recall at least one conscious experience associated with their DOA episodes (Castelnovo et al., 2021b). One of these two children reported a full complex hallucinatory experience of a soccer ball being thrown out of the window of the room, which in the dream served as a soccer field. Two additional children (10 %) expressed the feeling of having dreamt something.

A more recent retrospective study in adults found that the frequency of conscious experiences associated with SW increased from childhood through adolescence and into adulthood (Kalantari et al., 2022). In contrast, the recall of sleep mentation related to ST remained consistent over time, likely because highly emotional content is less easily forgotten. Moreover, the frequency of dream recall was positively correlated with the recall of DOA-related conscious experiences.

As discussed in (Castelnovo et al., 2021b), several factors may contribute to the lower recall rate of conscious experiences in children with DOA. These factors include potentially fewer lifetime episodes due to their younger age, or more likely, the lower likelihood of waking up soon after episodes, which directly correlates with recall rate and could influence the recall frequency (Castelnovo et al., 2021b). Developmental differences in brain activity during DOA episodes may also explain the varying recall rates. For example, children exhibit higher, more localized slow wave activity with a more posterior peak of distribution (Kurth et al., 2010; Castelnovo et al., 2023). These differences can also explain lower dream recall rates in young children compared to adults (David Foulkes, 1999). Indeed, dreams are known to develop in frequency and complexity with brain maturation, and to correlate well to visuo-spatial abilities but not language abilities (Nir and Tononi, 2010).

### 2.3. Qualitative features of conscious experiences during DOA episodes

#### 2.3.1. Length/complexity

Conscious experiences during episodes of DOA has been described in varying terms in the literature. Some studies characterized it as fragmentary (Fisher et al., 1974; Kales, 1980a, 1980b; Schenck et al., 1989b), other as static visions of single scenes, while others reported complex, dynamic conscious contents with plot development (Oudiette et al., 2009; Pillmann, 2009; Castelnovo et al., 2021a, 2021b; Siclari, 2024). Some discrepancies emerge between studies in the frequency of simple versus complex conscious experiences, possibly due to the methodology used to classify the experiences and the intrinsic variability of patient reports. While Oudiette et al. reported a single visual scene in 96 % of cases (Oudiette et al., 2009), Castelnovo et al. (Castelnovo et al., 2021b) found "static" images in about 50 % of cases (both children and adults). Siclari reported that 22 % of patients described their experiences as always or often being long and story-like, never short and scene-like. In contrast, 69 % of patients reported their experiences as always or often consisting of a short single scene, rarely or never being story-like (Siclari, 2024).

Of note, Cataldi et al., reported 32 conscious experiences collected immediately after observed DOA episodes (Cataldi et al., 2024). These experiences were mainly constructed delirious / dreamlike scenarios (78 %) but also included isolated imagery (16 % e.g., cookies, landscapes) or thoughts (6 %, e.g., about taxes, bills).

### 2.4. Content

The reported content of conscious experiences described in the literature spanned a wide range, from scenarios involving self-preservation or protecting loved ones from perceived dangers (e.g., fire, ceiling collapse, earthquake, insect or rodent infestation, confinement in an inescapable box, encountering strange machinery approaching the bed) to instances of defending against assailants and intruders (e.g., strangulation, confrontation with a large snake, burglary, giant spiders descending from the ceiling, entry of a person through a bedroom transom). These occurrences typically (about 50 % of the cases) took place within the patients’ homes, predominantly in the bedroom setting (Uguccioni et al., 2013; Castelnovo et al., 2021a, 2021b).

Notably, Cataldi et al. upon immediate recall (Cataldi et al., 2024) reported similar scenarios, with patients attempting to prevent impending danger or its consequences (e.g., finding a baby daughter who had fallen off the bed) alongside more ordinary situations (e.g., explaining how to fall asleep quietly).

Gnoni et al. recently reported three cases of NREM parasomnias associated with Cotard delusion (Gnoni et al., 2020) characterized by feelings of being dead and/or qualitative alterations in the sense of bodily being due to bizarre sensations in the body.

In some instances, reported content appeared to be linked to actual events or past memories (Morris, 1951; Hartman et al., 2001; Arnulf et al., 2014; Baldini et al., 2019; Rocha and Arnulf, 2020). One study investigated "re-enacting" behaviors from preceding wakefulness, where patients with DOA (n = 19) were trained to memorize a sequential visuo-motor task during the day. Only one patient exhibited nearly exact replication of the trained motor memory during a DOA episode (raising both arms as if to press imaginary response buttons). However, this patient reported a feeling of having dreamt but was unable to recall any conscious/dream content (Oudiette et al., 2011).

When compared to dream reports associated with RBD episodes, “dream” reports in DOA were notably longer when collected in an in-laboratory setting after an immediate or morning recall (Uguccioni et al., 2013). However, they were less complex overall, though they contained similar levels of bizarre elements and threats. Notably, conscious experiences in DOA was marked by a lower level of aggression and a higher occurrence of misfortunes and disasters compared to RBD.

Furthermore, DOA reports featured more discontinuous elements, characterized by sudden appearances or disappearances. In contrast, RBD dream reports showcased more instances of human and animal aggression. In DOA, subjects mainly fled from disasters, with only 25 % fighting back when attacked. On the other hand, 75 % of RBD subjects counterattacked when assaulted. Interestingly, the bedroom was included in the dream setting in 42 % of DOA reports, while almost never in RBD dreams (Uguccioni et al., 2013).

### 2.5. Content – action isomorphism

Isomorphism, denoting a close correspondence between the subjective conscious experience reported by patients and the actual motor behaviors observed by witnesses or through video-recordings, has been frequently documented. This phenomenon has been reported in older anecdotal case reports (Bonkalo, 1974; Yellowlees, 1878; Ekirch and Shneerson, 2011), as well as in more recent studies capturing episodes during vPSG or through home-video recordings (Kavey and Whyte, 1993; Schenck and Mahowald, 1995; Pressman et al., 2005; Pilon et al., 2008; Oudiette et al., 2009; Bhat et al., 2012; Mwenge et al., 2013; Uguccioni et al., 2013; Rocha and Arnulf, 2020; Castelnovo et al., 2021a).

Interestingly, a recent serial awakening study with immediate recal of DOA-related conscious experiences, reported that in about half of cases there was a clear correspondence between the reported experience and behavior, while in 13 % it was only partially apparent, in 34 % there was no apparent correspondence, and in 6 % the report was completely incompatible with the behavior (Cataldi et al., 2024).

#### 2.5.1. Emotions

Emotions frequently associated with DOA episodes have been reported to be predominantly negative and distinctly unpleasant, including apprehension, fear, and fright over misfortune and imminent danger and claustrophobia scenarios (Bonkalo, 1974; Yellowlees, 1878; Fisher et al., 1974; Oswald and Evans, 1985; Gottlieb et al., 1986; Kavey and Whyte, 1993; Broughton et al., 1994; Guilleminault et al., 1995; Schenck and Mahowald, 1995; Hartman et al., 2001; Mahowald et al., 2003; Pressman et al., 2005; Pilon et al., 2008; Oudiette et al., 2009; Pillmann, 2009; Ekirch and Shneerson, 2011; Bhat et al., 2012; Mwenge et al., 2013; Uguccioni et al., 2013; Arnulf et al., 2014; Szűcs et al., 2014; Haridi et al., 2017; Baldini et al., 2019; Rocha and Arnulf, 2020; Castelnovo et al., 2021a, 2021b). Interestingly, a study on facial expressions during sleep found that while frowns were observed in adults during normal sleep, particularly during REM sleep, overtly negative facial expressions were primarily seen in patients with parasomnias (Maranci et al., 2021).

In contrast, reports of neutral or even positive emotions were substantially less frequent (Kavey and Whyte, 1993; Guilleminault et al., 1995; Oudiette et al., 2009; Baldini et al., 2019; Castelnovo et al., 2021a). Only in a minority of cases were patients with DOA observed to exhibit laughter during episodes, suggesting an underlying sense of mirth (e.g., sleep joking) (Clé et al., 2019). However, two crucial points must be underscored regarding the described emotions. Firstly, conscious experiences were usually retrospectively collected over a lifetime span, suggesting the potential for negative emotions recall bias. Secondly, the time elapsed between the events and reporting to someone else could influence the memory of conscious experiences.

This discrepancy is evident in two different studies conducted by Siclari et al.: while a negative emotional tone was reported to occur often or always in 75 % of patients interviewed retrospectively (Siclari, 2024), in a laboratory setting, overt expressions of fear were observed in only 23 % of DOA episodes (Cataldi et al., 2024).

### 2.6. Phenomenology

Conscious experiences associated with DOA episodes are frequently described as dreamlike (Bonkalo, 1974; Fisher et al., 1974; Schenck and Mahowald, 1995; Hartman et al., 2001; Pressman et al., 2005; Oudiette et al., 2009, 2011, 2012; Pillmann, 2009; Nir and Tononi, 2010; Uguccioni et al., 2013; Szűcs et al., 2014; Haridi et al., 2017; Rocha and Arnulf, 2020; Castelnovo et al., 2021b) or as nightmarish (Morris, 1951; Arnulf et al., 2014). The prevalent characterization of the content of conscious experience associated with DOA episodes as dreamlike stems from the understanding that dreams are mental and experiential phenomena occurring during sleep, characterized by diminished attention and volitional control, lack of self-awareness, altered reflective thinking, occasional hyperemotionality, and memory impairment. Typically, when dreaming, individuals are unaware that they are dreaming and are oblivious to their physical location. They do not realize their lack of influence on the dream plot or the presence of temporal incompatibilities and bizarre elements, except in cases of lucid dreaming (Baird et al., 2019). This altered consciousness or reduced reflective consciousness is a hallmark feature of dreams (Siclari et al., 2020). In contrast, waking conscious experiences entail an awareness of internally generated images, temporal and spatial orientation, and the ability to consciously control thoughts or images when recalling the past, contemplating the future, or allowing thoughts to wander.

More specifically, conscious experiences during episodes of DOA has been associated with NREM dreams (Oudiette et al., 2009) and reported as fragmentary (Fisher et al., 1974; Kales, 1980a, 1980b; Schenck et al., 1989b), thought-like (Oudiette et al., 2009; Arnulf et al., 2014) or confused (Bonkalo, 1974). Indeed, in healthy subjects, NREM dreams tend to be less vivid, less complex, less narrative-driven (Foulkes, 1996). Consistent with these observations, a study comparing REM sleep behavior disorder (RBD) with DOA found that RBD dreams were typically more intricate and story-like (Uguccioni et al., 2013).

However, other authors have variously described DOA conscious experiences as imagelike (Oudiette et al., 2009), vivid (Oswald and Evans, 1985; Hartman et al., 2001) or bizarre (Oudiette et al., 2009; Uguccioni et al., 2013).

Notably, conscious experiences during DOA has sometimes been described as hallucinatory (Kavey and Whyte, 1993; Castelnovo et al., 2021b, 2021a; Schenck, 2005) due to a lack of reality testing combined with sensory illusions or misidentifications of persons (akin to a Capgras syndrome), in which patients misinterpret elements of their environment (Siclari, 2024) or false perceptions. In these instances, internally generated characters and objects are projected into the real home environment. Ninety-one of the patients interviewed by (Siclari, 2024) reported at least one episode with false perceptions, and roughly half of the patients (53 %) experienced them always or often. In some cases, specific elements of the external environment were hallucinated, while in certain rare extreme instances, the entire environment could be hallucinated. In a laboratory study, hallucinations and/or perceptual illusions were present in 52 % of episodes (Cataldi et al., 2024). Hallucinations were reported to be multisensory in nature and never criticised by the patients. Additionally, indirect evidence of hallucinatory experience is provided by "pointing behaviors" during episodes (Pilon et al., 2008; Mwenge et al., 2013; Castelnovo et al., 2021b), and by content analysis of DOA mentation, which highlighted the high prevalence of in-home settings as confirmed by Castelnovo et al. (2021b), and Uguccioni et al. (2013). These experiences are more akin to psychotic-like hallucinatory experiences than to dreaming experiences (Castelnovo et al., 2021b).

Brain activity in this particular state must be unique due to the subjects' ability to interact in a complex manner with the environment while experiencing hallucinations, allowing for the ability to move without stumbling or falling during an episode. Interestingly, Gnoni et al. recently described complex nocturnal visual hallucinations in DOA patients associated with low-voltage mixed-frequency EEG activity before eye opening. This activity persisted while patients were observed staring or visually tracking before the onset of motor behavior (Gnoni et al., 2022).

### 2.7. Sexsomnia, sleep related eating disorders and swallowing and choking syndrome

Despite the paucity of available literature, it is also interesting to underline how sexsomnia, a variant of DOA (CA), is rarely reported to have any associated conscious experience (Andersen et al., 2007; Organ and Fedoroff, 2015; Schenck, 2015; Pirzada et al., 2019). Strikingly, in a series of 17 patients, aggressive content or content involving misfortune was not been described (Dubessy et al., 2017). In another series of 24 patients with sexsomnia, only one subject reported aggressive content, and another reported erotic content, while three others described variable, unrelated content (Rossi et al., 2023). In the same case series, only 4 out of 24 patients could partially or fully regain full consciousness soon after the episodes. Among them, one participant reported waking up with the feeling that sexual intercourse had been initiated before falling asleep, while another recalled waking up in the middle of the act and noticing he was wearing a condom, with no memory of having put it on. Another NREM parasomnia, sleep related eating disorder could be associated with variable degree of conscious experiences, but considerably less frequently than the classic DOA (Winkelman et al., 2011; Brion et al., 2012; Inoue, 2015).

A rare variant of sleep terrors, known as parasomniac choking, involves sudden arousals during N3 sleep accompanied by a terrifying sensation of choking, despite the upper airways being open. This is often associated with a hallucinatory perception of swallowing an unusual object that obstructs the airway, which they try to either swallow or pull out of their mouth (Flamand et al., 2015). Reported objects include rings, nails, pebbles, chewing gum, spoons, forks, electrical cables, lizard tails, needles, brushes, computers, or gas containers. In this specific form of DOA, hallucination is the rule, and the absence of such content is the exception.

### 2.8. Impact on clinical management

According to international diagnostic criteria (both ICSD-3-TR and DSM-5), one of the key criteria for diagnosing DOA is the presence of partial or complete amnesia for the episode and limited imagery, such as a single visual scene.

Based on the findings of the current review, there is a risk that these criteria may lead to the erroneous exclusion of DOA diagnosis when patients report conscious experiences during episodes. This concern is reinforced by a recent study indicating that sensitivity for DOA diagnosis in adults improves when the ICSD-3-TR/DSM-5 criteria regarding conscious content recollection and event amnesia are disregarded (Loddo et al., 2019).

Therefore, these findings underscore the importance of advocating for a revision of the diagnostic criteria for DOA in future editions of international guidelines to optimize them for diagnosing both traditional amnestic cases during childhood and adult cases that are frequently associated with complex conscious experiences (dreams, hallucinations) (Mainieri et al., 2023). A note regarding "recurrent, complex dream-enacting behaviors during the episodes in some adults" has been included in the ICSD-3-TR. However, no modifications in the diagnostic criteria of DOA (or of any other sleep disorder) were allowed in the ICSD-3-TR due to the constraints imposed by the Board of Directors of the American Academy of Sleep Medicine (American Academy of Sleep Medicine, 2023). In this respect, the Montpelier group has recently proposed updates to the DOA diagnostic criteria and classifications (Lopez and Dauvilliers, 2024). Our suggestion, based on the current literature cited herein, is that ICSD- 3-TR criterion C (limited or absent cognition or imagery) should be revised to now read: “In children there is usually limited (e.g. single visual scene) or absent cognition or imagery. However, in adults, associated cognition or dream imagery can range from being absent to limited to complex and lengthy dream-like/hallucinatory experiences” (Mainieri et al., 2023). Also, Criterion D (partial or complete amnesia for the episode) should be modified to now read: “In children there is usually complete or partial amnesia for the episode. However, in adults there can be a broad range of recall, from complete or partial amnesia to substantial recall”.

Additionally, the acknowledgment that dream-enacting behaviors may frequently occur in adult DOA, and not just exclusively in RBD, will inevitably heighten diagnostic challenges. However, other factors identified in the current review may aid in differentiating between DOA and RBD. These include incorporating an home-setting environment, or observing escape behaviors rather than aggressive actions. An additional level of complexity could be represented by other conditions, such as Obstructive Sleep Apnea Pseudo-RBD (Antelmi et al., 2021) and Sleep-Related Psychogenic Disorders (Lopez et al., 2022), which could involve similar reports of dream-enacting behaviors.

In this respect, we expect that, enhancing the characterization of conscious experiences during clinical episodes and implementing standardized questionnaires for collecting conscious experiences immediately upon awakening from abnormal behavioral episodes, will enhance the diagnostic specificity of vPSG, especially in the differential diagnosis between DOA and Sleep-related Hypermotor Epilepsy.

### 2.9. Impact for dream research

A major challenge in dream research is studying a phenomenon that occurs during sleep and can only be examined through recall and reports after the fact. While dream reports are essential and generally reliable for scientific investigation, they are inherently fleeting and prone to recall bias, which can lead to distortions or omissions in memory. Spontaneous or provoked awakenings in a lab setting are considered the "gold standard" for collecting dream reports, but these methods may introduce biases due to the controlled experimental conditions. NREM parasomnias, similar to sleep talking (Alfonsi et al., 2019), offer an intriguing window to accessing dream experiences. The congruence between observed behaviors (both before awakening and during post-episode confusion) and the reported conscious experience suggests that the patients’ reports are not solely reflective of confabulation or prolonged mental confusion after NREM parasomnia episodes. Moreover, EEG studies have shown that brain activity following episodes with conscious recollections significantly differs from brain activity following episodes without conscious experiences, which supports the reliability of these reports.

However, it must be noted that: 1) some indifferences exist between typical dreams and NREM parasomnias reported conscious experiences (see next paragraph); 2) clear inconsistencies between reported content and parasomnia behavior were observed in up to 40 % of cases (Siclari, 2024), similar to findings in sleep talking research, where concordance was absent in 30–40 % of NREM sleep talking episodes and in only ~15 % of REM speech episodes (Arkin et al., 1970). These discrepancies may be related to patients reporting dreams that occurred prior to the parasomnia episode, which may not match their behavior during the event. Additionally, some conscious scenarios, such as visualizing landscapes or thinking about taxes, may not produce clear, observable behaviors.

Despite the aforementioned potential limitations, NREM parasomnia episodes can still offer valuable insights into existing dream theories. In this context, the frequent retrospective reports of negative emotional tones and threat-related content lend particular relevance to the Threat Simulation Theory of dreaming (Valli and Revonsuo, 2009, Scarpelli et al., 2024). This theory suggests that dreaming serves an evolutionary purpose by simulating threatening situations, allowing individuals to rehearse and refine survival strategies in a safe environment. More specifically, the mental content associated with sleep terrors (ST) often aligns with scenarios predicted by the Threat Simulation Theory, including imminent danger (Uguccioni et al., 2013). In line with this, postpartum mothers frequently report dreaming about their baby being in danger, often accompanied by behaviors like sitting up in bed and searching for the baby. These actions are indicative of confusional

arousals and are clearly reported by mothers as dream-enacted behaviors (Nielsen and Paquette, 2007). It can be postulated that these frequent dreams, often enacted, simulate high-risk threats in new parents and may represent a universal human experience. These types of content (e.g., baby in danger) have been frequently observed in various case series (Oudiette et al., 2009) and in video-confirmed ST, SW, and CA behaviors (Mwenge et al., 2013, Cataldi et al., 2024).

NREM parasomnias may also align with an alternative model (which is not mutually exclusive): the Emotion Regulation Theory (Levin and Nielsen, 2009). This theory posits that normal dreaming serves a fear-extinction function (Wamsley and Stickgold, 2010), with nightmares representing failures in emotion regulation due to two key processes: 1) affect load, which is influenced by daily emotional pressures, and 2) affect distress, which is a predisposition to experience events with heightened negative emotional reactivity. Applying this framework to NREM parasomnias, stress can elevate affect load (Lopez et al., 2013; Baldini et al., 2019; Castelnovo et al., 2021c) thereby increasing the frequency and intensity of episodes. Additionally, a heightened susceptibility to affect distress may shape the phenomenological expression of NREM parasomnias, particularly within its various subtypes.

### 2.10. Impact on consciousness research

The phenomenological descriptions of conscious experiences during parasomnia episodes reviewed here help characterize the associated states of consciousness. As illustrated in Fig. 1, a recent unified framework of conscious experiences (Martial et al., 2020), building on two previous models (Laureys, 2005; Sanders et al., 2012) Laureys et al., 2005), conceptualizes consciousness as a multifaceted phenomenon with three major dimensions: wakefulness, connectedness, and internal awareness. According to this model, patients with NREM parasomnias experience a clear dissociation among these three dimensions during their nocturnal episodes. Specifically, NREM parasomnia states can be seen as occupying an intermediate level of wakefulness and existing on a continuum with respect to connectedness and internal awareness. This framework also allows for comparisons between NREM parasomnias and other subjective experiences with similar states of consciousness but different phenomenology, such as NREM dreaming and hallucinations.

Similar to NREM sleep, consciousness during parasomnia episodes appears to vary during this state, ranging from episodes with unconsciousness and largely automatic behaviors to vivid conscious experiences. When consciousness is present, it displays several core features of dreaming consciousness, including delusional thinking, hallucinations, metacognitive deficits, impaired insight, and variable, but often pronounced, amnesia (Siclari, 2024). However, unlike normal dreaming, a state in which consciousness is disconnected from the environment in both the motor and sensory domains, in sleepwalking motor output is, by definition, present as patients can translate intentions into actions. Sensory disconnection, on the other hand, is variable. As illustrated by several examples (Siclari, 2024) in some cases patients are totally disconnected from their envrionment, moving within fully hallucinated surroundings, while in other cases they can perceive and interact with the real environment. Again in other cases, the environment is "perceived" but misinterpreted, in the form of perceptual illusions or misidentification syndromes, suggesting that the connection to the environment is present along a "perception-illusion-hallucination" continuum (Siclari, 2024). In addition, like dream consciousness (Tononi et al., 2024), consciousness in NREM parasomnia episodes can

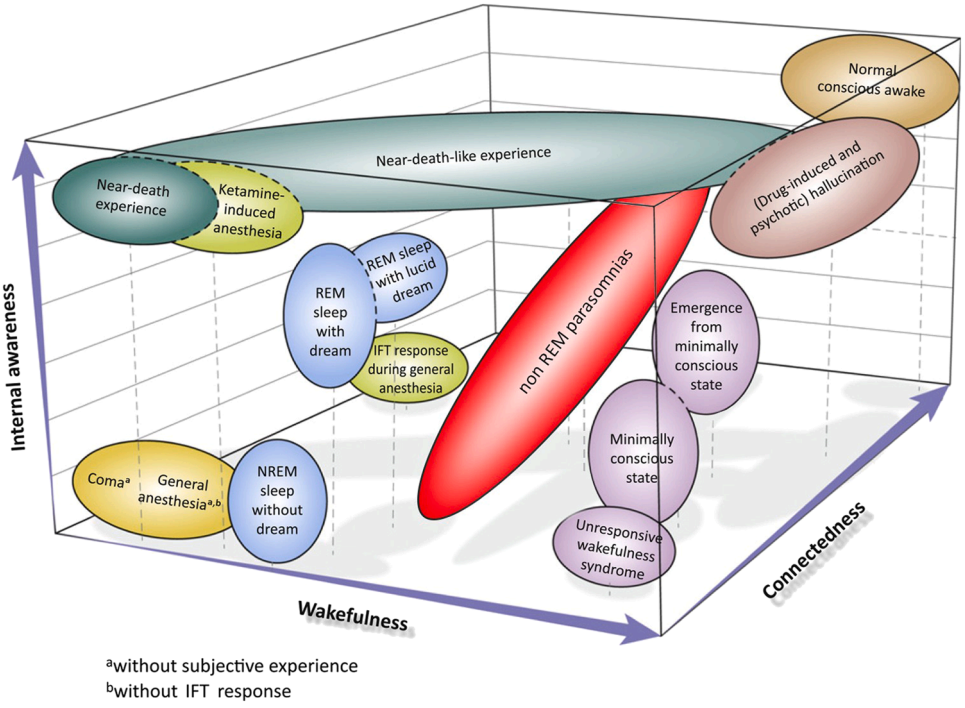


**Fig. 1. Illustration of Different States and Conditions Based on Wakefulness, Connectedness, and Internal Awareness.** Wakefulness is typically associated with spontaneous or stimulus-induced eye opening. Internal awareness refers to first-person subjective experiences—such as mental imagery, inner speech, or mind-wandering—that are independent of external stimuli. Connectedness (or external awareness) indicates the engagement with the external world, allowing the experience of external stimuli, whether in a state of wakefulness or non-wakefulness. These three major components can be used to study physiologically, pharmacologically, and pathologically altered states of consciousness. The shadows drawn on the bottom flat surface of the figure allow to situate each state with respect to levels of wakefulness and connectedness. In a normal conscious awake state, the three components are at their maximum level. In contrast, states such as coma and general anesthesia have these three components at their minimum level. All the other states and conditions have at least one of the three components not at its maximum. NREM parasomnias can be regarded as intermediate sleep-wake states with various degrees of internal awareness and disconnection from the environment, offering a unique approach to study disconnected consciousness in humans. Abbreviations: IFT, isolated forearm technique; NREM, non-rapid eye movement; REM, rapid eye movement. This figure was adapted from Martial et al., (2020). The work was re-used under open access license (CCY BY)].

be variably dissociated from memory, metacognition, executive functions, and even behavior, appearing thus in a particularly "pure" and uncontaminated form, conferring further experimental advantages for the study of consciousness. Thus, because of the variably preserved consciousness and sensory disconnection from the environment, NREM parasomnias represent a valuable model to study the neural correlates of these features.

In particular, understanding whether local wake-like activity observed during DOA episodes is sufficient to facilitate the re-emergence of consciousness, and to what extent, can pave the way for novel research into consciousness and its neurobiological underpinnings. The diminished awareness of the surroundings and amnesia have been suggested to relate to an increased or persistent bursts of sleep-like delta waves across frontoparietal associative networks and hippocampal spindles (Terzaghi et al., 2009; Terzaghi et al., 2012), while complex motor behaviors relate to the activation of the motor cortex (Terzaghi et al., 2012). Similarly, the heightened emotional nature of DOA could result from the limbic system's activation, including the cingulate cortex, insular cortex, temporopolar cortices, and amygdala (Terzaghi et al., 2012), disengaged from the prefrontal cortex. Interestingly, a slight decrease in delta power and a distinct emergence of beta activity has been recorded within the ventralis intermedius nucleus (Vim) of the thalamus in one stereo-EEG study (Sarasso et al., 2015). The fact that Vim is thought to function as a hub for sensory-motor integration (Mai and Forutan, 2012) suggests that the thalamic gate for transmission from the periphery to the cortex is partially open, potentially allowing for partial responsiveness to peripheral stimuli. However, it remains unclear whether this is sufficient to enable conscious experiences.

Consciousness has been previously investigated in both physiological and pathological conditions, such as dreams (Nir and Tononi, 2010; Siclari et al., 2017) and coma (Casali et al., 2013). Dreaming, opposed to unconsciousness, was shown to be associated with lower delta power and higher beta and gamma power over posterior brain regions in a high-density EEG study comprising over 1000 serial awakenings (Siclari et al., 2017). The ability to recall dream experiences in this study correlated with high-frequency brain activity in more anterior regions (Siclari et al., 2017, 2018). Interestingly, a case study involving 20 episodes from a 12-year-old sleepwalker (Castelnovo et al., 2022), revealed lower slow wave activity power spectral density values compared to slow-wave sleep in a similar posterior cortical spot . The only study in which conscious experiences and amnesia were probed immediately after behavioral DOA episodes in 22 patients and related to brain activity, measured with high-density EEG, found similar activations to those previously documented for dreams when patients were reporting conscious experiences, suggesting that DOA experiences share EEG correlates with dreams (Cataldi et al., 2024). Again, similar to the dream study, the ability to recall conscious experiences correlated with EEG activity in a separate set of brain regions compared to amnesia, suggesting different correlates for amnesia of episodes and actual conscious experiences.

While a negative correlation between EEG slow wave activity (1–4 Hz) and sleep-related conscious experiences is largely acknoledged, one should not draw conclusions about unconscious states from slow wave activity alone (Frohlich et al., 2021). In frontal brain regions for instance, slow wave amplitude positively correlates with dream experiences in normal sleep and during DOA episodes (Siclari et al., 2018; Cataldi et al., 2024). In this context, other measures can be informative, such as electrophysiological complexity indices alongside spectral power (Frohlich et al., 2021). Traditional measures of brain connectivity, such as Lempel–Ziv complexity coherence and phase transfer entropy, offer promising avenues for exploring the relationship between mental activity, consciousness level, and underlying brain dynamics during DOA episodes. For example, Castelnovo et al. (Castelnovo et al., 2022) observed higher levels of connectivity using phase transfer entropy during DOA episodes compared to those during slow wave sleep, and more similar to those during wakefulness (Nieminen et al., 2016). Future studies employing these techniques are poised to offer valuable insights into DOA episodes and, on a broader scale, into altered conscious mental states characterized by hallucinatory and dissociative experiences.

### 2.11. Impact on legal issues

DOA episodes may involve violent actions resulting in harm to oneself or others (Siclari et al., 2010). The reviewed medical literature delineates several instances of homicide or attempted homicide (Yellowlees, 1878; Morris, 1951; Podolsky, 1959; Oswald and Evans, 1985; Gottlieb et al., 1986; Howard and D'Orbán, 1987; Broughton et al., 1994; Mahowald et al., 2005; Ekirch and Shneerson, 2011; Willock, 2022) and sexual assault (Ekirch and Shneerson, 2011) occurring during suspected DOA episodes.

Determining the presence/level of consciousness during DOA episodes and their potential role in intentional actions is crucial, as "Murder only exists when there is provable intent to kill" (Broughton et al., 1994). Based on the current electrophysiological evidence indicating the abnormal coexistence of local sleep and wakefulness, "normal" daytime consciousness cannot be presumed during DOA episodes. As reviewed, individuals experiencing DOA appear to undergo hallucinatory and delusional states during these episodes, making them unaware of the consequences that their actions have in the real external environment. Regrettably, due to the lack of clear legal guidance and diagnostic criteria, some offenders have been convicted while others have been acquitted, and legal controversies surrounding sleep-related criminal cases persist, as the presence of parasomnia cannot be definitively proven at the time the defendant purportedly committed the offense (Castelnovo et al., 2024). Since cases often lack diagnostic clarity, one study conducted by Castelnovo et al. (2024) proposed updated guidance to enhance future reporting and understanding of such incidents, to establish a clear diagnosis and differentiate sleep-related violent acts from feigned behavior.

## 3. Limitations and future perspectives

Some earlier reports, primarily from an older literature, exhibited a lack of methodological precision (e.g. Podolsky et al., 1959) in describing conscious experiences during DOA episodes. These reports relied on anecdotal evidence from dramatic clinical cases or case reports, often involving violent and aggressive behaviors. The methodological procedures for assessing conscious experiences were frequently not reported, and diagnoses were often based solely on clinical history and observed behaviors during episodes, without objective sleep assessments (Bonkalo, 1974; Yellowlees, 1878; Howard and D'Orbán, 1987; Pressman et al., 2005; Ekirch and Shneerson, 2011). Among most studies reviewed, only some mentioned adherence to international diagnostic criteria, varying according to the respective publication years (ICSD-1, ICSD-2, ICSD-3, DSM-4, DSM-5).

In all systematic studies except for Kales et al. (Kales, 1980a, 1980b), vPSG was integrated into the diagnostic procedure. However, even in studies where clinical diagnosis was objectively evaluated, the methodology for assessing dream recall or mental content exhibited substantial variability across studies. This variability encompassed factors such as the timing of recall (retrospective lifetime recollection, recall immediately post-episode during laboratory vPSG, or morning recall following in-laboratory vPSG), the nature of the interview ("Were you dreaming or not, just before waking up?" or "What was going through your mind before waking up?"), the format of the interview (unstructured and spontaneous records versus structured interviews), the sample size (ranging from 1 to 73), the age range (from children to young adults and older adults, with most patients in their 30 s), and the involvement of witnesses or family members during clinical interviews (Kales, 1966; Kales et al., 1966; Castelnovo et al., 2021b).

Small sample sizes and inconsistent assessment methods may limit

the generalizability of findings and obscure potential patterns of conscious experiences. For instance, the current literature does not yet allow for a detailed assessment of differences in recall among various NREM sleep parasomnia subtypes, and our conclusions on children are mainly based on one single study.

To address the aforementioned methodological shortcomings in future research, we recommend conducting studies with larger sample sizes to stratify for age and clinical subtype to improve generalizability, and employing standardized and consistent assessment methods to reduce variability and enhance the reliability of data on conscious experience and behavior. In particular, future research should focus on conducting serial awakening paradigms in pediatric populations.

## 4. Conclusions

The extent of conscious experience during DOA episodes has been a subject of ongoing and growing discussion (Longe et al., 2022). This review aimed to ascertain whether DOA episodes correlate with conscious experiences and, if so, to what degree and in what form. Despite certain limitations across the literature, a consistent trend of evidence has emerged, indicating that many affected individuals could recall their subjective experiences during DOA episodes (approximately 70–90 % recall of at least one episode in their lifetime, and about 50–60 % of the episodes are followed by a conscious experience if patients are actively probed immediately after the episode's end), with an "isomorphism" between subjective counscious experiences and acted behaviors in more than half of the cases.

Notably, while gender-specific differences are not extensively documented, age discrepancies are apparent, with significantly higher recall rates noted in adults compared to children. Furthermore, the described conscious experiences often manifested as fragmentary and brief, but could also be intricate and lengthy, and frequently accompanied by negative emotions and misfortune. Additionally, the reported coscious content commonly exhibited vivid, dreamlike characteristics, with some authors highlighting its hallucinatory nature based on both observed behavior and subjective accounts.

## Acknowledgments

We would like to thank Matteo Broggi for his invaluable graphical support in creating Fig. 1. F.S. is supported by the European Research Council Starting Grant no. 101039782 DREAMSCAPE.

## Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.neubiorev.2024.105919.

## Data Availability

No data was used for the research described in the article.

## References

Alfonsi, V., D'Atri, A., Scarpelli, S., Mangiaruga, A., De Gennaro, L., 2019. Sleep talking: a viable access to mental processes during sleep. Sleep. Med Rev. 44, 12–22. https://doi.org/10.1016/j.smrv.2018.12.001.

American Academy of Sleep Medicine, 2023. The International Classification of Sleep Disorders – Third Edition, Text Revision (ICSD-3-TR). Darien, IL: American Academy of Sleep Medicine.

American Psychiatric Association, 2013. Diagnostic and Statistical Manual of Mental Disorders. American Psychiatric Association. https://doi.org/10.1176/appi.books.9780890425596.

Andersen, M.L., Poyares, D., Alves, R.S.C., Skomro, R., Tufik, S., 2007. Sexsomnia: abnormal sexual behavior during sleep. Brain Res Rev. 56, 271–282. https://doi.org/10.1016/j.brainresrev.2007.06.005.

Antelmi, E., Lippolis, M., Biscarini, F., Tinazzi, M., Plazzi, G., 2021. REM sleep behavior disorder: mimics and variants. Sleep. Med Rev. 60. https://doi.org/10.1016/J.SMRV.2021.101515.

Arkin, A.M., Toth, M.F., Baker, J., Hastey, J.M., 1970. The degree of concordance between the content of sleep talking and mentation recalled in wakefulness. J. Nerv. Ment. Dis. 151, 375–393. https://doi.org/10.1097/00005053-197012000-00003.

Arnulf, I., Zhang, B., Uguccioni, G., Flamand, M., de Fontréaux, A.N., Leu-Semenescu, S., et al., 2014. A scale for assessing the severity of arousal disorders. Sleep 37, 127–136. https://doi.org/10.5665/sleep.3322.

Baird, B., Mota-Rolim, S.A., Dresler, M., 2019. The cognitive neuroscience of lucid dreaming. Neurosci. Biobehav Rev. 100, 305. https://doi.org/10.1016/J.NEUBIOREV.2019.03.008.

Baldini, T., Loddo, G., Sessagesimi, E., Mignani, F., Cirignotta, F., Mondini, S., et al., 2019. Clinical features and pathophysiology of disorders of arousal in adults: a window into the sleeping brain. Front Neurol. 10. https://doi.org/10.3389/fneur.2019.00526.

Bassetti, C., Vella, S., Donati, F., Wielepp, P., Weder, B., 2000. SPECT during sleepwalking. Lancet 356, 484–485. https://doi.org/10.1016/S0140-6736(00)02561-7.

Bhat, S., Chokroverty, S., Kabak, B., Yang, Q.R., Rosen, D., 2012. Dream-enacting behavior in non-rapid eye movement sleep. Sleep. Med 13, 445–446. https://doi.org/10.1016/j.sleep.2011.10.029.

Bonkalo, A., 1974. Impulsive acts and confusional states during incomplete arousal from sleep: Criminological and forensic implications. Psychiatr. Q 48, 400–409. https://doi.org/10.1007/BF01562162.

Brion, A., Flamand, M., Oudiette, D., Voillery, D., Golmard, J.-L., Arnulf, I., 2012. Sleep-related eating disorder versus sleepwalking: a controlled study. Sleep. Med 13, 1094–1101. https://doi.org/10.1016/j.sleep.2012.06.012.

Broughton, R., Billings, tR., Cartwright, tR., Doucette, D., Edmeads, tJ., Edwardh, M., et al. (1994). Medico-legal Issues Homicidal Somnambulism: A Case Report. 17, 253–264. Available at: https://academic.oup.com/sleep/article/17/3/253/2749505 (Accessed January 30, 2024).

Casali, A.G., Gosseries, O., Rosanova, M., Boly, M., Sarasso, S., Casali, K.R., et al., 2013. A theoretically based index of consciousness independent of sensory processing and behavior. Sci. Transl. Med 5. https://doi.org/10.1126/scitranslmed.3006294.

Castelnovo, A., Amacker, J., Maiolo, M., Amato, N., Pereno, M., Riccardi, S., et al., 2022. High-density EEG power topography and connectivity during confusional arousal. Cortex 155, 62–74. https://doi.org/10.1016/j.cortex.2022.05.021.

Castelnovo, A., Lividini, A., Riedner, B.A., Avvenuti, G., Jones, S.G., Miano, S., et al., 2023. Origin, synchronization, and propagation of sleep slow waves in children. Neuroimage 274, 120133. https://doi.org/10.1016/j.neuroimage.2023.120133.

Castelnovo, A., Loddo, G., Provini, F., Manconi, M., 2021a. Frequent, complex and vivid dream-like/hallucinatory experiences during NREM sleep parasomnia episodes. Sleep. Med 82, 61–64. https://doi.org/10.1016/j.sleep.2021.03.032.

Castelnovo, A., Loddo, G., Provini, F., Miano, S., Manconi, M., 2021b. Mental activity during episodes of sleepwalking, night terrors or confusional arousals: differences between children and adults. Nat. Sci. Sleep. Volume 13, 829–840. https://doi.org/10.2147/NSS.S309868.

Castelnovo, A., Schraemli, M., Schenck, C.H., Manconi, M., 2024. The parasomnia defense in sleep-related homicide: a systematic review and a critical analysis of the medical literature. Sleep. Med Rev. 74, 101898. https://doi.org/10.1016/j.smrv.2024.101898.

Castelnovo, A., Turner, K., Rossi, A., Galbiati, A., Gagliardi, A., Proserpio, P., et al., 2021c. Behavioural and emotional profiles of children and adolescents with disorders of arousal. J. Sleep. Res 30. https://doi.org/10.1111/jsr.13188.

Cataldi, J., Stephan, A.M., Haba-Rubio, J., Siclari, F., 2024. Shared EEG correlates between non-REM parasomnia experiences and dreams. Nat. Commun. 15, 3906. https://doi.org/10.1038/s41467-024-48337-7.

Cavallero, C., Cicogna, P., Natale, V., Occhionero, M., and Zito, A. (1992). Dream Research Slow Wave Sleep Dreaming. *Sleep* 15, 562–566. Available at: ⟨https://academic.oup.com/sleep/article/15/6/562/2749336⟩ (Accessed March 14, 2024).

Clé, M., Maranci, J.B., Weyn Banningh, S., Lanfranchi, J., Vidailhet, M., Arnulf, I., 2019. Smiling asleep: a study of happy emotional expressions during adult sleep. J. Sleep. Res 28, e12814. https://doi.org/10.1111/jsr.12814.

David Foulkes, 1999. Children's Dreaming and the Development of Consciousness. Harvard University Press.

Dubessy, A.-L., Leu-Semenescu, S., Attali, V., Maranci, J.-B., and Arnulf, I. (2017). Sexsomnia: A Specialized Non-REM Parasomnia? *Sleep* 40. doi: 10.1093/sleep/zsw043.

Ekirch, A.R., Shneerson, J.M., 2011. Nineteenth-century sleep violence cases: a historical view. Sleep. Med Clin. 6, 483–491. https://doi.org/10.1016/j.jsmc.2011.08.007.

Fisher, C., Kahn, E., Edwards, A., Davis, D.M., Fine, J., 1974. A Psychophisiological study of nightmares and night terrors. J. Nerv. Ment. Dis. 158, 174–188. https://doi.org/10.1097/00005053-197403000-00002.

Flamand, M., Boudet, S., Lopes, R., Vignal, J.-P., Reyns, N., Charley-Monaca, C., et al., 2018. Confusional arousals during non-rapid eye movement sleep: evidence from intracerebral recordings. Sleep 41. https://doi.org/10.1093/sleep/zsy139.

Flamand, M., Herlin, B., Leu-Semenescu, S., Attali, V., Launois, C., Arnulf, I., 2015. Choking during sleep: can it be an expression of arousal disorder? Sleep. Med. 16 (11), 1441–1447. https://doi.org/10.1016/j.sleep.2015.03.023.

Foulkes, D., 1964. Theories of dream formation and recent studies of sleep consciousness. Psychol. Bull. 62, 236–247. https://doi.org/10.1037/H0042134.

Foulkes, D., 1996. Dream Research: 1953-1993. Sleep 19, 609–624. https://doi.org/10.1093/sleep/19.8.609.

Frohlich, J., Toker, D., Monti, M.M., 2021. Consciousness among delta waves: a paradox? Brain 144, 2257–2277. https://doi.org/10.1093/brain/awab095.

Gnoni, V., Duncan, I., Wasserman, D., Higgins, S., Drakatos, P., Birdseye, A., et al., 2022. Nocturnal visual hallucinations in patients with disorders of arousal: a novel

behavioral and EEG pattern. Croat. Med J. 63, 438–447. https://doi.org/10.3325/cmj.2022.63.438.
Gnoni, V., Higgins, S., Nesbitt, A.D., Wasserman, D., Duncan, I., Birdseye, A., et al., 2020. Cotard parasomnia: le délire de negation that occur during the sleep-wake dissociation? J. Clin. Sleep. Med. 16, 971–976. https://doi.org/10.5664/jcsm.8430.
Gottlieb, P., Christensen, O., Kramp, P., 1986. On serious violence during sleep-walking. Br. J. Psychiatry 149, 120–121. https://doi.org/10.1192/bjp.149.1.120b.
Guilleminault, C., Moscovitch, A., Leger, D., 1995. Forensic sleep medicine: nocturnal wandering and violence. Sleep 18, 740–748. https://doi.org/10.1093/sleep/18.9.740.
Haridi, M., Weyn Banningh, S., Clé, M., Leu-Semenescu, S., Vidailhet, M., Arnulf, I., 2017. Is there a common motor dysregulation in sleepwalking and <scp>REM</scp> sleep behaviour disorder? J. Sleep. Res 26, 614–622. https://doi.org/10.1111/jsr.12544.
Hartman, D., Crisp, A.H., Sedgwick, P., Borrow, S., 2001. Is there a dissociative process in sleepwalking and night terrors? Post. Med J. 77, 244–249. https://doi.org/10.1136/pmj.77.906.244.
Howard, C., D'Orbán, P.T., 1987. Violence in sleep: medico-legal issues and two case reports. Psychol. Med 17, 915–925. https://doi.org/10.1017/S0033291700000726.
Inoue, Y., 2015. Sleep-related eating disorder and its associated conditions. Psychiatry Clin. Neurosci. 69, 309–320. https://doi.org/10.1111/pcn.12263.
Jacobson, A., Kales, A., Lehmann, D., Zweizig, J.R. (1966). Somnambulism: All-Night Electroencephalographic Studies. *American Association for the Advancement of Science*.
Kalantari, N., McDuff, P., Pilon, M., Desautels, A., Montplaisir, J.-Y., Zadra, A., 2022. Self-reported developmental changes in the frequency and characteristics of somnambulistic and sleep terror episodes in chronic sleepwalkers. Sleep. Med 89, 147–155. https://doi.org/10.1016/j.sleep.2021.12.008.
Kales, A., 1966. Somnambulism: Psychophysiological Correlates. Arch. Gen. Psychiatry 14, 595. https://doi.org/10.1001/archpsyc.1966.01730120035005.
Kales, A., 1980a. Somnambulism. Arch. Gen. Psychiatry 37, 1406. https://doi.org/10.1001/archpsyc.1980.01780250092011.
Kales, J.D., 1980b. Night Terrors. Arch. Gen. Psychiatry 37, 1413. https://doi.org/10.1001/archpsyc.1980.01780250099012.
Kales, A., Jacobson, A., Paulson, M.J., Kales, J.D., Walter, R.D., 1966. Somnambulism: Psychophysiological Correlates. Arch. Gen. Psychiatry 14, 586. https://doi.org/10.1001/archpsyc.1966.01730120026004.
Kavey, N.B., Whyte, J., 1993. Somnambulism Associated With Hallucinations. Psychosomatics 34, 86–90. https://doi.org/10.1016/S0033-3182(93)71932-5.
Kurth, S., Jenni, O.G., Riedner, B.A., Tononi, G., Carskadon, M.A., Huber, R., 2010. Characteristics of sleep slow waves in children and adolescents. Sleep 33, 475–480. https://doi.org/10.1093/SLEEP/33.4.475.
Laureys, S., 2005. The neural correlate of (un)awareness: lessons from the vegetative state. Trends Cogn. Sci. 9, 556–559. https://doi.org/10.1016/j.tics.2005.10.010.
Levin, R., Nielsen, T., 2009. Nightmares, bad dreams, and emotion dysregulation. Curr. Dir. Psychol. Sci. 18, 84–88. https://doi.org/10.1111/j.1467-8721.2009.01614.x.
Loddo, G., Vignatelli, L., Zenesini, C., Lusa, F., Sambati, L., Baldelli, L., et al., 2019. Interobserver reliability of ICSD-3 diagnostic criteria for disorders of arousal in adults. Sleep. Breath. 23, 1309–1314. https://doi.org/10.1007/s11325-019-01937-w.
Longe, O., Omodan, A., Leschziner, G., Rosenzweig, I., 2022. Non-REM parasomnias: a scoping review of dreams and dreamlike mentation. Croat. Med J. 63, 525–535. https://doi.org/10.3325/cmj.2022.63.525.
Lopez, R., Dauvilliers, Y., 2024. Challenges in diagnosing NREM parasomnias: Implications for future diagnostic classifications. Sleep. Med Rev. 73. https://doi.org/10.1016/J.SMRV.2023.101888.
Lopez, R., Jaussent, I., Dauvilliers, Y., 2015. Pain in sleepwalking: a clinical enigma. Sleep 38, 1693. https://doi.org/10.5665/SLEEP.5144.
Lopez, R., Jaussent, I., Scholz, S., Bayard, S., Montplaisir, J., Dauvilliers, Y., 2013. Functional impairment in adult sleepwalkers: a case-control study. Sleep 36, 345–351. https://doi.org/10.5665/sleep.2446.
Lopez, R., Lefevre, L., Barateau, L., Micoulaud-Franchi, J.-A., Dauvilliers, Y., Schenck, C. H., 2022. A series of 8 cases of sleep-related psychogenic dissociative disorders and proposed updated diagnostic criteria. J. Clin. Sleep. Med. 18, 563–573. https://doi.org/10.5664/jcsm.9654.
Mahowald, M.W., Schenck, C.H., Bornemann, M.A.C., 2005. Sleep-related violence. Curr. Neurol. Neurosci. Rep. 5, 153–158. https://doi.org/10.1007/s11910-005-0014-3.
Mahowald, M.W., Schenck, C.H., Goldner, M., Bachelder, V., Cramer-Bornemann, M., 2003. Parasomnia pseudo-suicide. J. Forensic Sci. 48, 2002399. https://doi.org/10.1520/JFS2002399.
Mai, J.K., Forutan, F., 2012. Thalamus. The Human Nervous System. Elsevier, pp. 618–677. https://doi.org/10.1016/B978-0-12-374236-0.10019-7.
Mainieri, G., Loddo, G., Provini, F., Nobili, L., Manconi, M., Castelnovo, A., 2023. Diagnosis and management of NREM sleep parasomnias in children and adults. Diagnostics 13, 1261. https://doi.org/10.3390/DIAGNOSTICS13071261.
Maranci, J.B., Aussel, A., Vidailhet, M., Arnulf, I., 2021. Grumpy face during adult sleep: a clue to negative emotion during sleep? J. Sleep. Res 30, e13369. https://doi.org/10.1111/jsr.13369.
Martial, C., Cassol, H., Laureys, S., Gosseries, O., 2020. Near-death experience as a probe to explore (Disconnected) consciousness. Trends Cogn. Sci. 24, 173–183. https://doi.org/10.1016/j.tics.2019.12.010.
Mcnamara, P., Johnson, P., Mclaren, D., Harris, E., Beauharnais, C., Auerbach, S., 2010. Rem and nrem sleep mentation. *Int Rev. Neurobiol.* 92 69–86. https://doi.org/10.1016/S0074-7742(10)92004-7.
Morris, N., 1951. Somnambulistic Homicide: Ghosts, Spiders, and North Koreans. Res Judicatae 5, 29.
Mwenge, B., Brion, A., Uguccioni, G., Arnulf, I., 2013. Sleepwalking: long-term home video monitoring. Sleep. Med 14, 1226–1228. https://doi.org/10.1016/j.sleep.2013.04.027.
Nielsen, T., Paquette, T., 2007. Dream-associated behaviors affecting pregnant and postpartum women. *Comparative Study*. Sleep 30 (9), 1162–1169. https://doi.org/10.1093/sleep/30.9.1162.
Nieminen, J.O., Gosseries, O., Massimini, M., Saad, E., Sheldon, A.D., Boly, M., et al., 2016. Consciousness and cortical responsiveness: a within-state study during non-rapid eye movement sleep. Sci. Rep. 6, 30932. https://doi.org/10.1038/srep30932.
Nir, Y., Tononi, G., 2010. Dreaming and the brain: from phenomenology to neurophysiology. Trends Cogn. Sci. 14, 88–100. https://doi.org/10.1016/j.tics.2009.12.001.
Organ, A., Fedoroff, J.P., 2015. Sexsomnia: sleep sex research and its legal implications. Curr. Psychiatry Rep. 17, 34. https://doi.org/10.1007/s11920-015-0568-y.
Oswald, I., Evans, J., 1985. On serious violence during sleep-walking. Br. J. Psychiatry 147, 688–691. https://doi.org/10.1192/bjp.147.6.688.
Oudiette, D., Constantinescu, I., Leclair-Visonneau, L., Vidailhet, M., Schwartz, S., Arnulf, I., 2011. Evidence for the re-enactment of a recently learned behavior during sleepwalking. PLoS One 6, e18056. https://doi.org/10.1371/journal.pone.0018056.
Oudiette, D., Leu, S., Pottier, M., Buzare, M.-A., Brion, A., Arnulf, I., 2009. Dreamlike mentations during sleepwalking and sleep terrors in adults. Sleep 32, 1621–1627. https://doi.org/10.1093/sleep/32.12.1621.
Pillmann, F., 2009. Complex dream-enacting behavior in sleepwalking. Psychosom. Med 71, 231–234. https://doi.org/10.1097/PSY.0b013e318190772e.
Pilon, M., Montplaisir, J., Zadra, A., 2008. Precipitating factors of somnambulism symbol: impact of sleep deprivation and forced arousals. Neurology 70, 2284–2290. https://doi.org/10.1212/01.WNL.0000304082.49839.86/ASSET/0E50E55E-4E1C-480C-A921-48874AB3AFC4/ASSETS/GRAPHIC/6FSM1.GIF.
Pirzada, A., Almeneessier, A.S., BaHammam, A.S., 2019. Abnormal sexual behavior during sleep: sexsomnia and more. Sleep. Vigil. 3, 81–89. https://doi.org/10.1007/s41782-019-00057-5.
Podolsky, E., 1959. Somnambulistic homicide. Med Sci. Law 1, 260–265. https://doi.org/10.1177/002580246100100304.
Pressman, M.R., Mahowald, M.W., Schenck, C.H., 2005. Sleep terrors/sleepwalking–Not REM behavior disorder. Sleep 28, 278–279. https://doi.org/10.1093/sleep/28.2.278.
Pressman, M.R., Meyer, T.J., Kendrick-Mohamed, J., Figueroa, W.G., Greenspon, L.W., Peterson, D.D., 1995. Night terrors in an adult precipitated by sleep apnea. Sleep 18, 773–775. https://doi.org/10.1093/sleep/18.9.773.
Ratti, P.-L., Amato, N., David, O., Manconi, M., 2018. A high-density polysomnographic picture of disorders of arousal. Sleep 41. https://doi.org/10.1093/sleep/zsy162.
Rocha, A.L., Arnulf, I., 2020. NREM parasomnia as a dream enacting behavior. Sleep. Med 75, 103–105. https://doi.org/10.1016/j.sleep.2020.02.024.
Rossi, J., Gales, A., Attali, A., Leu-Aemenescu, A., Dodet, P., Groos, E., Arnulf, I., 2023. do the eeg and behavioral criteria of nrem arousal disorders apply to sexsomnia? Sleep 46 (7), zsad056. https://doi.org/10.1093/sleep/zsad056.
Sanders, R.D., Tononi, G., Laureys, S., Sleigh, J.W., Warner, D.S., 2012. Unresponsiveness ≠ Unconsciousness. Anesthesiology 116, 946–959. https://doi.org/10.1097/ALN.0b013e318249d0a7.
Sarasso, S., Pigorini, P., Proserpio, S., Gibbs, A., Massimini, M., Nobili, L., 2015. Fluid boundaries between wake and sleep: experimental evidence from stereo-EEG recordings. Arch. Ital. Biol. https://doi.org/10.12871/0002982920142311.
Scarpelli, S., Alfonsi, V., De Gennaro, L., 2024. Exploring the role of dreams: insights from recent studies. Curr. Opin. Pulm. Med. https://doi.org/10.1097/MCP.0000000000001112.
Schenck, 2005. Schenck D.C.H. Paradox Lost - Midnight in the Battleground of sleep and dreams - violent moving Nightmares, REM sleep behavior disorder, first ed., 2005. Extreme-Nights, LLC.
Schenck, C.H., 2015. Update on Sexsomnia, Sleep Related Sexual Seizures, and Forensic Implications. NeuroQuantology 13. https://doi.org/10.14704/nq.2015.13.4.873.
Schenck, C.H., Mahowald, W., 1995. A polysomnographically documented case of adult somnambulism with long-distance automobile driving and frequent nocturnal violence: parasomnia with continuing danger as a noninsane automatism? Sleep 18, 765–772. Available at: https://academic.oup.com/sleep/article/18/9/765/2749747.
Schenck, C.H., Milner, D.M., Hurwitz, T.D., Bundlie, S.R., Mahowald, M.W., 1989. A polysomnographic and clinical report on sleep-related injury in 100 adult patients. Am. J. Psychiatry 146, 1166–1173. https://doi.org/10.1176/AJP.146.9.1166.
Siclari, F., 2024. Consciousness in non- <scp>REM</scp> -parasomnia episodes. J. Sleep. Res. https://doi.org/10.1111/jsr.14275.
Siclari, F., Baird, B., Perogamvros, L., Bernardi, G., LaRocque, J.J., Riedner, B., et al., 2017. The neural correlates of dreaming. Nat. Neurosci. 20, 872–878. https://doi.org/10.1038/nn.4545.
Siclari, F., Bernardi, G., Cataldi, J., Tononi, G., 2018. Dreaming in NREM sleep: a high-density EEG study of slow waves and spindles. J. Neurosci. 38, 9175–9185. https://doi.org/10.1523/JNEUROSCI.0855-18.2018.
Siclari, F., Khatami, R., Urbaniok, F., Nobili, L., Mahowald, M.W., Schenck, C.H., et al., 2010. Violence in sleep. Brain 133, 3494–3509. https://doi.org/10.1093/brain/awq296.
Siclari, F., Valli, K., Arnulf, I., 2020. Dreams and nightmares in healthy adults and in patients with sleep and neurological disorders. Lancet Neurol. 19, 849–859. https://doi.org/10.1016/S1474-4422(20)30275-1.
Stallman, H.M., Kohler, M., 2016. Prevalence of sleepwalking: a systematic review and meta-analysis. PLoS One 11, e0164769. https://doi.org/10.1371/journal.pone.0164769.

Szűcs, A., Kamondi, A., Zoller, R., Barcs, G., Szabó, P., Purebl, G., 2014. Violent somnambulism: a parasomnia of young men with stereotyped dream-like experiences. Med Hypotheses 83, 47–52. https://doi.org/10.1016/j.mehy.2014.04.012.

Terzaghi, M., Sartori, I., Tassi, L., Didato, G., Rustioni, V., LoRusso, G., et al., 2009. Evidence of dissociated arousal states during NREM parasomnia from an intracerebral neurophysiological study. Sleep 32, 409–412. https://doi.org/10.1093/sleep/32.3.409.

Terzaghi, Michele, Sartori, I., Tassi, L., Rustioni, V., Proserpio, P., Lorusso, G., et al., 2012. Dissociated local arousal states underlying essential clinical features of non-rapid eye movement arousal parasomnia: an intracerebral stereo-electroencephalographic study. J. Sleep. Res 21, 502–506. https://doi.org/10.1111/j.1365-2869.2012.01003.x.

Tononi, G., Boly, M., Cirelli, C., 2024. Consciousness and sleep. Neuron 112, 1568–1594. https://doi.org/10.1016/j.neuron.2024.04.011.

Uguccioni, G., Golmard, J.-L., de Fontréaux, A.N., Leu-Semenescu, S., Brion, A., Arnulf, I., 2013. Fight or flight? Dream content during sleepwalking/sleep terrors vs rapid eye movement sleep behavior disorder. Sleep. Med 14, 391–398. https://doi.org/10.1016/j.sleep.2013.01.014.

Valli, K., Revonsuo, A., 2009. The threat simulation theory in light of recent empirical evidence: a review. Am. J. Psychol. 122, 17–38.

Wamsley, E.J., Stickgold, R., 2010. Dreaming and offline memory processing. Curr. Biol. 20, R1010–R1013. https://doi.org/10.1016/j.cub.2010.10.045.

Willock, B., 2022. On dreaming, parasomnia, dream enactment, and murder. Psychoanal. Psychol. 39, 97–110. https://doi.org/10.1037/pap0000382.

Winkelman, J.W., Johnson, E.A., Richards, L.M., 2011. Sleep-related eating disorder. Handb. Clin. Neurol. 98, 577–585. https://doi.org/10.1016/B978-0-444-52006-7.00037-X.

Yellowlees, D., 1878. Homicide by a Somnambulist. J. Ment. Sci. 24, 451–458. https://doi.org/10.1192/bjp.24.107.451.