5.
DREAM ENACTMENT AND VIOLENT BEHAVIOUR DURING REM SLEEP
A new forensic and psychophysiological issue

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Until a few decades ago sleep was considered a «passive» state, namely a physiological condition for resting and recovery from the fatigue accumulated in the previous period of wake, without signs of cognitive activity except the sporadic occurrence of dreaming. Today a wealth of laboratory, neurophysiological and behavioural data indicates that sleep is a considerably «active» state of the brain associated with various cognitive, autonomic, endocrine, and motor fluctuations (Mong *et al.*, 2011).

A complex and continuous cognitive activity has been documented during all stages of sleep in laboratory studies since the discovery of rapid eye movements (REM) sleep (Aserinsky & Kleitman, 1953) and cyclical architecture of sleep (Dement & Kleitman, 1957). In particular, mental activity with more or less dream-like (i.e., vivid, bizarre and dramatic) features is reported after about 50% of awakenings from non-REM (NREM) sleep and about 80% of awakenings from REM sleep (for review, see Nielsen, 2000). Moreover, a period of sleep following training further enhances and stabilizes memory consolidation of new items of declarative and non-declarative knowledge. Conversely, changes in the duration and/or circadian location of sleep (consequent to an experimental manipulation mimicking the everyday condition of shift-workers) impair the consolidation process during sleep and thus reduce memory performance in subsequent waking.

In addition, motor events (such as gross body movements, leg and arm movements and vocalizations) occur during REM and NREM sleep in normal (i.e., healthy) subjects, as documented in laboratory studies (for review, see Montagna, 2003). Some of these events may be complex and potentially aggressive and violent in patients with NREM and REM sleep parasomnia (namely disorders of arousal, and REM sleep behaviour disorder – RBD), and nocturnal epileptic seizures (Plazzi *et al.*, 2005).

Clinical observations and laboratory data (collected using polygraphic techniques) from the 1950s have convergently indicated that aggressive and violent behaviours occur quite frequently during sleep, albeit with different characteristics, in patients with NREM and REM sleep parasomnias. These findings have

raised the problem of the potential coexistence of sleep and violence in a larger proportion of the general population than is usually supposed on the basis of dramatic media reports of (nearly always) somnambulistic homicide or attempted homicide (Broughton *et al.*, 1994; Cartwright, 2004). This issue has several aspects relevant for sleep medicine (diagnosis and therapy of the motor dyscontrol during sleep), forensic medicine (lack of individual responsibility for physical harm to other people during sleep: Filley *et al.*, 2001), and psychophysiology of sleep and dreaming (role of the physical and social environment as a «trigger» for arousal disorders and dream enactment: Siclari *et al.*, 2010).

Here we report some epidemiological data on violent behaviours during sleep, and then focus on a specific type of aggressive-violent behaviour occurring in RBD cases. The sleep medicine interest in RBD consists in evaluating the effectiveness of both behavioural strategies and sleep habits to prevent violent behaviours, and of drug therapy for their treatment and/or inhibition. The forensic interest in RBD consists in identifying sleep-related variations (up to the loss) of individual responsibility for the consequences of violent and potentially dangerous behaviours (the coexistence of sleep and violence being known since the middle ages – for review, see Cartwright, 2004). The psychophysiological interest in RBD, as enacting contents of the concomitant dream experience, consists in the possibility to observe the motor characteristics of behaviours, and hence the reciprocal influence of environmental stimuli and dream experience.

5.1. Violent behaviours in NREM sleep parasomnias

The most widely applied definition of «violence» in the context of sleep-related forensic medicine is of an aggressive act inflicting unwarranted physical harm on other people or him/herself (Filley *et al.*, 2001). This act can be considered as not «premeditated», namely purposeful and goal-directed, but rather «impulsive», that is a response to a frustrating or threatening event that induces anger and occurs regardless of any potential goal (Siever, 2008).

It is currently well-documented that several sleep disorders, including parasomnias and nocturnal epileptic seizures (mainly in the context of nocturnal frontal or temporal lobe epilepsy), may have a potential for violent behaviours during sleep (for review, see Schenck *et al.*, 2009), even if the association of violence and sleep is not an essential feature of any sleep disorder. In NREM sleep, violent behaviours have been reported during sleepwalking, sleep terrors and confusional arousals and within the context of frontal lobe and temporal lobe seizures. In REM sleep, violent behaviours have been reported in association with RBD.

The prevalence rate of sleep-related violent (namely, directed to oneself, other individuals or to objects, without awareness of the action and with complete amnesia of the episode upon awakening) behaviours in the general population is not negligible. It has been estimated at about 2% in a large population study carried out using telephone interviews (Ohayon *et al.*, 1997). The prevalence rate

is obviously much higher in samples of patients with sleep disorders who consult sleep clinics: for example, patients responsible for harmful behaviours among those consecutively recruited at a sleep clinic for sleep terrors and sleepwalking (59%; Moldofsky *et al.*, 1995) and those with nocturnal wandering of different etiologies (70%; Guilleminault *et al.*, 1995).

The disorders of arousal, which are common in childhood (20%), but may persist in adulthood (4%), consist of incomplete awakenings from NREM sleep, usually slow wave sleep (SWS) and in the first half of the night. They are characterized by reduced vigilance, impaired cognition, retrograde amnesia for the motor event and various motor activities (from repetitive and purposeless movements to complex behaviours such as eating, driving and aggression: American Academy of Sleep Medicine, 2005). The most frequent disorders are confusional states upon awakening (e.g., sleepwalking and sleep terror, with intense autonomic activation and unresponsiveness to external stimuli) and rarely recur over the same night or arise from daytime naps. When reported, mental activities associated with episodes of sleepwalking or sleep terrors are usually unpleasant, with aggression on behalf of the sleeper (24%), misfortune (54%) and apprehension (84%) (Oudiette *et al.*, 2009b).

The diagnosis of sleepwalking and related disorders is largely based on clinical history, as they rarely occur during standard sleep recordings for diagnostic purposes. Thus, sleep recording data (except the possible occurrence of one or complex behaviours during the night of sleep recording) cannot by themselves constitute definitive evidence for the diagnosis of sleepwalking. This contrasts with forensic practice, where defence experts and attorneys usually seek to find some piece of evidence able to convince the court that the client was likely to have been sleepwalking when the criminal act was committed. It is apparent that more reliable indications could be provided by a multi-night observation of possible nocturnal episodes by means of infrared-videocamera recordings at home, as recently made for the purposes of differential diagnosis (Derry *et al.*, 2009; Nobili, 2009).

Aggressive/violent behaviors accompanying disorders of arousal seem to occur in different ways across confusional arousals (after awakening provoked by someone else), sleepwalking (when the individual is approached by another person or incidentally encounters someone else during the sleepwalking episode) and sleep terrors (a reaction to a dreamed or hallucinated frightening image that the individual can subsequently describe). Physical contact and proximity seem to play an important role as triggering factors of sleep-related violence in confusional arousals (about 100%), sleep terrors (about 80%) and sleepwalking cases (from 40 to 90%) associated with «provocations», including noise, touch and/or close proximity of the victim (for review, see Pressman, 2007).

Functional neuroimaging studies on normal subjects have shown that during NREM sleep the prefrontal cortex is hypoactive compared with the resting wakeful state (Maquet *et al.*, 1996, 1997; Braun *et al.*, 1997; Kaufmann *et al.*, 2006). These findings have suggested that arousal disorders share some characteristics of both sleeping and waking states, as confirmed by observations on patients

with arousal disorders and nocturnal frontal lobe epilepsy (Bassetti *et al.*, 2000; Vetrugno *et al.*, 2005; Terzaghi *et al.*, 2009). However, even if violent behaviours are facilitated by the hypoactivity of prefrontal associative cortices (being functionally related to planning, attention and judgement), their occurrence on a particular night depends on a balance between SWS pressure and arousing factors. Arousing factors are environmental (auditory and tactile) stimuli and perhaps some contents of mental activity itself, which are however rarely reported accurately after awakening (Oudiette *et al.*, 2009b), as patients are often in a confusional state. A dysfunctional coexistence of local cortical arousal and local cortical sleep has been recently documented in a patient with arousal disorder who incidently underwent an intracerebral stereo-electroencephalographic study (Terzaghi *et al.*, 2012).

It is also noteworthy that episodes of sleepwalking-related violence against other individuals almost never occur more than once (Schenck & Mahowald, 1995). The majority of cases describe close proximity or direct provocation before violent behaviours. The functional deactivation of the frontal lobes during SWS may be similar to changes in frontal lobe size and activity that has been reported in individuals prone to waking violence. It thus seems plausible that incomplete gating of afferent impulses by the thalamus may allow sleepwalking episodes to be triggered and sleepwalking violence to occur. Since there is no evidence of substantial neurophysiological and polysomnographic differences between violent sleepwalkers and other sleepwalkers, it may be supposed that the casual presence of physical contact or proximity with other individuals could be the most frequent (and perhaps important) factor distinguishing violent from nonviolent sleepwalkers.

5.2. VIOLENT BEHAVIOURS AND REM SLEEP PARASOMNIAS

Since the first description (Schenck *et al.*, 1986), RBD, which is characterized by a loss of normal muscle atonia and increase in phasic muscle activity during REM sleep, is the REM sleep parasomnia most often associated with enactment (i.e., acting out) of content of the concomitant mental activity. Violent behaviours have been posited to be an enactment of aggressive contents of the concomitant mental activity. This enactment may occur during all periods of REM sleep, but more frequently in those of the second half of the night in all patients except those with narcolepsy. RBD is more prevalent in males after the age of 50 (again except patients with narcolepsy-cataplexy: see below) and in at least 60% of cases represents an early (often the first) manifestation of a synucleinopathy (including Parkinson's disease, multisystem atrophy and dementia with Lewy bodies: for review, see Iranzo *et al.*, 2009) or is associated with brainstem lesions or limbic encephalitis.

Dream enactment also occurs in idiopathic RBD, a chronic progressive disorder toward a neurodegenerative disease (with a conversion rate of 46% within

5 years), with increasing complexity, intensity, and frequency of expressed behaviours. Although irregular jerking of the limbs may occur nightly in RBD patients, the major movement episodes appear intermittently. Vocal behaviours range from short vocalizations to long articulated speech. Most patients complain of sleep injury but rarely of sleep disruption, being awakened by the, often persistent, yelling of the bed-partner rather than by their own violent activity.

The contents of mental activity of patients with idiopathic and secondary RBD are more aggressive than those of normal subjects, regardless of their level of daytime waking aggressiveness (Fantini *et al.*, 2005).

Violence with RBD may result in injury to the patient him/herself (generally occurring when the patient hits the furniture or wall, or falls out of bed) or bed-partner, sometimes with severe injuries (in about 3% of cases: Boeve, 2010; Olson *et al.*, 2000; Schenck *et al.*, 2009). In RBD patients arousal from sleep to alertness and orientation is usually immediate and accompanied by fairly detailed recall of dream content (unlike the confusional arousals observed in the disorders of arousal such as sleepwalking or sleep terrors). After awakening, behaviour and social interactions are appropriate, again contrary to disorders of arousal, or delirious states, and the autonomic activation is always low or absent, contrasting with the frightened awakening from NREM parasomnia. Moreover, the motor activities during REM sleep, although complex and violent, are briefer than those seen in disorders of arousal.

The polygraphic evidence of increased phasic muscle activity and loss of normal muscle atonia (RWA) during REM sleep (the cut-off scores having been provided by Montplaisir *et al.*, 2010, and by Ferri *et al.*, 2008, respectively) is considered the hallmark for diagnosis of RBD (American Academy of Sleep Medicine, 2005). The presence of dream recall is not considered sufficient to reliably differentiate RBD from arousal disorders (Schenck & Mahowald, 2005; Mahowald *et al.*, 2011). Appropriate medication can suppress both the most vigorous sleep behaviours and the abnormal dreaming of RBD patients (Pelayo & Deepti, 2010).

Dream-enacted episodes usually do not play out customary dreams, but rather distinctly altered, stereotypical repetitive, and «action-packed» dreams. A «typical RBD nightmare» experienced by RBD patients consists of an attack by animals or unfamiliar, sometimes bizarre people (Olson, 2000; Boeve *et al.*, 2007; Schenck & Mahowald, 2005). In response to this attack the dreamer would either fight back in self-defence or else attempt to flee. The often contradictory behavioural correlate (e.g., a man fighting to defend his wife from an aggressor whereas is actually striking her in bed) of the dramatic event experienced during an RBD episode is clearly indicative of the functioning of several cognitive processes (multimodal perception and attention, memory and imagery) during REM sleep.

The potentially great interest in RBD for the general understanding of dreaming relies on the «interactive» components (such as physical and verbal contact and environmental stimuli) of several RBD episodes. Indeed, both clinical reports and laboratory observation have suggested that two distinct processes, namely an initial «acting out one's dream» and a subsequent «dreaming around

one's action», may co-exist in an RBD episode (Boeve *et al.*, 2007). This means that convergent indications of how a dream is developed in concomitance with an RBD episode may be gathered from PSG indicators, behavioural (video)recordings, and dream reports (Arnulf, 2010, 2012).

5.3. RBD IN PATIENTS WITH NARCOLEPSY-CATAPLEXY

Violence during an RBD episode has usually been interpreted as due to enactment of aggressive contents of dream experience (Schenck *et al.*, 1993). Accordingly, RBD has been considered to reflect an individual «acting out one's dream», namely dream content dictates the vocalizations and motor behaviours that are exhibited. Less attention has been paid to the other possibility (RBD as reflex of individual «dreaming around one's actions»), according to which dream content could evolve secondarily around what is initially exhibited. This means that even in the cases of a seemingly striking discrepancy between the «dreamed» aggressor and victim and the real ones (with the dreamer provoking harm or injury to the bed-partner) the mechanisms involved in «acting out one's dreams» and «dreaming around one's actions» could have worked in concert.

This possibility clearly relies on the sequential, rather than alternative, nature of the two processes described by Boeve and coworkers (2007). In its favour lies the fact that RBD patients often report dreams that seem to «incorporate» specific environmental stimuli. This possibility deserves attention, given the wealth of evidence from normal subjects that current environmental stimuli may be incorporated (namely, reproduced with some transformation) as contents into the concomitant dream experience. Stimulus incorporation has been investigated by delivering one (auditory, olfactory or tactile) stimulus during a given stage of sleep and assessing the outcomes of its on-line processing, usually through the analysis of dream contents reported after an awakening provoked a while after the stimulus delivery (Bastuji *et al.*, 2002; Perrin *et al.*, 2002).

In favour of the sequential nature of the two processes outlined above are several theoretical arguments and some items of indirect evidence collected on patients with narcolepsy-cataplexy (NC). Indeed, RBD episodes in patients with narcolepsy also occur in adolescence and adulthood and with onset after clinical manifestations of the disease (Schenck & Mahowald, 1992; Nishino & Kanbayashi, 2005; Nevsimalova *et al.*, 2007), generally when accompanied by cataplexy (the estimates ranging from 40 to 57%: Mattarozzi *et al.*, 2008). In general terms, REM sleep of NC patients is characterized by a number of dissociated REM-sleep events (cataplexy, sleep paralysis, hypnagogic hallucinations), besides a partly altered architecture of night-time NREM and REM sleep relative to normal subjects (AASM, 2005). The indicators of REM-sleep related phasic – such as the density of rapid eye movements and the number of muscle twitches – and tonic activities – such as the proportion of REM sleep without atonia (RWA) – have higher values in NC patients than in normal subjects (Dauvilliers *et al.*, 2007).

At a theoretical level, REM sleep maintains a high responsiveness to external stimuli of distinct modality (acoustic, tactile, olfactory, visual: Koulack, 1969; Burton *et al.*, 1988; Trotter *et al.*, 1988). The behavioral response to external stimuli is not necessarily an awakening (as disruption of sleep), but may be (a) the encoding of stimuli into working memory, with the possibility to persist for several seconds (as accessible to post-awakening retrieval: Shimizu *et al.*, 1977); (b) the re-activation of related (as previously associated in a more or less recent waking period) items of information stored in long-term memory (Smith, 1995; Hennevin *et al.*, 1995, 2007); (c) the activation of a possible previously conditioned behavioral response (Burton *et al.*, 1988); (d) the incorporation of the stimuli as contents within the frame of the ongoing mental activity during REM sleep (Dement & Wolpert, 1958; Schredl *et al.*, 2009). Interestingly, the processing of external stimuli (which is not limited to REM sleep: Perrin *et al.*, 2002), also has the possibility of multiple (for example behavioural and cognitive) outcomes (Burton *et al.*, 1988).

The phenomenon of stimulus incorporation into dream content makes it plausible that initial motor behaviors enacting concomitant dream content (for example, vocalizations or limb movements) may be perceived, *per se* or in combination with current tactile (e.g., sheets or furniture) or auditory stimuli (e.g., yelling of bed-partner), as dangerous or threatening. As such, they may be processed and converted into contents of a fight or dramatic event, in response to which the aggressive/violent imagery activated may be also enacted as aggressive/violent behaviors.

We recently collected some (albeit indirect) evidence supporting this «interactive» hypothesis. We examined the physiological and behavioural features of RBD in patients with NC for two reasons.

First, several clinical and behavioural features of RBD exhibited by NC patients are compatible with the possibility of a distinct form (associated with hypocretin-1 deficiency: Knudsen *et al.*, 2010) with respect to both the idiopathic form and that accompanying or heralding neurodegenerative diseases (such as Parkinson, multiple system atrophy and Lewy-body dementia). In particular: (a) RBD is not an every-night phenomenon in NC patients unlike other types of patients (e.g., those with multiple system atrophy display RBD nearly every night); (b) RBD onset in NC patients may overlap other typical heralding symptoms of the disease (namely, cataplexy and sleepiness) in young adults and children, contrary to other RBD patients; (c) RBD episodes in NC patients often show less violent motor characteristics (Schenck & Mahowald, 1992; Mayer *et al.*, 1994; Oudiette *et al.*, 2009a).

Second, there is a wide discrepancy between the low proportion of aggressive and potentially harmful behaviours documented in video-PSG laboratory recordings compared with that estimated on the basis of retrospective reports obtained in clinical interviews of NC patients (Scaglione *et al.*, 2005). This discrepancy could be accounted for mainly in terms of the different amount of environmental stimuli (the patient always being alone in the laboratory bed and usually without heavy blankets or covers hampering movements) potentially triggering harmful

behaviors or in terms of different characteristics of the dream experience concomitant to the RBD episode. The latter may depend overall on the time of night of RBD occurrence. Indeed, in normal subjects the contents of REM dreams are usually more emotionally charged, dramatic and violent in the second half of the night (Pivik & Foulkes, 1968; Foulkes & Schmidt, 1983). To decide in favour of either hypothesis, we examined the motor and PSG characteristics of RBD episodes and their temporal location over the night in a sample of NC patients with clinically documented RBD (Cipolli *et al.*, 2011). The rationale of the study was that if the contents of REM-dreams are less violent in the first compared with the second half of the night in NC patients as well as in normal subjects, then the motor features of RBD episodes, as enacting REM-dream contents, should also be less frequently violent-aggressive in the first than in the second half of the night.

The findings obtained (Cipolli *et al.*, 2011) have shown that the occurrence of RBD episodes in NC patients does not depend on the time of night (RBD episodes being distributed equally in periods of REM sleep of the first and second halves of the night), unlike all other RBD patients, in whom RBD episodes occur mainly in REM sleep of the second half of the night (Iranzo *et al.*, 2009). Additionally (and importantly), aggressive-violent behaviours – usually observed in patients with idiopathic or secondary RBD – resulted mostly in RBD episodes of the second half of the night, whereas vocalisations and mimics/pantomimes were comparable in RBD episodes of the two halves of the night. This picture is consistent with time-of-night variation in the features of dream content enacted in RBD episodes. Finally, vocalizations were found to occur nearly always at the beginning of RBD episodes in both halves of the night, in keeping with the possibility that they constitute an environmental stimulus able to alarm the bed-partner and raise his/her attempts to awaken the patient and, thus, involuntarily provide further tactile and/or auditory stimuli to process.

It also seems worth pointing out that the occurrence of an RBD episode per night was less frequent in NC patients (2/3) than in patients with idiopathic or secondary RBD, thus confirming that it is not an every night phenomenon even though the number of REM periods over the night is about twice that of other RBD patients. The lower occurrence of RBD episodes per REM sleep period in NC patients compared with other RBD patients mirrors the difference in the Atonia Index (AI), which is lower in NC patients (80%) than in controls (90-95%), but substantially higher than in idiopathic and secondary RBD cases (less than 60%: Ferri *et al.*, 2008).

Taken together, these findings provide some support for the hypothesis that the presence of aggressive/violent behaviours is not an essential feature of RBD, but depends on a delicate balance between the «intrinsic» characteristics of dream experience (more dramatic and emotionally charged in REM periods of the second half of the night) and the environmental (physical and interpersonal) stimuli. This inference obviously needs to be supported by more direct laboratory evidence, which could be expected primarily from multi-night studies with video-PSG recording and dream reporting after awakening from periods of REM sleep with and without RBD in NC and other RBD patients.

Behavioral evidence may also be found in the cases where the balance between the «intrinsic» characteristics of dream experience and environmental stimuli are abruptly modified, for example by marriage, as happens in NC patients, who may have had RBD episodes since adolescence. A typical example of a potentially dangerous experience of dreaming of a married patient may be that of a grabbing and attacking an individual when in fact his wife is grabbing the patients' arms in an attempt to suppress the fighting behaviour during a dream. This event, which is not rarely reported (for review, see Boeve, 2010) by bed-partners of patients with idiopathic and secondary RBD, is particularly traumatic in newly-married women. Indeed, when RBD suddenly occurs in people who have been married for decades before the onset of symptoms, their partners realize that these often violent behaviours conflict with the waking personality of their spouses and become more worried about the safety of their spouses than the potential danger to themselves. This explains the scarcely reported marital discord and adverse psychological consequences even when RBD results in injury to the bed-partner (Schenck *et al.*, 1993). On the contrary, the young bed-partners of NC patients may be unexpectedly faced with the disruptive behaviour of RBD, and the potential for sleep-related violence. Moreover, the strong negative reaction of young NC patients to a wife's attempt to disrupt sleep when RBD occurs may cause them to feel severely anxious and depressed. Ingravallo and coworkers (2010) described a case of repeated sleep-related violence from RBD in a young NC patient causing injuries to his wife and resulting in a criminal charge of assault, followed by a divorce trial, as the wife was not convinced of the non-intentionality of assaultive behaviours. This case raises the question of the forensic implications of RBD, besides the psychosocial burden of NC in partners and in patients, and, thus, the need to consider the possibility of «parasomnia pseudo-assaults» whenever the violence occurs during the night and the victim requires medical assistance.

5.4. CONCLUSIONS

In 1995 the medical-legal category «parasomnia with continuing danger as a noninsane automatism» was proposed (Schenck & Mahowald, 1995) on the assumption that the risk of recurrent sleep violence is not related to the legal concept of «insanity» (which would require psychiatric confinement), but rather to a «noninsane» condition, that is a physiologic disorder of sleep (which would require intervention by a sleep medicine specialist). The forensic aspects of the parasomnias have received growing attention, particularly in relation to inadvertent (attempted) murder or suicide associated with sleepwalking, a NREM sleep parasomnia. Likewise, RBD should be considered a noninsane automatism, as individuals with RBD are acting within the bounds of the dream, and are unaware of their surroundings – and therefore could not form intentions or appreciate the potentially criminal nature of the acts.

As RBD carries well-documented, potential forensic consequences, it is apparent that future reports of clinical cases need to detail aggressive and violent RBD behaviors, their longitudinal course, extent of severity and resulting injuries (including risk of lethality to self and others), video-PSG findings, comorbidities, and victim vulnerabilities. The extension of the database of potential forensic RBD cases can assist in the advancement of medical and legal education and assistance and in scientifically informed judicial decisions. It is also apparent that the legal implications of sleep disorders (sleep-related behaviors, errors, and accidents can seriously affect individuals and society in terms of harm, cost, and efficiency) imply an ethical obligation on the part of sleep researchers to protect the safety of patients, bed-partners or other people accidentally encountered in sleepwalking episodes.

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