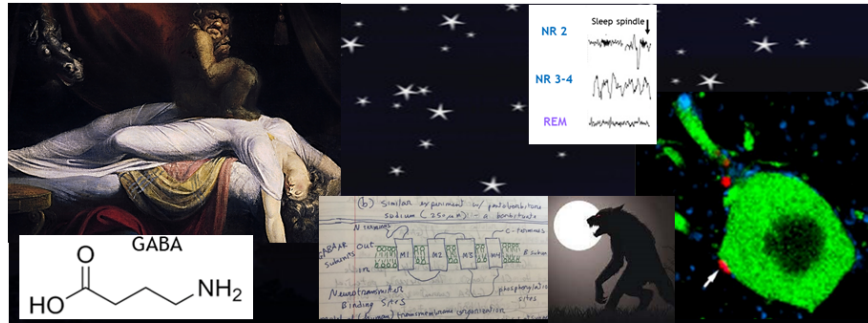


# Sleep and Violent Behavior

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*My report investigating the neurobiology underlying sleep and the forensic implications of sleep related violent behavior.*



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**Abbreviations** | EEG, electroencephalogram; GABA, gamma aminobutyric acid; NREM or NR, non-rapid eye movement; RSD, rapid eye movement sleep behavior disorder; REM, rapid eye movement; s, second(s);  $\mu\text{m}$ , micron,  $\mu\text{V}$ , microvolt.

## Introduction

Violent behaviors associated with sleep are a rare occurrence, affecting approximately 2+% of the populace (Schenck, 2019; Weiss, 2011) and only a fraction of these instances involve criminality. Adjudicating such episodic cases can be confounding since sleepers necessarily lack intentionality.

Sleep is not a void of consciousness, but rather represents altered states of consciousness. The human brain is dynamic with fractionated functionality, so no single phase of sleep or wakefulness ever globally controls the brain. Unlike being generally anesthetized, the sleeping brain is not a passive bystander in the 'switched off' position. Instead, the brain deftly shifts between phases of non-rapid eye movement (NREM), rapid-eye movement (REM) and wakefulness like an auto transmission to optimally steer the sleeper through the night.

Potentially violent sleep disorders, notably parasomnias, occur as the sleeper shifts between these phases, or, envisioned as a Venn diagram, when these states simultaneously overlap, precariously stranding the sleeper in uncharted mental territory. Refer to **Figure 1**.



**Figure 1 | The incubus**

*Incubus*, romantic era Swiss painting by Henry Fuseli (1781). The incubus represents the physiological phenomenon termed sleep paralysis, which are concurrent states of REM sleep and wakefulness. Purportedly displayed in Sigmund Freud's office. Image courtesy of online source.

## Sleep stages

While awake, perceptions are vectored towards reality that is our external environment, responding to stimuli with interactive engagement. Conversely, we are disengaged with reality during sleep. This perceptual distinction is outstanding considering that sleep accounts for a third of our existence. Refer to **Figure 2.** 10, 9, 8, 7.....Now you are getting very sleepy. So what really happens in the dark hours of the night? Follow me.

During NREM1, the hypnagogic stage of sleep, electroencephalogram (EEG) recordings reveal an approximate 50% reduction in neural activity, deepening the amplitude of theta brain waves measured in microvolts per second ( $\mu\text{V/s}$ ). There is a threshold of awareness during NREM1. Imagine drifting off while reading on the cozy sofa (not this report though) or sort-of sleeping on a long airplane flight. Bang! Your attention snaps back into focus with any arousing stimuli, such as a knock on the door or alarm bell. Hypnotists coax you into NREM1, maintaining this state while giving you suggestions.

Progressing deeper into NREM2 sleep characterized by sigma waves, bursts of neural oscillatory activity known as sleep spindles occur. Spindling represents neurons firing in synchronicity, connecting across the neocortex. Spindles are associated with the consolidation of long-term memory and sensory processing integrated with emotional expression. Organs are regenerating at the cellular level, the immune system is restoring, etc. Muscle tone is increasingly relaxed through NREM2, 3 and 4.

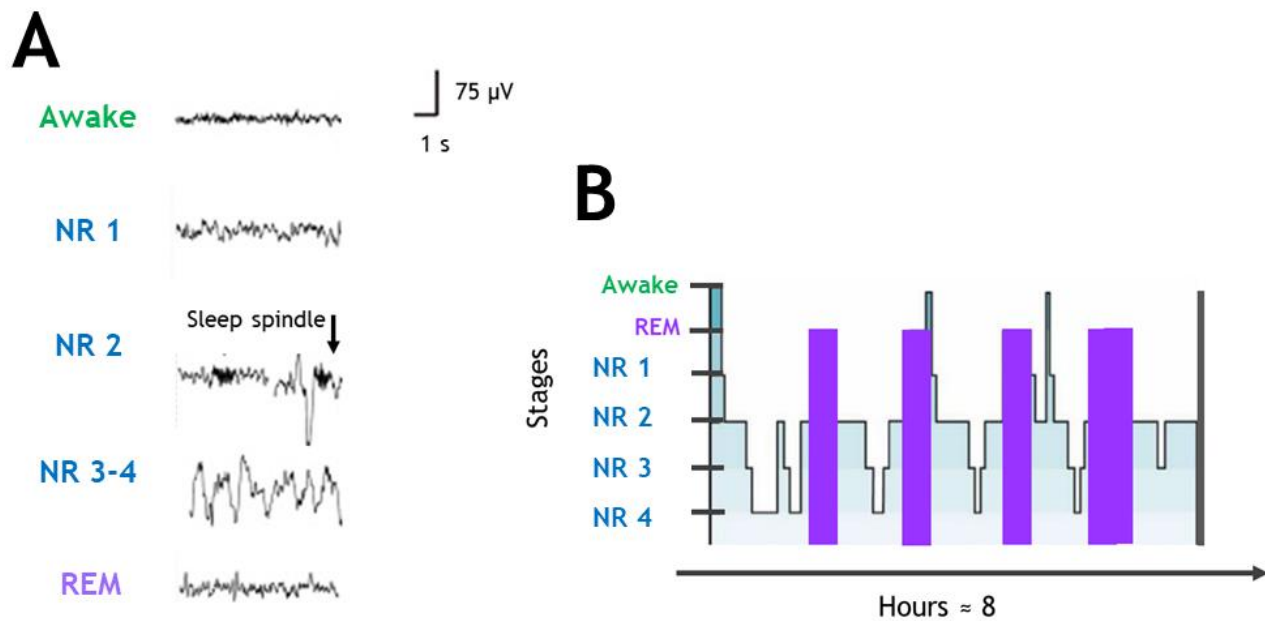
- Side note: EEG recordings reveal that sleep spindling patterns in the schizophrenic brain are lacking or aberrant. Would adjusting sleep patterns be therapeutic for those with schizophrenia and related psychotic disorders? But back to the story.

Fast asleep, NREM3 and 4 now ensues, deep amplitude delta waves. By now, the sleeper is insular to wakefulness, nearly impervious to otherwise disruptive stimuli. If the sleeper is somehow forcibly awakened, then they may be disorientated and agitated, stumbling from bed. Appropriately termed in French, *l'ivresse du sommeil*, the "drunkenness of sleep." If you have ever overslept through an alarm, grumpily fixing your first cup of morning coffee, blame NREM4.

- Side note: During my neuroscientific research, I was involved with stereotaxic brain surgery on laboratory rats. Ketamine, a dissociative agent, was titrated so that the rat

was deeply anesthetized with absent reflexes throughout the surgery till recovery. However, touching the rat's neck still elicited a twitch. Why? Evolutionarily, rats have conserved their ancient defenses, protecting their vulnerable jugular vein despite being deeply anesthetized. But back to the story.

The hallmark of REM sleep is dreaming. The sleeper's eyes movements (known as saccades) are effectively watching the dream activity. Importantly, muscle atonia during REM sleep ensures that the sleeper is not physically acting out their dreams. Imagining your worst nightmare, now you know why muscle atonia during REM sleep critically matters.



**Figure 2 | Sleep stages**

A) EEG tracings of sleep stages ( $\mu$ V/s): REM (purple), NR 1-4 (blue) and awake (green). Tracings reveal an approximate 50% amplitude reduction in neural activity between NR 1 (light sleep) and wakefulness. Sleep spindles (sigma waves) during NR 2 represent the processes of memory consolidation and emotional integration during sleep. Deep sleep occurs during NR 3 and 4 (delta waves). Sleepers are difficult to wake during delta wave sleep. Dreaming occurs during REM sleep and sleepers are relatively easy to wake. Note that the amplitude and frequency of neural activity during REM looks similar to wakefulness. B) Hypnogram showing exemplary stages of sleep (Y axis) during a typical 8 hour night (X axis). Figure modified by Du Beau.

## Parasomnias

If the demarcation between the various sleep stages blurs, concurrent states of disordered arousal elicit a behavioral brew storm that can be potentially violent. Episodic violence during sleep affects approximately 2+% of the population (Schenck, 2019; Weiss, 2011) with a subset of these cases involving criminality. Parasomnias pose an enigmatic dilemma since sleepers are neither truly awake nor asleep, yet their actions seem superficially volitional. Refer to **Table 1**.

Somnambulism (sleepwalking) is an amalgam of deep delta wave NREM sleep stages and wakefulness. Approximately 3% of the genetically predisposed adult population may innocuously experience sleepwalking, not usually entailing violent behavior. Children, teens and young adults are most prone to sleepwalking, although exceptions abound. 'Walking' may be a generalized misnomer, however, since sleepwalking also encompasses other physical activities, ranging from eating, driving, making phone calls and even holding conversations (although the sleeper is not at their witty best) with slurred or strange speech, and other related tasks. The sleeper may appear confused or even pedantic, behaving as if an automaton.

The sleepwalker is not dreaming, but rather experiences a dissociative state of consciousness coupled with motor activity. Occurrences are most often reported in the early nighttime hours, relatively soon after the onset of sleep. Sleepwalkers are notoriously hard to rouse, awaking agitated and disorientated. While visual processing allows the sleeper to navigate, their unfocused stare is devoid of the realistic identification of visual stimuli. After all, we perceive with our mind (specifically via the occipital lobe and visual cortices), not our eyes.

Confusional arousals entail the sleeper waking into a dissociated state of consciousness devoid of any later conscious memory. Sleep terrors occur when the sleeper screams during sleep, sometimes becoming physically assaultive. Related, sleepers with periodic limb movement disorder can injuriously enact their dreams, though usually confined to their bed.

Sleep paralysis is a scary transitory episode sandwiched between waking and REM sleep with muscle atonia such that the sleeper cannot move during a nightmare, oftentimes reporting the sense of being in the presence of an oppressive stranger (**Figure 1**).

Rapid eye movement sleep behavior disorder (RSBD) is a dynamite combination of vividly lucid REM sleep with a repertoire of motor activity plus wakefulness, noting that EEG recordings of REM sleep amplitudes resembles wakefulness. RSBD episodes oftentimes happen in morning after hours of sleep. RSBD sleepers are interactively dreaming while in a suggestible hypnagogic state, and, resultantly may potentiate violent behavior.

Features	Parasomnias potentially associated with violent behavior	
	RSBD	Somnambulism & Arousal disorders
Muscle atonia	Intermittent	No
Sensory perception	Yes	No, except navigation threshold
Sleep state	REM + wakefulness	NREM 3 - 4 + wakefulness
Dreaming	Yes	Possible
Timing	Early morning	Early night
Attentional arousal	Awakeable	Trouble waking, disorientation/agitation
Memory recall	Partial	No
Medical typology	Mature to older adult	Young adult, especially male

**Table 1 | Parasomnias and violent behavior**

## Dyssomnias

Dyssomnias are a class of conditions such as insomnia, narcolepsy and circadian rhythm disorders that exist beyond the scope of sleep. Dyssomnias can potentiate risky behavior, compromise reaction time, limit attentional focus and interfere with good judgment. If you have ever pulled an all-nighter while cramming for an exam, or travelled across multiple time zones, you have experienced acute dyssomnia. Salute to the coffee industry.

Valdez, Alaska (1989): Captain Hazelwood crashed the Exxon Valdez oil tanker into a reef while suffering from dyssomnia ironically associated with drug use to induce sleep, causing a catastrophic 37,000 metric ton ( $\approx$  10.5 million gallon) oil spill. According to the *National Sleep Foundation*, approximately 40% of American drivers admit to have fallen asleep while driving. Dyssomnias account for misadventures ranging from botched surgeries, extramarital affairs, house fires and violent crimes including murder.

## Fictional accounts of sleep

Imagine living eons ago, huddling around the light of a bonfire as night falls, finally retreating to the security of your cave with companions in darkness. Sleep leaves you vulnerably exposed to dangerous predators who may be lurking invisibly in the dark. Still the phenomena of sleep is shrouded in mystery. Provocative renditions of sleep are expressed through historical storytelling cross culturally. Refer to **Figure 3**.

The Sandman is historically described in folklore (circa 1700s onward), known as *Moş Ene* (Romania), *Ole Lukøje* (Germanic) or *Bonhomie sept-heur* (French Canadian), etc. The Sandman sprinkles dust in the eyes of dyssomniac children, prompting them to dream by holding an illustrated umbrella over their beds. Sinister accounts report that the Sandman sprinkles dust in children's eyes to blind them, resultantly capturing them or collecting their eyes during sleep. This depiction describes the sight of a sleepwalker, seeing with the mind rather than the blind albeit functional open eyes.

Werewolves may exemplify morphing from normalcy into a dangerously murderous being, triggered by moonlight, indicative of RSBD, then waking without memory recall of the nocturnal event. Sleeping Beauty falls into a virtually impenetrable state of deep delta wave sleep (**Figure 2A**).

The Golem (גלמי, Hebrew, Psalm 139:16) describes a suggestible automaton-like being who wanders in a sleepwalking stupor. The Golem's innocuous wanderings may become unpredictably hostile under threatening circumstances, akin to a parasomniac arousal disorder. Sleep paralysis provides a thematic account for alien abduction phenomenon, the sleeper experiencing a preternatural sense of being watched or examined while defenselessly powerless to intervene on their own behalf.

Hogwarts wizards and witches wisely warn against waking the wrath of a dangerous sleeper, *draco dormiens nunquam titillandus*, "never tickle a sleeping dragon." Sage advice, yes?



**Figure 3 | Fictional characters**

A) *Sandman*, post-impressionistic Swiss painting by Nils Dardel (1927). B) Depiction of a werewolf. C) Sleeping Beauty's impenetrable sleep state. Images courtesy of online sources.

### Neurochemistry of disordered sleep

Neuroscientists learn the most about the brain when something goes wrong with it. Sedating psychotropic drugs (benzodiazepine class known as hypnotics) prescribed to treat insomnia can be effective, however, a paradoxical side effect can be physical activity while asleep. Historically, during my doctoral neuroscience research, I was curious about why. Refer to **Figure 4**. No need to struggle with my handwriting (**Figure 4A**), here is the upshot:

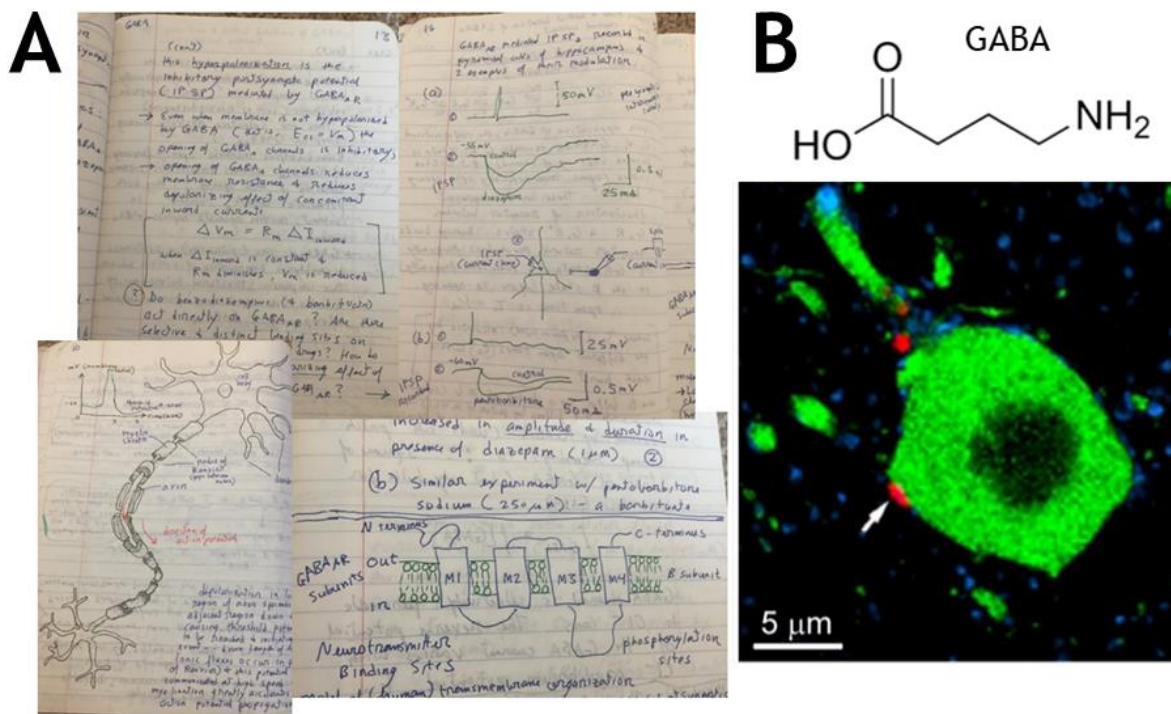
- Neuroscience primer: Hypnotics work by activating inhibitory receptors in the brain. Gamma aminobutyric acid (GABA) is an inhibitory neurochemical associated with sleep. By design, neurons each have specialized receptors on their surface membranes activated by various neurochemicals such as GABA - imagine them like little electrical outlets.



There are two subunits on each GABA receptor: GABA<sub>A</sub> and GABA<sub>B</sub>. This design accounts for why muscles are still during REM sleep. The outstanding issue is that hypnotic drugs may only activate one of the two inhibitory GABA receptors, allowing complex repertoires of physical activity to occur even while you are sleeping!

A Massachusetts man (2006) under the influence of the hypnotic drug Zolpidem (Ambien) was driving while soundly asleep, fatally crashing into a stranger who was changing his flat tire on the roadside (Weis *et al.*, 2011). This notorious case was successfully defended, exonerating the sleeping driver, and other similar therapeutic misadventures involving such psychotropics have occurred too.

- My unsolicited advice? Nix the hypnotic prescription and go with milk and cookies and counting sheep instead.



**Figure 4 | Hypnotic neurochemistry**

**A** Photographs of pages from my old laboratory notebook, asking why benzodiazepines might bind selectively to GABA neural receptors in the brain, thus allowing for motor activity during sleep resulting in episodic somnambulism. **B** My confocal microscopy image showing a neuron (green) being inhibited by GABA (red), scale bar = 5 microns (µm). The chemical structure of GABA above. Figure by Du Beau.

## Forensic implications and intentionality

Parasomniac sleepers exhibiting automatism exist in the uncharted mental territory of altered consciousness, neither precisely awake nor aware. The preponderance of sleep disordered incidents do not involve violence. Most sleepers only selectively remember dreams after waking, and, of course, are not responsible for the content. But what if that nightmare actually comes to fruition?

Criminal behavior leading to conviction necessitates the commission of a prohibited act, *actus reus*, coinciding with a guilty state of mind, *mens rea*. Sleep is not a state of insanity, of course, and sleepers do awaken. However, volitional intent is necessarily absent during sleep, which carries substantial legal ramifications (Model Penal Code).

- Ontario Canada (1987): Kenneth Parks drove 14 miles to his parents-in-laws' house while soundly asleep. Lucidly dreaming, Kenneth fatally bludgeoned his mother-in-law with a tire iron and choked his father-in-law. Waking to the blood stained scene, Kenneth drove himself to the nearby police station, explaining what happened in a disorientated mental state, genuinely horrified by what he had just done. Kenneth's medically verified parasomniac RSBBD case was deemed defensible in the court of law.
- Phoenix Arizona (1997): Scott Falater stabbed his wife multiple times near their backyard pool while asleep. Returning half hour later, Scott found his wife still alive and drowned her in the pool. Scott was convicted for murder.
- Glasgow Scotland (1878): Simon Fraser arose from his bed while asleep, dreaming a demonic beast was chasing him, which then leapt on his toddler's bed nearby. Simon awoke to his wife's screams - he had killed the toddler. Simon was acquitted of murder based on his parasomniac condition, then termed "somnomania."

Where is the statutorily defined demarcation between knowledgeable intentionality and recklessness? Making inferential assessments about a sleeper's mental state can be a challenging task for adjudicators of the law, especially leery of malingering. Neuroscientific investigations of parasomnias inform the jurisprudence of sleep related violence.

The following criteria must all be met to satisfy the legal plea of parasomnia:

- Clinical polysomnographic exam to verify the presence of disordered sleep
- Time of night (Refer to **Table 1**) congruent with documented events
- Consideration of mitigating factors such as extreme stress, sleep deprivation, alcohol/drug use or comorbid condition/illness
- Genetic markers, familial predisposition, personal history
- Confirmatory witness accounts
- Independent expert scientific opinion

## Conclusion

Sleep stages represent active neural states, yet still may be regarded as elusive since sleep lies within the realm of altered consciousness. This report explores sleep related violence as a phenomenological subset within the spectrum of sleep disorders with forensically identifiable determinants. Since parasomniac sleepers necessarily lack intentionality, triers of the law give special credence when adjudicating sleep related offenses. Enriching our understanding of parasomnias and dyssomnias lends to revealing the neurobiology underlying states of consciousness, running parallel to inform the jurisprudence of sleep related violent behaviors.

*“Let us sleep for in dreams we enter a world that is entirely our own. Let us swim through the deepest ocean or glide over the highest cloud.” – Albus Dumbledore (J.K. Rowling)*

## Author’s note

I am an independent forensic science consultant, a neuroscientist (PhD) and criminal behavioral analyst/profiler (D-ABP) with expertise in bloodstain pattern analysis.

This report is not intended to be an exhaustive review of sleep disorders. I declare no conflict of interest. Questions and comments are welcome.

This report and all contents must be cited: Du Beau, A. (2020). Sleep and violent behavior. <https://matanuskaforensicscience.com/>

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