Animal "Hypnosis" and Waking Nightmares
Biological and Experiential Origins of Malevolent Spirits

James Allan Cheyne[1]

Abstract – A restraint-induced immobility traditionally known as animal hypnosis or tonic immobility (TI) has been suggested as a model for the terrifying "waking nightmare" of sleep paralysis (SP), on several occasions though no previous systematic review comparing the two phenomena has been undertaken. Both include, as a central defining feature, a state of profound but reversible general atonia. TI is potentiated by fear and by threat cues associated with predators. SP is associated with transitions between waking and sleep, and almost universally accompanied by intense fear and frequently by sensations of an evil threatening presence along with a variety of hallucinations consistent with threat and assault. Numerous parallels between the two include behavioral, neurological, hormonal, and general physiological features. Perhaps most intriguing are parallels between the phenomenology of hypnagogic/hypnopompic hallucinations during SP and environmental conditions and events known to induce, potentiate, or exacerbate TI. The review concludes with two speculative hypotheses of exaptation and cooption. First, it is argued that predator-avoidance mechanisms of TI may be coopted for, and simulated in, REM states, appearing as dream imagery in conventional nightmares and hypnagogic hallucinations in SP. Second, these REM experiences, in turn, may be secondarily coopted as experiential sources for cultural beliefs in spirit beings and spirit worlds.

Key Words: tonic immobility – animal hypnosis – nightmares – sleep paralysis – predation – night spirits

„Tierhypnose" und wach erlebte Alpträume
Biologische und erfahrungsbasierte Ursprünge bösartiger Geister

Zusammenfassung – Eine zwangsinduzierte Lähmung, die traditionell als Totstellreflex oder tonische Immobilität (TI) bekannt ist wurde gelegentlich als Modell für die furchteinflößende alptraumartige Erfahrung der Schlafparalyse (SP) vorgeschlagen. Allerdings fehlte bislang ein systematischer Vergleich der beiden Phänomene. Als zentrales definitorisches Merkmal beinhalten beide einen Zustand hochgradiger, aber reversibler allgemeiner Atonie (Muskelerschlaffung). TI wird verstärkt durch Furcht und Zeichen der Bedrohung, die mit den Raubtieren assoziiert werden. SP

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1 Prof. em. Dr. James A. Cheyne promovierte 1969 im Fach Experimentelle Psychologie. Seine Forschungsgebiete liegen im Bereich der Entwicklungs- und Sozialpsychologie, Ethologie, Soziobiologie und kognitiven Neuropsychologie mit einem besonderen Interesse an multivariater Statistik und der mathematischen Modellierung großer Datensätze. Er ist Professor Emeritus der University of Waterloo.

ist verknüpft mit den Übergangsphasen von Wachen und Schlaf und fast immer begleitet von intensiver Angst sowie häufig von Halluzinationen einer bedrohlichen Präsenz gemeinsam mit einer Vielzahl von Empfindungen, die mit Bedrohung und Angriff verbunden sind. Zahlreiche Parallelen zwischen den beiden Phänomenen beinhalten verhaltensbezogene, neurologische, hormonelle und generelle physiologische Merkmale. Vielleicht am faszinierendsten sind die Parallelen zwischen der Phänomenologie von hypnagogen/hypnopompen Halluzinationen während der SP und den Umweltbedingungen und Ereignissen, von denen man weiß, dass sie TI induzieren, potenzieren oder verschärfen. Der Überblick schließt mit zwei spekulativen Hypothesen von Exaptation und Kooption. Zum einen wird argumentiert, dass die Raubtiervermeidungsmechanismen der TI für die REM-Schlafphasen kooptiert und simuliert sein könnten und als Traumbilder in konventionellen Albträumen und als hypnagoge Halluzinationen in SPs auftreten. Zum anderen könnten diese REM-Schlaf-Erfahrungen im Gegenzug sekundär kooptiert werden als erfahrungsbasierte Quellen für kulturabhängige Glaubensvorstellungen von spirituellen Wesen und Welten.

Schlüsselbegriffe: tonische Immobilität – Tierhypnose – Alpträume – Schlafparalyse – Prädation – Geistererscheinungen

Tonic Immobility

Tonic Immobility is one of the oldest studied phenomena of animal behavior (Gallup, 1974; Ratner, 1967; Völgyesi, 1966). Indeed, references to this phenomenon have been noted in the Old Testament, the Talmud, and the Odyssey (Klemm, 1971; Völgyesi, 1966). Over a 300-year history of systematic study, this phenomenon has gone by many names. Table 1 lists over 30 terms that have been employed in the literature through the years. Though "animal hypnosis" remains common in popular usage, scientific research appears to have settled on the conceptually neutral term tonic immobility (TI), for the time being at least, although even this relatively description term is not without its critics (Woodruff, 1977). It is also possible that TI is a member of a family of immobility responses (Lefebvre & Sabourin, 1977), of which TI may represent the most elementary form.

Behaviorally, TI is a state of profound but temporary paralysis of the major muscles. The basic initiating condition for TI is restraint and its attendant tactile and proprioceptive sensations (Maser & Gallup, 1977; Klemm, 1971). TI is significantly potentiated by fear (Gallup, 1974). Indeed, as early as 1671, Kircher had clearly articulated the essential conditions for TI: namely, that "the creature suddenly finds itself constricted and vainly tries to get free; then, becoming immobilized through fear and compulsion, it yields "to the will of its conqueror"" (Cited in Völgyesi, 1966, p. 2). Animals lie almost motionless during the paralysis, most often in the supine position and, after a variable period of time or when signs of threat are removed,

1. akinesis,	18. rho,
2. animal hypnosis	19. mesmerism,
3. animal magnetism,	20. monidideismus,
4. bewitchment,	21. myotonia congenita,
5. catalepsy,	22. paroxysmal inhibition,
6. cataplexy,	23. playing possum,
7. death feigning,	24. reflex immobilization,
8. death feint,	25. sham death,
9. entrancement,	26. still reaction,
10. fascination,	27. terror paralysis,
11. fright paralysis,	28. thanatosis,
12. hypertonicity,	29. thanatomimesis,
13. immobility reaction,	30. Totstell-Reflex,
14. immobilization reflex,	31. Totstellung,
15. inhibition,	32. phasic immobility
16. inhibitory state,	33. contact defensive immobility
17. letisimulation,	34. clipnosis

Table 1: Some Alternate Terms for Tonic Immobility
(Sources: Gallup, 1974, Klemm, 1971, Marks, 1987, Ratner, 1967; Woodruff, 1977)

quickly recover. In the laboratory, TI may be induced in many animals by simple inversion and restraint in a supine position. Duration of immobility may be increased by the use of bandages, clips, and troughs that create pressure on the torso and back of the neck (Gallup & Rager, 1996). Repetitive or rhythmic tactile stimulation reminiscent of "mesmeric passes" may also be used (Gilman & Marcuse, 1949; Lefebvre & Sabourin, 1976; Völgyesi, 1966). Although animals appear to be unconscious or asleep they open their eyes periodically apparently monitoring the surrounding environment (Klemm, 1971). In addition to intermittently opening and

closing of eyes, TI may be characterized by tremors in the extremities, as well as bradycardia, hyperventilation, and reduced core temperature (Carli, 1977; Gallup & Rager, 1996; Klemm, 1971), although these responses may vary considerably across species and method of induction (Lefebvre & Sabourin, 1976). In addition to many names for the same phenomenon, there are also several different immobility states. Many of them are likely derivative of the same state or members of a family of related states.

TI and Predator Avoidance

TI has long been conjectured to be a strategy for predator avoidance (Romanes, 1884). Ratner (1975) conjectures that TI is a "defensive immobility" and describes a sequence of four relatively fixed action patterns in which prey animals engage when: 1) *stalked, 2) chased, 3) seized, and 4) restrained* by predators (Figure 1). The four corresponding defense strategies are 1) *freezing, 2) fleeing, 2) fighting, and 4) tonic immobility*. Freezing is a therefore a response to a relatively distal threat (a hawk circling overhead, a pair of eyes in the dark). As predators are often particularly sensitive to movement, freezing may sometimes render the prey much more difficult to see. In this "frozen" state the potential prey appears alert and is able to respond very quickly to changes in the attitude, position, movements or other features of the threatening agent. A lapse of attention of the predator, on the one hand, or a sudden approach, on the other, may lead to *flight*. If the predator pursues and captures the prey a *struggle* will ensue. Finally, *tonic immobility* is the response to being *held* and mauled by a predator (Ratner, 1975). This final cataleptic-like state of many prey animals following the struggle phase is sometimes also referred to as "*death feigning.*" This last stage therefore represents a reaction to an all but hopeless situation (Carleton, 1969). We may then call immobility in this last phase an *aporetic* immobility (aporia = "no way out") reflecting, as the fundamental eliciting condition, a situation from which escape seems impossible. In laboratory settings, when an animal is held until it stops struggling and develops the catatonic-like waxy tonic immobility, the firm restraint likely mimics the final stage of the predatory sequence (Figure 1). In the laboratory, the duration of TI can be substantially increased in the presence of a model of a predator or even a pair of disembodied staring eyes (Gallup and Maser, 1977). These results also reveal that the immobility does not preclude continued assessment of threat. The cessation of struggle and the profoundly unresponsive immobility will then sometimes cause predators momentarily to release the victim, which then escapes (Ratner, 1975; Sargeant & Eberhardt, 1974). Anecdotally, Romanes (1884) cites an observation of a Mr. Blythe that "a fox has been known to personate a defunct carcass, when surprised in a hen-house, and has even suffered itself to be carried out by the brush and thrown out on a dungheap, whereupon it instantly rose and took to its heels, to the astounding dismay of its human dupe" (p. 304). More systematic observations of ducks corroborate such

anecdotes regarding the effectiveness of TI as an antipredator strategy (Sargeant & Eberhardt, 1974). Some animals, such as the opossum, will sometimes be suddenly aroused from TI and bite its captor. Such a sudden attack will often startle the predator, which may reflexively withdraw long enough to provide an opportunity for escape. Thus, TI may be an adaptive strategy for coping with otherwise hopelessly inescapable situations such as being caught and held by predators or when reaching the point of exhaustion in flight or fight situations.
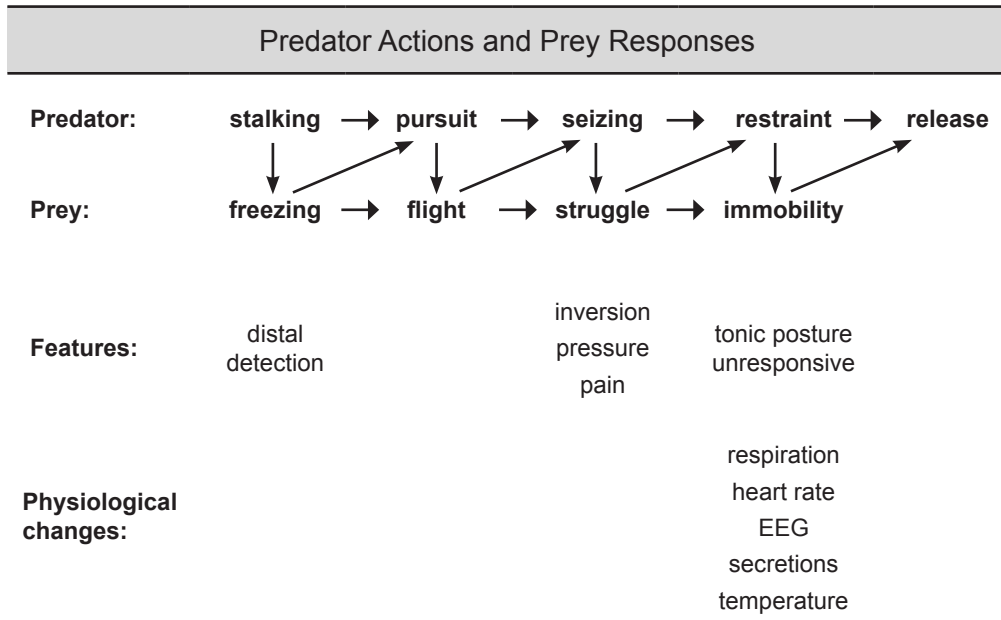
Predator Actions and Prey Responses

Predator: **stalking** → **pursuit** → **seizing** → **restraint** → **release**

Prey: **freezing** → **flight** → **struggle** → **immobility**

Features: distal detection   inversion pressure pain   tonic posture unresponsive

Physiological changes: respiration heart rate EEG secretions temperature

Figure 1: Sequence of predator – anti-predator tactics (modified from Ratner, 1975)

Some have argued that death feigning should be distinguished from mere reflex immobility the former being a much more developed and explicit strategy (Darwin, 1884; Lefebvre & Sabourin, 1976). Several species engage in rather elaborate rituals immediately prior to the period of immobility. The turkey vulture's death feigning involves regurgitation of its half-digested carrion lunch (Vogel, 1950). It is indeed difficult to imagine a more nauseating predator defense than vulture vomit. In the same olfactory spirit, the opossum secretes a foul-smelling excretion from its anal glands prior to being immobilized (Weidorn, 1954), as does the West Indian wood snake (Morris, 1990). These fetid strategies may simulate death and decay through the evocation of putrefaction and thereby act as disincentives to consumption by the predator.

Darwin (1884) insightfully observed, however, that the poses of death feigning in a variety of animals deviated considerably from their actual appearance when dead. Different species of frogs may adopt various contradictory poses, for example, some retracting their limbs and others extending them (Morris, 1990). Several snakes present a convincing tableau of death by rolling over to expose their bellies, opening their mouths, and allowing their tongues to loll in the dust. From the point of view of the human investigator, however, there is a telling flaw in the performance. If the snake is turned over, it promptly rolls back into the "proper" death pose. This curious obtuseness has puzzled a number of human observers. Whereas the insistence on resuming the "proper" pose might seem counter-productive to a rather analytic human, to a predator responding less reflectively and more reflexively to sensory cues, however, the proper presentation of death cues may well be a most effective strategy. The case of the West Indian wood snake is particularly instructive in its almost excessive histrionics. When threatened, this snake first coils itself tightly and releases a malodorous fluid from special glands. It next releases blood into its eyes producing a dull lifeless appearance. The pièce-de-résistance, however, is the rupturing of capillaries in the mouth. In its final tableaux, the animal presents itself in slack-jawed and bloody repose. This is a truly impressive display of signals. Indeed, the performance is just that – an elaborate display of signals. All these histrionics seem less an authentic imitation of death than a medley of greatest hits of evolved cues signaling death. What predators are sensitive to is not an abstract representation of death, but rather to certain sign stimuli that control their behavioral repertoire. Hence, the wood snake provides a particularly virtuoso display designed to capture the attention and control the behavior of even the most stolid predator.

Curiously, animals with more elaborate death feigning rituals seem less immobilized than those engaging only in TI. The opossum may, when stimulated, retract limbs, close eyes, turn the head, and retract lips in the classic "possum smile." As noted above, death-feigning snakes often appear to be protesting too much that they are well and truly dead. It has also been argued that the "death simulating" strategies are part of a prior, active phase of resistance and do not accompany the immobility itself (Vogel, 1950; Weidorn, 1954). This may be a bit overstated but death feigning could be a composite strategy borrowing features from difference phases of the defensive repertoire. Nonetheless, it is clear that TI is not an isolated response but part of a complex antipredator strategy involving an elaborate and integrated array of defensive tactics with immobility as a central feature.

Related Immobilities

There are a few other possibly related forms of immobility (Table 2). The immature of many mammalian young such as rat pups exhibit a tonic form of immobility during maternal transport involving grasping (biting) of the offspring by the back of the neck (Brewster & Leon,

Immobility Type	Conditions
Defensive Immobilities	Predator Response / Intraspecific Combat
	Distal predator induced freezing
	Seizing and holding induced TI
	'Death feigning' rituals
	Rape induced immobility
Copulatory immobility	Female immobility with lordosis during copulation
Transport immobility	Transport of young
Some Immobility Syndromes in Humans	
Sleep Paralysis	SOREMP, neurochemical anomalies of pons, hypothalamus
Cataplexy	Narcolepsy
Parkinson's Disease	Degeneration of extrapyramidal system
Locked-in Syndrome	Damage to anterior pons

Table 2: Functional Taxonomy of Transient Immobility Response Types

1980). It has also been reported that females of several species of cats show TI during copulation (Ewer, 1973). Although these appear to be associated with reproductive rather than defensive systems, it is possible that they access the same underlying neural systems. Both the transport and the copulatory immobilities entail bite-induced pressure to the back of the neck as well as restraint. This neck pressure has been simulated in the laboratory by exerting pressure on the skin along the neck and spine using clamps or clips to induce "clipnosis". Lefebvre & Sabourin (1976) suggest that the immobility induced by techniques of pinching skin may be less generalized and profound than that induced by inversion and restraint.

Sleep Paralysis

Sleep paralysis (SP) is a waking conscious state of involuntary immobility occurring just prior to falling asleep or immediately upon wakening. In its approximately 125-year history of study, SP, like TI, has gone by various names. Hishikawa (1976) provides a list of almost a dozen names. Moreover, SP has been and continues to be confused with night terrors, anxiety dreams, and

sleeping nightmares. Some of this confusion has historical roots. Liddon (1967), for example, notes that the term nightmare originally referred to sleep paralysis with hypnagogic or hypno-pompic hallucinations. This confusion is especially evident in Jones's (1928) classic work, *On the Nightmare.*

Although individuals are unable to move during SP or cry out, they often report being able to open their eyes. SP will typically last from a few seconds to several minutes. The main feature is the inability to move while conscious and in spite of making concerted efforts to do so. An individual in the SP state may be aroused from this state, however, by the simple touch or even voice of another (Thorpy, 1990; Williams & Karacan, 1978). Subjects are aware of their condition and are able to describe the experience vividly afterwards (Hishikawa, 1976). They are also able to perceive environmental events during the episode and subsequently to report accurately on them (Hishikawa & Kaneko, 1965).

SP has traditionally been associated with narcolepsy as part of the "narcoleptic tetrad" (Daly & Yoss, 1974), SP is, however, much more common than narcolepsy. Indeed, the incidence of SP among narcoleptics may barely exceed that found in the general population. Hishikawa (1976) cites incidence rates of SP among Narcoleptics from 17% to 57% over four studies. We have recorded percentages of SP in non-clinical populations of varied from 3% to 62% over eight studies with most estimates between 25% and 40% (Cheyne, Newby-Clark, & Rueffer, 1999; See Sharpless & Barber, 2011, for a review). Moreover, in extensive multinational WWW surveys we have conducted several involving tens of thousands of SP experients we have consistently found less than 2% to have been diagnosed with narcolepsy. Although, 2% is much higher than the .06% (range = .03% - .16%) incidence reported for narcolepsy in the general population (ICSD), people with diagnosed narcolepsy clearly represent a very small minority of SP experients.[2]

SP is widely thought to be a manifestation of physiological changes during rapid eye movement (REM) periods and, in particular, a dissociation of the atonic component of REM from

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2 SP and narcoleptic cataplexy are often linked or confused (Hishikawa, 1976). Narcoleptics often suffer from both SP and cataplexy. Both are characterized by a loss of muscle tone without loss of consciousness. In both cases, individuals are aware of their surroundings while sometimes simultaneously experiencing complex visual and auditory hallucinations as well as out-of-body experiences (Guilleminault & Gelb, 1995). During cataplexy there is loss of the H- and T-reflexes (Guilleminault, 1976). There are differences, however, in the eliciting conditions and associated emotions. Cataplexy is usually brought on by sudden emotion, whereas SP is associated with sleep onset or offset. In addition, although cataplexy is brought on by several strong emotions including anger, excitement, surprise, and elation; fear and anxiety, so strongly associated with SP, appear to inhibit cataplexy (Guilleminault & Gelb, 1995). There is also some evidence for some dissociation between the two types of symptoms in narcoleptics (Sours, 1963). On the other hand, cataplectic episodes, which often lead to sleep, is sometimes followed by SP (Hishikawa & Kaneko, 1965).

other aspects of REM sleep (Hishikawa, 1976; Hishikawa & Shimizu, 1995; Hishikawa, Sumitsuji, Matsumoto, & Kaneko, 1965; Hishikawa, Koida, Yoshino, Wakamatsu, Sugita, Iijima, & Nanno, 1978). Paralysis of major muscles systems is a hallmark of the REM state and depends upon a complex set of GABA and glycine inhibition of motor neurons. (Brooks & Peever, 2012). SP is commonly classified as a REM sleep disorder (e. g., Mahowald & Rosen, 1990). Hishikawa *et al.* (1978) report that SP and hypnagogic hallucinations were associated with sleep-onset REM periods (SOREMP) with a latency of less than 2 minutes from physiological indications of REM onset. Transient alpha activity in the EEG is also higher during SP. Although the mechanisms may be the same for motor inhibition during SOREMP as for later REM, the inhibition may be even greater during SOREMP. Stimuli capable of rousing people from REM sleep may be detected and remembered by people during SOREMP although they were unable to respond to them (Hishikawa, 1976).

SP Hallucinations

In addition to the basic experience of paralysis, frightening in itself, dramatic and terrifying imagery frequently accompanies the immobility. Indeed, it is through the phenomenology of SP that some of the most striking similarities with TI are to be found. SP is often accompanied by an acute sense of threat, immanent danger, and, ultimately, intense fear. The sense of dread and terror is consistent with observed elevated heart rate or tachycardia during SP (Fukuda, 1989). A variety of hallucinatory experiences are reported during SP. These range from nonspecific sounds and shapes, shadowy outlines, vague rustlings, or soft footfalls to specific hallucinations of human, animal, or demonic beings. Proportions of different hallucinations reported to occur during SP are provided in Table 3.

SP episodes frequently include a vivid but nonspecific sense of a threatening evil presence. The presence may felt to be out of sight behind or just off to the side by the bed, or sitting on one's chest or back. The sense of presence is a kind of intuition and hence is itself non-sensory but is often followed, or accompanied, by sensory hallucinations in several modalities. These include illusory auditory, visual, and tactile experiences. The auditory hallucinations vary on a continuum of specificity from rustling sounds and footsteps, through indistinct voices, to daemonic gibberish, and brief but specific threats. Visual hallucinations are typically of humans, animals, and supernatural apparitions varying from shadowy outlines to vividly hideous hags, trolls, and death-heads. Tactile sensations can range from light touches to sensations of being grabbed and held with great force. Respiratory difficulty is very common and is associated with feelings of pressure (often construed as something or someone sitting on one's chest), suffocation, choking, pain, and thoughts of impending death. Also reported are feelings of floating off the bed, spinning around on different axes, and flying, sometimes through spiral tunnels, as

Common Experience Types	Percentages during:	
	Lifetime of Episodes	Single Episodes
INTRUDER (THREAT)		
Felt presence	71	58
Hallucinations: Visual	63	43
Auditory	63	45
Tactile	47	30
Movement of Bed Covers	17	13
INCUBUS (ASSAULT)		
Death Thoughts	64	37
Pressure	62	53
Breathing	60	47
Choking/Suffocating	21	30
Pain	29	22
VESTIBULAR-MOTOR		
Movement	52	24
Floating	44	21
Out-of-Body Experiences	43	22
Falling	38	8
Flying	24	4
Autoscopy	23	13
EMOTIONS		
Fear	95	85
Bliss	13	12

Table 3: Percentages of People Reporting Different Sleep Paralysis Experiences (Cheyne, 2016)

well as illusory movement and locomotion, involving sitting up, getting out of bed and moving across the room – often followed by suddenly finding oneself back in bed still paralyzed. "Elevator" feelings of rapidly rising and falling are also reported. Vivid out-of-body experiences (OBEs) can also be experienced and sometimes autoscopic experiences of seeing one's body lying on the bed from a station point above. Many experients may report only one or none of

these experiences. Others report many or, occasionally, most of these hallucinations. SP, with or without elaborate hallucinations, is typically extremely frightening. Experients often report that, before learning about SP, they suspected that they were suffering from serious psychiatric or neurological disorders, and even daemonic possession or alien abduction.

Detailed analysis of these hallucinations has provided consistent evidence that they are organized around three major themes that have been labeled: Intruder, Incubus, and Vestibular-Motor hallucinations (Cheyne, 2003; Cheyne & Girard, 2007; Cheyne, Rueffer, & Newby-Clark, 1999; see Table 3). *Intruder* experiences include the sensed presence and the sensory hallucinations (visual, auditory, and tactile) hallucinations. Incubus experiences include breathing difficulties, bodily pressure, pain, and death thoughts. These two factors are correlated and associated with intense fear. The qualitative features of these experiences are thematically consistent with threat and assault, respectively, by an external agent or entity.

Theory of SP Hallucinations

Given consistent evidence that SP is a REM phenomenon, theory has been guided by models of dreaming. In particular, elements of the activation-synthesis and subsequent AIM models of dream generation (Hobson & McCarley, 1977; Hobson, Pace-Schott, & Stickgold, 2000; Hobson, Stickgold, & Pace-Schott, 1998; McCarley & Hobson, 1979) have been particularly useful in understanding the origins and structure of SP hallucinations (Cheyne, 2003, 2010; Cheyne, Rueffer, & Newby-Clark, 1999). Central among these features have been motor inhibition, sensory gating, and pontine activation of a variety of cortical and subcortical areas. Also useful in theorizing about SP experiences have been models of emergency response to threat (LeDoux, 1994, 1996, 2000; Whalen, 1998), which, interestingly, share a number of features with REM generation.

Among the proposed functions of REM are the organization and maintenance of evolved sensitivities and behaviors (Jouvet, 1975; Revonsuo, 2000). Predator detection, risk assessment, and avoidance incorporate some of the most fundamental evolved strategies of organisms (Blanchard & Blanchard, 1988; Lima & Bednikoff, 1999). Under conditions of uncertain, hidden, or ambiguous threat, organisms must rapidly obtain information about predators that have themselves developed elaborate strategies to make detection and discrimination unlikely (Blanchard & Blanchard, 1988; Curio, 1993). Whalen proposed that these functions were achieved by the extended amygdala and related structures such as the nucleus basalis of Meynert (Whalen, 1998; Whalen, et al., 1997). These structures constitute a system I have referred to as a threat activated vigilance system (TAVS; Cheyne, 2003). The postulated function of the TAVS is to disambiguate potential signs of danger by focusing attention, lowering sensory thresholds, and creating perceptual biases. The TAVS bias therefore results in a grea-

ter likelihood of acceptance of ambiguous stimuli as portents of danger. Given that the initial detection of potential threat cues in the natural environment changes the *a priori* probability of threat, this heuristic of a temporary bias can be seen to be biologically quite functional. Predator avoidance systems require precise and timely assessment of predator type, location, and risk. Prolonged uncertainty under unresolved but potentially dangerous situations is extremely aversive and reduction of uncertainty, particularly under predator threat, is highly, and probably uniquely, motivated (Blanchard & Blanchard, 1988). Given that motivational states have their own distinctive associated subjective feelings, we have argued the endogenous activation of the TAVS during REM and SP are experienced as an ominous but elusive sense of presence (Cheyne, 2001).

Neuroimaging studies of REM sleep implicate such potential TAVS-relevant limbic structures as the pontine tegmentum, amygdala and associated entorhinal cortex, lateral hypothalamus, and anterior cingulate cortex as well as in areas of the ventral processing stream (fusiform, inferotemporal, and ventral lateral occipital cortices) and limbic-related projection areas (Braun et al, 1997; Maquet et al, 1996; Nofzinger, Mintun, Wiseman, Kupfer, & Moore, 1997). Thus, there is evidence for a link between visual association areas, object identification (implicated by the ventral stream involvement), and limbic activity. Based on the forgoing neuroimaging data, we have proposed that changes in pontine neuromodulation can endogenously activate the TAVS during REM dreams and SP hallucinations. Endogenous activation of the TAVS would then generate biased dream imagery in the same way perception of environmental events is biased under threat, generating threatening dream experiences. Moreover, during SP the experient is awake and aware of being paralyzed, alone in the dark, and in a defenseless supine position. This awareness will almost certainly increase fear and further reinforce the activation of the TAVS and therefore increase the probability that SP episodes contain more fear and violence than do dreams (Parker & Blackmore, 2002).

The Incubus factor includes experiences consistent with traditional accounts of *incubus attack*, in which a creature is perceived to sit on the chest while assaulting the sleeper. The common factor in such experiences is the motor paralysis, experienced as restraint during attempts to move or breathe deeply. The latter could also be interpreted as being caused by a weight or pressure on the chest (Cheyne, Rueffer, & Newby-Clark, 1999). Additional features of REM respiration potentially contributing to such experiences include shallow rapid breathing, hypoxia, hypercapnia, and partial occlusion of airways, as well as variable tidal volume and breathing rate and reduced thoracic contribution to breathing during REM (Douglas, 1994). Respiratory difficulty might be experienced as choking or suffocating (Hishikawa & Shimizu, 1995). Thus events associated with motor inhibition will lead, *ex hypothesi*, to classic incubus experiences of assault accompanied by pain arising from corollary discharge undampened by proprioceptive feedback (because of the paralysis) following execution of motor programs likely initiated as

struggle to overcome the perceived restraint (Cheyne, Rueffer, & Newby-Clark, 1999). These experiences share with the previous cluster of intruder-related experiences the transparent relation to the presence and actions of an external agent.

TI and SP Compared

Although TI has frequently been proposed as a model of human hypnosis (Pavlov & Petrova, 1934; Preyer, cited in Romanes, 1884; Völgyesi, 1966) this hypothesis has fallen into disfavor in recent times (e. g., Klemm, 1971; Gallup & Maser, 1976, Gallup & Rager, 1996; Ratner, 1967). TI has also been proposed as a model for several neurological and psychiatric disorders including catalepsy, cataplexy, and catatonia (Preyer, cited in Romanes, 1884; Gallup and Maser, 1977) as well as for SP (Gallup & Maser, 1976; Gallup & Rager, 1996; Klemm, 1971; Marks, 1986).

A number of parallels between TI and SP will already be evident to the reader. Most obviously, both TI and SP involve as a primary defining feature a profound but temporary immobility. As noted above, many of the hallucinoid experiences associated with SP are consistent with features of, and often interpreted as, threat and assault. Both are associated with high levels of fear. More generally, several decades ago, Klemm (1971) noted a number of close parallels between TI and paradoxical (REM) sleep in animals including the fact that both involve generalized reduced muscle tone, pupil constriction, elevated arousal thresholds, EEG desynchrony, as well as similar developmental trends. He also noted differences, however, such as the absence of rapid eye movements during TI. Other obvious major differences may be seen in the eliciting conditions; restraint or entrapment in one case and sleep-wake or wake-sleep transitions in the other. The purpose of the remainder of this paper is systematically to review these and other apparent similarities and differences in the two phenomena.

Inversion and Restraint

As noted, inversion and restraint are critical inducing conditions for TI. Thus supine body position, along with strong proprioceptive and tactile stimuli, is a critical component in the induction of TI (Gallup; 1974; Klemm, 1976; Rakshit & Klemm, 1980). Rough handling of chickens, for example, increases duration of immobility responses compared to gentle handling (Jones, 1992). In laboratory settings animals are inverted and restrained manually or by special devices (Gallup & Rager, 1996), such as a V-shaped (Ratner, 1958) or U-shaped (Klemm, 1966) trough. Both of these, but especially the U-shaped trough, increase the duration of TI. One possibility is that the troughs, particularly the U-shaped trough, sustain physical contact throughout the period of immobility likely mimicking the sensations of restraint (Braud & Ginsburg 1973; Ginsburg, 1975; Klemm, 1966b). The use of troughs also relatively effectively maintains the

animals in the inverted position preventing them from rolling over as well as applying pressure to the dorsal surface of the neck and spine. As noted previously, TI duration may also be increased by wrapping the animal in bandages or attaching clips to various parts of the body, especially the neck region, all of which would effectively maintain a sense of continuing restraint (Fleischmann & Urca, 1988; Lefebvre & Sabourin, 1977; Meyer, 1990). Indeed, pressure applied to the midline of the dorsal surface at the nape of the neck significantly potentiated the duration of TI (Cruz & Junquera, 1993; Meyer, 1990). Significantly, there is somatotopic mapping for the neck region in the dorsal gray linked to the amygdala, regions implicated in the neurological underpinnings of TI (Cruz & Junquera, 1993) as well as SP.

SP does not typically involve objective restraint, but does entail a vivid subjective impression of being restrained. Many SP sufferers report that they feel that they have been physically restrained by some person or creature during the episode (Cheyne, 2001). Experients sometimes report feeling tangled in bedclothes and reports of something pulling at the bed sheets is common in folklore as well as in modern surveys (Hufford, 1982). Sensations of touching and restraint of various body parts are also rather common and tend to be closely associated with the threatening sensed presence (Cheyne, 2003).

A brief informal survey of photographs of tonically immobilized animals in research reports and academic books on the subject suggests to me that the supine position is favored 10:3 as a position for artificial laboratory induction, at least for illustrative purposes (Gallup & Masur, 1977; Volgyesi, 1966). More systematic investigations provide evidence that restraint in side or prone positions reduced the incidence and duration of TI relative to the supine position (Gilman, Marcuse, & Moore, 1950). Gallup & Rager (1996) note that this finding was unreliable, however, and further note that "inversion makes it easier to identify response termination" (p. 61), which would, of course, complicate comparisons between different positions. Nonetheless, the association between the supine position and sustained immobility is quite striking given that many species look quite awkward and appear to be unstable in this position (See especially photographs in Völgyesi, 1966). Indeed, it is possible that the inconsistency of the position effect in laboratory studies is a result of animals rolling over during TI, especially when placed on a smooth, slippery, flat surface, such as a lab table.

It has long been commonly believed that lying in the supine position is a proximate cause of sleep paralysis. Jones (1951) discusses numerous traditional sources for this belief. Hufford (1982) reports that the supine position during meditation (yoga: corpse pose) may increase the likelihood of sleep paralysis and estimates that 90% of his informants experienced sleep paralysis in the supine position. Hufford does not comment, however, on the normal sleeping position of his sample. Spanos, McNulty, DuBreuil, Pires, & Burgess (1995) reported that 70% of their subjects claimed to have been in the supine position during sleep paralysis. Again, no

information is provided on the normal sleeping position for subjects in that sample. Fukuda, Ogilvie, Chilcott, Vendittelli, & Takeuchi (1999) report that 58% of Canadian and 84% of Japanese students reported being in the supine position during sleep paralysis. This is in contrast to only 4% and 41% of Canadian and Japanese students, respectively, reporting being in the supine position during regular sleep. This study makes it clear that the supine position is much more commonly reported for sleep paralysis than for normal sleep. The regular sleeping position data reported provided by Fukuda et al. does not differentiate between sleep paralysis and non-sleep paralysis cases. Hence it is not possible to determine from that study whether those who have experienced SP differ in their normal sleeping position from those who have never experienced SP. In a later study that did compare reported sleeping positions during normal sleep of sleep paralysis experients with non-experients no differences were found (Cheyne, 2002a). Although only a minority (22%) of both experients and non-experients reported normally sleeping in the supine position it was clearly the predominate position (74%) during sleep paralysis relative to prone and right and left side positions, not very different from the 10:3 ratio noted above for TI induction. It is, of course, possible the reported position at sleep onset is not a reliable indicator of actual position during even the early stages of sleep. In general, body motility is relatively high prior to entry in to REM states (Hobson, Spagna, & Malenka, 1978; De Koninck & Gagnon, 1983) although this does not necessarily lead to any consistent change in body position. As it turns out, the proportions of both SP experients and non-experients reporting normally sleeping in different positions in the Cheyne (2002b) study is closely consistent with those reported for lab studies across all stages of sleep (Lorrain & DeKoninck, 1998).

Lying in the supine position will likely, in humans, involve some pressure to the back or side of the head or neck, which might contribute to the precipitation of a SP episode. It is also possible that the supine position is associated with feelings of vulnerability to attack. Immobilized mental patients have been reported to find restraint in the supine position less tolerable than in the prone position (Aschen, 1995). More generally rats provide evidence of more elevated adrenocortical stress to supine that prone restraint (Natelson, Ottenweller, Cook, Pitman et al., 1989). Infants have been reported to be more than twice as likely to roll from supine to prone position as from the prone to supine (Togari, Kato, Saito, & Yamaguchi, 2000).

The supine position appears also to have important physiological effects that might exacerbate and potentiate both TI effects and SP subjective experiences. The supine position is associated with upper airway obstruction by collapsed soft tissue (Penzel, Möller, Becker, Knaack, & Peter, 2001) and poor oxygenation (Cakar, derKloot, Youngsblood, Adams, & Nahum, 2000). The supine position also produces greater compressive force on the lungs from the heart (Albert & Hubermeyer, 2000). In view of these effects, it is not surprising that the supine position increases the likelihood and severity of obstructive sleep apnea (Berger, Oksenberg, Silverberg,

Arons, Radwan, & Iaina, 1997; Cartwright, 1984; Cartwright, Diaz, & Lloyd, 1991; Pevern-agie & Shepard, 1992), which has been reported to be associated with SP (Ohayon, Zulley, Guilleminault, & Zirne, 1995).

Threat and Assault

There has been little assessment of the effect of position on the nature or intensity of hypnago-gic/hypnopompic experiences accompanying sleep paralysis. Given that tonic immobility is a response to threat and attack by a predator, Cheyne (2002b) predicted that the supine position during sleep paralysis may be more likely to be associated with threat and assault hallucinations than other sorts and reported significant though small positive associations of the supine posi-tion with threat and assault hallucinations but not with floating or out-of-body hallucinations.

In summary, the reported subjective experiences of the threatening presence and the crush-ing pressure on the chest would seem to mimic some of the sensations of being attacked, seized, and held down by a predator/attacker. These are just the sorts of experiences one might expect to be associated with a state related to that of tonic immobility, given the context of death feign-ing. The strong association of sensed presence and fear as well as the perception of the threaten-ing presence is consistent with the association of immobility states with predator threat.

Fear and Pain

Romanes (1884) credits a certain Mr. Couch for the first articulation of the hypothesis that TI is a consequence of terror, although Völgyesi (1966) notes that Kircher had proposed a similar hypothesis in 1671. TI and freezing responses are widely used in research as behavioral indices of fear many species. Moreover, there is substantial evidence that fearful contexts increase the duration of TI though fear in itself is clearly insufficient to produce it (Gallup, 1974, 1977). Fear induced by electric shock, loud noise, repeated exposure to inescapable shock, conditioned fear cues, and suspension over a visual cliff during induction of TI have all been found to lead to increased duration (Gallup & Maser, 1976). Conversely, safety signals, such as cues that signal the termination of shock, reduce TI duration (Maser, Gallup, & Barnhill, 1973).

Mice with successive experiences of defeat show greater immobility than dominant males with successive experience with victories (Kudryavtseva & Bakshtanovskaya, 1989). Defeat in fights with conspecifics may induce immobility in rats as well (Williams, Just, & Worland, 1994). The related freezing response in rats has also been related to startle magnitude to an auditory stimulus (Plappert, Pilz, Schnitzler, & Ulrich, 1993). Stress and anxiety more generally seem to augment TI. Chickens administered an anxiogenic agent, had longer duration TI than

birds given control injections (Moriarty, 1995). Conversely, anxiolytics combining diazapam and melatonin have also been found to increase the immobility times of mice in a tail suspension test (Guardiola-Lemaitre, Lenegre, Porsolt, 1992).

Induction in a novel setting, which may be associated with increased vulnerability and hence fear, have been associated with increased duration of TI in guinea pigs compared to induction in home cage (Liberson, Bernsohn, Wilson, & Daly, 1964) whereas prior handling experience and familiarization with surroundings may reduce TI (Grigor, Hughes, & Appleby, 1995). Previously habituated TI may also become dishabituated in a novel setting Gilman, Marcuse, & Moore, 1950). Anecdotally, many SP experients report that their episodes, particularly first episodes, occur in novel settings and when they are alone.

Pain also prolongs TI (Aloisi, Panerai, Carli, 1995). It may, however, be that fear associated with conditional signals for pain is what is affective (Kiernan, Westbrook, & Cranney, 1995). Painful tail pinching of rats following neck pinch induced TI produces immobility rather than the normal aversive response (Fleischmann & Urca, 1993). This effect may result from a lack of responsiveness to pain following neck pinch, which is consistent with the notion that TI is an antipredator strategy. Clearly, non-responsiveness to external stimuli and especially nociception would be critical to the effectiveness of this strategy.

As noted the most common themes of SP hallucinations are those of the threatening intruder and of physical and sexual assault. Across numerous studies fear and pain are consistently experienced during SP episodes with such themes (Cheyne, 2010). Fear is especially consistently reported in more than 80% of episodes (Cheyne & Girard, 2007) and with skewed distributions of intensity ratings with the highest frequencies of reports at the top end of the scale (Cheyne & Pennycook, 2013). Fear and pain are also consistently most strongly associated with the incubus factor and hence with hallucinations of assault (Cheyne, Rueffer, & Newby-Clark, 1999; Cheyne, 2003; Cheyne & Girard, 2007; see Figure 2). High reported levels of fear and pain during SP have successfully distinguished between individuals reporting childhood sexual abuse and those not reporting such experiences (Abrams, Mulligan, Carleton, & Asmundson, 2008).

Duration and Termination

Degree or intensity of TI is typically assessed by measuring the natural duration of TI to spontaneous recovery (Ratner, 1967) or by the number of induction attempts to induce TI or some combination of these two (Lefevbre & Sabourin, 1977a). TI has also been artificially terminated using visual (Doty, 1969) and auditory stimuli (Hatton & Thompson, 1975). The termination of TI is described as being abrupt rather than gradual (Gallup & Maser, 1976). Upon recovery from TI animals are typically immediately fully alert.

SP episodes typically end abruptly. People can generally be readily and completely aroused from SP by either tactile or auditory stimulation (Hishikawa, 1976). It is a common strategy among experients to have arranged with a spouse of sleeping partner to be sensitive to their moans and grunts and to arouse the apparent sleeper by calling out his/her name, or by touching or shaking the shoulder. Typically, when roused by a sleeping partner, or when spontaneously recovering from an episode, the person reports that s/he is immediately alert and fully mobile, though there are some reports of intense sleepiness, which may be particular to successive episodes on a single occasion.

TI and SP Mortality

In addition to fear and pain being setting conditions and augmenters of TI, the condition itself appears intrinsically to be an aversive one (Nash and Gallup, 1975). TI may, in extreme instances or with frequently repeated inductions, even prove fatal (Preyer, 1878, cited in Völgyesi, 1966; Romanes, 1884; Gallup, 1974; Gallup & Maser, 1976). With regard to SP, even a basic description makes it clear that it is an extremely aversive condition in the large majority of cases. People will frequently refer to their SP experiences as the most frightening experiences of their lives and many remark that fear is far too weak a term to describe the abject terror that accompanies their paralysis (Cheyne, 2001). Others report that nothing in waking life compares to the sense of terror in those few moments lying in bed. The anxiety and stress may endure for some time after recovery from individual episodes (Cheyne & Pennycook, 2013). This includes soldiers being treated for combat fatigue (Heide & Weinberg, 1945). As noted, the fear during SP episodes is particularly associated with the sensed presence, the crushing sensations on the chest, and the thought that one's condition is life threatening. Yet, many who acknowledge this also insist that there is something in the terror of SP that transcends these specific fears (Cheyne, 2001).

Kaada (1994, 1995) has argued that TI may be a cause of sudden infant death syndrome (SIDS). He acknowledges that there is strong evidence that prone sleeping places the infant at greater risk for SIDS than supine sleeping. The fact that the prone position is thought to produce this effect seems at odds with the effects of position on SP (especially the Old Hag experience) and the eliciting conditions for TI. Kaada notes, however, that the infant's movements are more restrained in the prone than in the supine position. He also argues that this effect peaks in winter because infants are more likely to be tightly wrapped or sleeping in the same bed as a parent. Sudden unexpected death syndrome (SUNDS) among the Southeast Asian Hmong, a rare condition associated with extreme stress, has also been associated with repeated SP-like episodes (Adler, 2011, 1991, 1994).

Attention and Consciousness

One of the most striking parallels between TI and SP is the marked dissociation between motor and sensory responsiveness. In spite of the profound motor inhibition in TI, animals clearly continue to monitor their environment (Ratner, 1967; Gallup, 1974; Gallup, Boren, Suarez, Wallnau, & Gagliardi, 1980) and are responsive to events in their immediate environment. Sensory stimulation, insufficient to disrupt TI, has been shown to produce cortical EEG desynchrony and hippocampal theta (Klemm, 1971) both of which are characteristic of REM states. Klemm also noted changes in late components of evoked potential, however, which may suggest that more complex sensory processing may be altered. Classical conditioning has been demonstrated, and is perhaps even enhanced during TI (Draper & Klemm, 1967). Klemm (1971) suggested that this implies a state of heightened attention during TI. Previously learned responses have been elicited and extinction has been demonstrated during TI (Gallup, Boren, Suarez, Wallnau, & Gagliardi, 1980). During SP people appear to be asleep but are actually often extremely attentive to their surroundings and able to report on events that occurred during the period of SP (Hishikawa, 1976; Hishikawa & Kaneko, 1965; Takeuchi, et al. 1992).

Eye Opening

In both TI and SP, both eye opening and eye movements are spared from the general motor paralysis. Although animals appear to be unresponsive during TI they will periodically open and close their eyes while otherwise remaining immobilized (Gallup & Maser, 1976; Klemm, 1971). Romanes (1884) reports a case in which eye blinking was detected in a "dead" wolf, prior to its recovery. A large proportion of SP sufferers report that they are able to open their eyes and look around the room and subsequently to be able to accurately report on events occurring in the room. Many years ago the present author experienced sleep paralysis lying down on a sofa at a Christmas party, during which he overheard a conversation, the contents of which he was able to corroborate upon recovery. In our surveys, we have asked SP experients about whether or not they open their eyes during SP and found that over 50% respond affirmatively. Of the others some indicate that they cannot and some report that they do not know because they are reluctant to try for fear of what they might see.

Muscle Tone

Muscle tone during TI is quite variable and may range from flaccid to rigid even within a given individual animal (Weidorn, 1954). The degree and extent of muscle tonus may depend upon the position in which the animal is placed during the restraint phase although animals may

sometimes remain immobile for remarkably long periods in even very awkward positions (Völgyesi, 1966). Muscle tonus during SP is usually quite low as measured by EMG from chin and neck muscles during SP (e.g., Hishikawa, 1977).

Reflex Suppression

Mono- and polysynaptic spinal reflexes may be suppressed during TI, though this is variable across species (Carli, 1968). H- and T-reflexes are abolished during SP (Hishikawa, 1977; Hishikawa & Shimizu, 1995).

Tremors in the Extremities

Animals often show "Parkinsonian-like" tremors in the extremities during TI (Gallup & Maser, 1976). These may resemble the tremulous movements of the extremities during REM sleep in animals. Klemm (1971), on the other hand, reports that phasic limb twitches reported for paradoxical sleep in several species are not present during TI. Curiously, Klemm himself, in the same article also describes "a fine tremor of the hind limbs" of rabbits during TI induction (p. 172), suggesting that this too may represent a similarity rather than a difference. Though I am not aware of any reports of overt tremors in individuals during episodes, feelings variously described as vibrations, trembling, shaking, or tingling feelings during SP are also reported by SP experients (Cheyne, 2002b), though these sensations have not been investigated systematically to date.

Neuroanatomy

TI is likely controlled by interneurons in the brainstem reticular formation (Klemm, 1966b, 1971). Lesion studies, surgical transection, electrical stimulation, and EEG recording all unequivocally implicate the brain stem and spinal cord as containing major structures controlling TI (Klemm, 1965, 1969, 1971; McBride & Klemm, 1969). In addition, periaqueductal gray matter (PAG), lateral and anterior hypothalamic nuclei, and central, basolateral and lateral posterior nuclei of the amygdala are important structures regulating TI (Monassi, Hoffman, & Menescal-de-Oliviera, 1997; Leite-Panissi, Monassi, & Menescal-de-Oliviera, 1999). Neocortical deactivation, inhibition, underdevelopment, or absence substantially reduces susceptibility to TI (Klemm, 1971; McGraw & Klemm, 1969).

As noted earlier, SP has been associated with REM states, particularly with sleep-onset and sleep-offset REM periods (SOREMP). REM atonia is generated in pontine cholinoceptive neu-

rons of the nucleus reticularis pontis oralis, which receives cholinergic inputs from laterodorsal and pedunculopontine tegmental nuclei (Hishikawa & Shimizu, 1995; Hobson & McCarley, 1977; Hobson, Stickgold, & Pace-Schott, 1998). Consistent with this claim, atonia during REM may be eliminated in cats via bilateral lesions in the dorsolateral pontine reticular formation (Siegel, 1994). More generally, atonia may be induced by injecting carbachol, a cholinergic agonist, or physostygmine, a cholinesterase inhibitor, into these same regions (Hishikawa & Shimizu, 1995). The atonia of SP may be associated with hypersensitivity of cholinoceptive neurons or from a failure of inhibition of such neurons because of hypoactivity of monoaminergic neurons in the locus coeruleus and raphé system (Hishikawa & Shimizu, 1995). The atonia itself is ultimately produced at the level of the spinal motoneurons through the activation of inhibitory interneurons (Chase & Morales, 1994). Muscle twitches seen in the extremities of animals during paradoxical sleep results from momentary depolarization of the motoneurons (Chase & Morales, 1994).

EEG Changes

Klemm (1966a) found a behavioral and physiological dissociation during TI such that, in spite of the motor inactivity and appearance of stupor, the EEG indicated an alert state. The alert state of the central nervous system is likely responsible for the quick recovery when threat cues are reduced. EEG during SP is consistent with an alert or drowsy awake state. Subjectively, people report a range of alertness from drowsy to wide-awake (Cheyne 2002b).

SP has been induced in 16 normal subjects in a sleep lab by forced awakening after 40 minutes of NREM sleep following REM sleep in the 1st or 3rd sleep cycle (Takeuchi, Miyasita, Sasaki, Inugami, & Fukuda, 1992). All subjects reported being unable to move while fully conscious of being in the lab. All but one subject reported audio-visual hallucinations and unpleasant affect. Takeuchi, Miyasita, Inugami, Sasaki, & Fukuda (1994) report of a hypnagogic hallucination without SP. A polysomnogram during hallucination recorded a mixed pattern, with muscle-tone inhibition, REM, slow eye movements (SEMs), and abundant alpha EEG trains. The hallucination during this episode had the affective qualities of those associated with SP.

Neurophysiology

TI has been hypothesized to be a consequence of a cholinergic inhibition system activated by adrenergic activity (Carleton, 1968; Thompson, 1976). Consistent with this, adrenaline administration potentiates TI (Gallup, 1974) possibly by activating the cholinergic inhibition system. Furthermore, blocking the cholinergic system with agents such as scopalomine hydrobromide,

which competes with acetycholine at receptor sites, reduces TI duration (Thompson, 1976). Conversely, physotigmine, which binds with acetylcholinesterase, potentiates TI (Thompson, 1976). As noted earlier SP is generally has been associated with anomalous interactions between adrenergic and cholinergic/cholinoceptive pontine neurons. Nitz, Andersen, Fahringer, Nienhuis, Mignot, & Siegel (1995) suggest that narcolepsy and possibly SP may be associated with an abnormal number of LDT and/or PPN cholinergic neurons.

Other Physiological Effects

Rabbits and chickens show a reduction in heart rate during TI (Gilman, Marcuse, & Moore, 1950; Nash, Gallup & Czech, 1976; Ookawa, 1972), although Klemm (1966) reported an initial acceleration prior to ultimate deceleration. Humans have been shown to produce an increase in heart rate following restraint or rapid inversion of body position (Crawford, 1977). Chicken and iguanas increase respiration immediately following induction of TI (Gilman, Marcuse, & Moore, 1950; Prestrude & Crawford, 1970; Nash, Gallup, & Czech, 1976). Squirrel monkeys, on the other hand, show reduced respiration rates following induction of TI. Core body temperature drops during TI in a variety of avian and mammalian species (Rager & Gallup, 1996). Feeling cold is not commonly reported during SP episodes, though we ask this question regularly. As a REM state SP would, however, likely be associated with some loss of temperature regulation and potential hypothermia.

Circadian Rhythm

TI sensitivity exhibits a circadian rhythm peaking just around the transition from light to darkness. TI durations in rats have been found to be longest immediately following and just prior to dark onset (Hennig and Dunlap, 1977). For chickens TI duration is longest just prior to light onset and shortest immediately after light onset (Stahlbaum, Rovee-Collier, Fagen, & Collier, 1986). Freezing responses to auditory stimulus (and brachycardia) in rats may be increased by induced variations in the circadian rhythm (Steenbergen, Koolhaas, Strubbe, & Bohus, 1989).

Although SP appears quite clearly to a phenomenon of sleep-wake and wake-sleep transitions, this need not imply that SP necessarily occurs at beginning or end of sleep though reported onset does peak around sleep onset and offset (Cheyne, 2002b). Frequency of SP is reported to be highest at sleep onset and intensity of hallucinations lowest at sleep offset. Interestingly, fear is reported to be lower when episodes occur at sleep onset (Cheyne, 2002b). Sleep onset episodes would more likely to have occurred during darkness than sleep offset periods.

Developmental Effects

TI appears to have specific periods of developmental onset (Gallup, 1974). Immature of many mammalian young such as rat pups exhibit TI during maternal transport (Brewster & Leon, 1980). Salzen (1963, 1979) argued the onset of TI in chicks was correlated with the development of fear. It has also been suggested that, although younger rats may be more susceptible than older, susceptibility may return in old rats (Klemm, 1971; McGraw & Klemm, 1969).

SP appears to have a clear course of developmental onset. Fukuda, Ogilvie, Chilcott, Vendittelli, & Takeuchi (1999,1998) and Wing, Lee, & Chen (1994) report rising rates of onset of sleep paralysis peaking in late adolescence. Buzzi & Cirignotta (2000) report equal rates of onset before and during the teen years and considerably diminished rates after 20, although this is based a small sample and detailed results are lacking. Cheyne (2002b) reported that the most common first onset of sleep paralysis was in the late teens. First SP episodes peaked around 17 with a rapid subsequent decline of first episodes, which become rare after the early 30s, but are occasionally reported in older adults. Approximately 60% reported the onset of sleep paralysis in the second decade of life, 17% in the first decade and 8% in the third decade.

TI, SP, and Rape Induced Paralysis

There is one other rather distinctive phenomenon that TI & SP share that brings together many of the similarities we have discussed – sexual assault. Suarez and Gallup (1979) suggest yet another form of transient immobility when they draw a number of parallels between TI and rape induced paralysis. They note that rape is a predatory act as well as a sexual one (Burgess & Holmstrom, 1974; Selkin, 1975). Certainly many of the features are present including a threatening agent, initial freezing, flight, if possible, and pursuit, followed by struggle and restraint, frequently leading to a state of immobility (Burgess & Holmstrom, 1976) in which the victim gives up struggling and may be unable to cry out. Over 50% of rape victims show some signs of immobility reactions (Burgess & Holmstrom, 1976; Amir, 1971). Victims may remain conscious throughout the assault and often remember events clearly. They may also report feeling very cold, shaking or trembling violently (Russell, 1974). As noted above, tremors are often associated with TI and numbness and vibrating sensations are sometimes reported for SP. Rape victims may also report an impression of insensitivity to pain (Schultz, 1975). Suarez and Gallup (1979) also present arguments similar to those made for TI regarding the functionality of the state of immobility. These functions include possible reduction in the level of physical violence and even cessation of the attack often because the attacker is no longer sexually aroused (Burgess & Holmstrom, 1976; Cohen, Garofolo, Boucher, & Seghorn, 1971; Storaska, 1975).
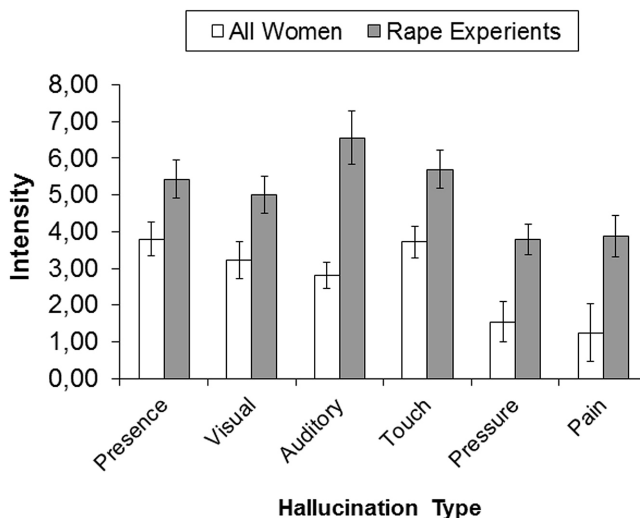
Figure 2: Hypnagogic and Hypnopompic Hallucinations associated with
Intruder and Incubus experiences are reported more frequently by rape-
experients than rape non-experients. Error bars are standard errors.
Rape experients: N = 32; Total: N = 1036

Occasionally women and, rarely, men will spontaneously describe the hallucinations accom-
panying SP as a rape or sexual assault experience (Cheyne, Rueffer, & Newby-Clark, 1999).
Traditional cultures, such as that of the Hmong, attribute nocturnal assaults accompanying
paralysis and extreme fear of an evil spirit, an attribute of which is the propensity to rape. In a
search through archive data from our own research we found 32 women and four men among a
sample of 1068 who spontaneously described their SP experience as rape-like. These women, in
comparison to women who did not refer to rape-like experiences, reported significantly higher
intensities of sensed presence, pain, visual, auditory, and tactile hallucinations, as well as erotic
feelings, and hallucinations of someone pressing down on them (Figure 2).

Sleepless in Zanzibar – The Popobawa: A nightmare figure that has received some publicity
in recent decades is a powerful dwarf called the *Popobawa* (*bat wing* in Swahili) of Zanzibar
in Tanzania (Nickell, 1996; Walsh, 2009). Although, as the name implies, the creature appears
vaguely as a kind of humanoid bat, it does take on different forms and hence seems also to
be a shape-shifter. Attacks by the Popobawa are also reputed to be quite physical, as bruises
and even broken ribs have been blamed on the Popobawa. Perhaps most terrifying about the
Popobawa, however, is that it appears to prefer to attack men at night to forcibly and roughly
sodomize them. "Something was pressing on me. I couldn't imagine what sort of thing it was.

You feel as if you are screaming with no voice. It was just like a dream but I was then thinking it was this Popobawa and he had come to do something terrible to me, something sexual. It is worse than what he does to women" (Nickell, 1995). There were several epidemics in the 1970s, 1980s, and 1990s, and again in 2006 sometimes, but not always, associated with times of stress. Interestingly, the 1995 epidemic occurred during Ramadan, a time of fasting, sleep loss, and, presumably, somewhat more reflection on things spiritual as well as during elections and during contentious relations with the mainland (e. g., Walsh, 2009).

Inevitably in such matters, people generate a variety of opinions about the provenance of the Popobawa. Some thought it was the work of Sheitan (Satan), a view ridiculed by many who were certain that it was called out by sorcerers. At one point the blame was placed on the spirit of a dead whale. Offerings to the whale's spirit were made, but to no avail. The attacks continued. Spared families and villages sometimes claimed protection by a superior spirit. Reports appeared of suspected agents of the Popobawa or the Popobawa itself being killed. Yet the attacks continued. Outsiders' were sometimes blamed. In the case of Zanzibar, which is an island, this means people from the mainland. Mainlanders are generally looked upon with suspicion and scorn by the islanders. In particular, members of the ruling party in Tanzania (on the mainland, that is, the ruling party is not popular on the island) were under considerable suspicion and rumours spread that politicians had deliberately brought many spirits to the island.

Concluding Observations and Speculative Hypotheses

Biological Exaptation Hypothesis. TI to REM: The numerous parallels between SP and TI are intriguing and suggest the possibility that they may share at least some evolved underlying mechanisms. As is evident from the review of literature, TI is widely thought to have evolved as a predator avoidance/escape mechanism. It is readily induced in many prey species by physical manipulations that mimic the actions of predators or assailants. Moreover, quantitative and qualitative analyses of SP experiences reveal that many SP experiences are readily and frequently interpreted as sensations consistent with threat and assault. The origin of SP in the TI response appears promising as a partial explanation for the major physiological and motor aspects of SP. The question remains, however: Why would the terrifying TI threat *experience* be visited upon individuals as a horrible nightmare? What function could be served here?

One hypothesis is that natural selection in its parsimony led to the utilization of the immobility response to suppress acting out of the motor programs active during REM dreams as an exaptation. Such a coopting of the mechanism for peripheral motor suppression might also have allowed, however, the co-activation of the closely linked evolved motivational and affective concomitants of the TI reaction that could then "contaminate" and bias dream imagery during

REM. Moreover, the motivational components might then actively facilitate the association of the paralysis of tonic immobility with REM dreams. The rationale for this hypothesis is developed in remainder of this section.

From the earliest research discoveries of REM physiology and its association with dreams, evolutionary arguments have linked this paradoxical state and its imagery with the development and maintenance of instinctual actions and sensitivities (e.g., Jouvet, 1975). Dreams in general have been frequently observed to have disproportionate frequency and intensity of threat and predation themes (Jouvet, 1949, 1999; Merritt, Stickgold, Pace-Schott, Williams, & Hobson, 1994; Revonsuo, 2000). Revonsuo (2000) specifically singles out the rehearsal of antipredator strategies of flight and flight responses as *the* major function of REM dreams. Though it seems unlikely that all dreams have such a function, it is clear that the implicit narratives of SP nightmares include the most primordial evolved actions and sensitivities for any species; namely, those necessitated by predation. Revonsuo observes that the predominance of predation themes is unlikely to reflect individual waking experiences in human populations that are unlikely to have had first-hand experience anything remotely as terrifying as nightmares in their waking lives. This appears to hold with even greater force for SP nightmares (Cheyne, 2001, 2003; Parker & Blackmore, 2002). Moreover, the motor hallucinations and fictive movements of dreams and seldom simply reproduce the mundane movements of everyday life (Hobson, Stickgold, & Pace-Schott, 1998). Thus, dreams and, especially nightmares contain extraordinary experiences of threat and danger rarely experienced in everyday life, but which are important at an evolutionary level.

Such functional evolutionary claims for dreaming are similar to long-standing speculations regarding the functions of play (e.g., Karl Groos, 1896). A constructive analysis is provided by Fagan (1976) who proposed a simulation model for play in which he argued that the difference between play and functional activity was one of *control* versus *information* functions. Engineers, he noted, optimize the dynamic properties of aircraft and of their control by putting them through "unusual" and "exaggerated" maneuvers during testing that would never be executed in the interest of normal flight. The familiar example is of a cat playing with a mouse, engaging in repeated and exaggerated predatory movements, occasionally at the cost of losing a meal. Such activity, when conducted in a controlled and safe environment, may have compensating payoffs in the optimization of speed, force, and accuracy of strategic moves during predation. The cat at play will also inevitably repeatedly capture and release its prey during such playful episodes, which might serve as, for example, a playful learning counter-strategy against being deceived by the TI tactic.

As play has obvious behavioral components the potential benefits of overt "practice" seem rather clear. Yet how would purely internal (i.e., neural) simulation of functional activities and sensitivities in dreams or nightmares optimize innate behaviors and sensitivities? A major

advantage of practice in play is that play tends to occur in safe contexts minimizing the risks entailed in the real world "trying out" of strategies in scenarios where life and death actually hang in the balance. Yet, even in the safest play settings there are always inherent risks undertaken when one pushes any system to its limits in the real world – deliberately or not – with or without due caution. Hence, it is actually a point in favor the simulation hypothesis in dreaming inasmuch as, by inhibiting actual movement, risk is reduced even more than in play and hence allows even greater boldness in exercising and integrating *at least the neural parameters of practice* (Cheyne 2000). Moreover, play has its own affective state, and hence, to that extent, fails to simulate the emotional/motivational components of adaptive strategies (e. g., serious fighting). In contrast, in dreams both the genetically prepared motor pathways and their connections to motivational neural systems may be strengthened during dream simulation. We might also expect that dream experiences as optimizing simulation will often have the unusual and exaggerated features of play but accompanied by relevant motivational system activation. Perhaps most importantly, the inhibition of the peripheral motor system in REM would also allow motor programs greater latitude to experiment with extreme affect intensity. The disconnection of the brain-body loop during REM, especially motor reactivity, may allow for less constraint on the neurological components of terror and the exercise of at least the central components of motor routines. Thus, arguments for the advantages of play as a practice mode may hold with even greater force for dreams when we consider motivation. Conventional nightmares and SP nightmares, though only subsets of all dreaming, appear to be the most obvious simulations of predator coping strategies.

Cultural Cooption: An Evolutionary Experiential Source Hypothesis: Finally, the SP nightmare as a sort of second-level exaptation, a derivative of a derivative so to speak, may have subsequently served a cultural function, the generation of distinctly perceptible spirit beings existing not merely in an ethereal dream world, but vividly in the wake world.

A major difference relevant here between frightening dreams and the waking nightmare of SP is that, although often frightening, dream experiences occur in a dream world that dissolves upon awaking and is generally readily distinguished from the world into which we wake. During SP, in contrast, the one is acutely aware of the actual wake world context during the SP experiences. This appears, based on the reports of experients, to engender substantially greater realism to SP experiences than to dream experiences (Cheyne, 2001). Thus, though dreams are frequently proposed as the source of spirit beliefs, it seems likely the SP experiences must be much more so (see also Davies, 2002). Thus, for traditional accounts of demons, shades, spirits, and lost souls, cultural traditions will then provide labels, narrative structure, and local explanations, along with some specific culture-specific imagery. The universal consistency of these cultural accounts suggests that there need be little filling in with additional experiences. All of the foregoing is consistent with an evolutionary perspective of neurological primacy of such anomalous conscious experiences.

The recent Popobawa "epidemics" provide an excellent example of how particular aspects of a core physiological experience can be selected to construct a particular myth. Some of the nightmare experiences associated with sleep paralysis, such as the rape scenarios described earlier, involve erotic and/or painful sensations of the genitals, rectum, and sometimes nipples. Not everyone has these experiences. Indeed, only a relatively small minority reports such experiences. Nonetheless, in any population, there will be people who have these particular experiences – along with the more common paralysis, pressure on the chest, and feelings of a malevolent presence, and so on. During an "epidemic" – *indeed, what constitutes the epidemic – these particular experiences will be more likely to be reported by those who specifically have the defining features of the epidemic* (i. e., experiences consistent with violent sexual assault in the case of the Popobawa), because they now constitute the core of a standard story and a context within which to frame them. Thus, *even if there were no increase in such experiences in the population*, there would *appear* to be an epidemic – simply because the relevant experiences are more likely to be reported and, by virtue of the availability of a terminology and a standard story, more reportable and recognizable. Sometimes these stories will become established for long periods and seem, especially in preliterate cultures, to have always be a part of the cultural lore. Given a combination of our human tendencies to embellish and alter stories, as well as the complexity of the supporting experiential reports, the standard stories will bifurcate, multiply, and show regional variations yet, because of their experiential base, retain a common core of experiences of things that do considerably more than go bump in the night. This certainly describes the global distribution of narratives of frightening night demons (e. g., Adler, 2011; Hufford, 1982). It must be acknowledged that the foregoing argument owns much to David Hufford's (1982) experiential-source hypothesis, but with details and evolutionary components that would not necessarily be endorsed by Hufford.

As noted in our introductory remarks, predation must be among the most fundamental of all evolutionary pressures and evolved responses to predation among our most fundamental physical, physiological, and psychological attributes. As for any complex, and imperfect, evolved mechanism there will be unanticipated outcomes that may themselves have consequences that may be coopted to serve other functions, biological or cultural. It is an intriguing possibility, I suggest, that one of our most primitive biological mechanisms might be an important, even decisive, source of spiritual experiences and beliefs considered so uniquely, fundamentally, and centrally cultural and immaterial.

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