THE 24 HOUR BRAIN

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July 2023

Our human body experiences a regular series of predictable biological Changes every 24 hours in our Circadian Cycle. We also encounter numerous unpredictable biological challenges from our environment which require adaptive problem-solving Changes.

THE ABILITY TO CHANGE WHEN CHANGE IS REQUIRED IS THE CORE OF OPTIMUM WELLNESS.

Our human Circadian Cycle is fundamental to health and wellbeing. If the cycle is disrupted, a range of complaints and disorders will emerge including sleep disturbances. It is possible to harmonize our Circadian Cycle in a return to its natural rhythms using unique forms of Light stimulation introduced at certain times of the day. Once shifting back into 24-hour harmony, a regular and satisfying return to natural sleep can be accomplished. (See the CONCLUSION section at the end of this paper for a more detailed summary.)

Here we discuss the brain and its Earthly rhythms of day and night. The brain is physical just as is the somatic body. It is a mistake to consider the brain as separate from the body. The organism we call "me" is a whole much greater than the sum of its parts (to quote the famous Systems Theory adage).

Firstly, our brain is always active throughout the 24-hour planetary spin period. About 2/3 of this 24-hours is spent awake with the remaining 1/3 asleep. Contrary to appearances, our brain remains impressively active even during sleep. Furthermore, the sleep phase has "sleeping dreams" and the awake phase has its own (less well known) "waking dreams".

Our brain is always busy, busy, busy. In fact, more than just being busy, our brain must experience a number of mandatory CHANGES every single 24 hours. Looking at what is called our "circadian cycle" is a great place to start an exploration of the 24 Hour Brain.

INTRODUCTION:

Early scientific study of the Circadian Cycle became pronounced in the 18th century.During that period, Jean-Jacques d'Ortous de Marin observed a plant opening and closing its leaflets each day in complete darkness, revealing the existence of a biological clock. (1)Fast forward to the 20th century and molecular biology yielded evidence of the fundamental light-dark cycles at the deepest genetic cellular level. (2, 3, 4)

The Circadian Cycle has importance far beyond the wake/sleep rhythms because it interacts with numerous critical physiological functions from general metabolic regulation, core temperature, mood, blood pressure and so on. Research reveals that circadian rhythms have an important influence on energy and fitness levels, as well as the functioning of essential bodily processes. A healthy circadian rhythm is linked to longevity, reduced stress levels, and a strong metabolism. (10) The circadian clock system is a major regulatory factor for nearly all physiological activities and its disorder has severe consequences on human health. Circadian Rhythm (CR) disruption is a common issue in modern society, and researches about people with jet lag or shift works have revealed that CR disruption can cause cognitive impairment, psychiatric illness, metabolic syndrome, dysplasia, and cancer. (19)

It is important to appreciate that the Circadian Cycle is controlled by two interactive processes:

1. the complex internal biological "clock" system and
2. the variety of external environmental conditions and factors.
3.

The success of the Circadian Cycle in promoting and maintaining health and wellness is directly related to our ability to Change and adapt to a fluctuating series of fluid demands on an hourly basis. (5, 20)

During a typical day, energy begins a slow climb on awakening and continues until early afternoon. Soon after, energy begins to decline, hitting a low around 3:00 pm. After the 3:00 pm lull, energy increases again, peaking around 6 pm. Alertness tends to wane for the rest of the evening and into the early hours of the morning, hitting its lowest point at 3:30 am. (10). It is of interest that the traditional Oriental principle of Yin and Yang shows a close correspondence to this cycling period. The Yang (day, bright) energy period is said the begin its ascent at 3:00 am while the Yin (night, dark) energy period is said to initiate its influence at 3:00 pm.

One recent study from MIT found that a protein that protects against diseases of aging also plays a critical role in controlling circadian rhythms. Scientists have also discovered a specific protein that works with the body's circadian clock to regulate key metabolic functions. Irregular circadian rhythms have been linked to chronic health conditions such as sleep disorders, obesity, and depression (13, 14, 15).

Circadian rhythms don't remain the same from birth to old age. A 2015 study found that clock-controlled genes fluctuate in the brain as people grow older. Researchers examined brain samples from deceased people of various ages, and found that younger brains had a daily rhythm in their clock genes while the rhythm had been lost in many of the genes of older people. Additional research suggests that a healthy circadian rhythm may help guard against such age-related diseases as dementia, hypertension, and Parkinson's. (10, 16, 17)

The circadian cycle is strongly associated with the body's metabolism. While genetics influence the body's ability to maintain energy balance through food and drink consumption, studies reveal that both circadian rhythm and environmental cues such as light also play a key role. (10, 18)
The human Circadian Cycle has series of highly predictable biological states. All of these states are not only predictable but also required and mandatory given their pervasive presence across all cultures and persons. The depth of applied physiological processes that rely on the regularity is constantly unfolding on medical research.

Numerous studies have clearly noted the serious consequences of Circadian Cycle disruption. Mice that experience early-life circadian disruption exhibit more anxiety-like behavior in the elevated plus maze, poorer spatial memory in the Morris Water Maze, and impaired working memory in a delayed match-to-sample task. Additionally, neuron morphology in the amygdala, hippocampus and prefrontal cortex is adversely impacted. Pyramidal cells in these areas had smaller dendritic fields, and pyramidal cells in the prefrontal cortex and hippocampus also exhibited diminished branching orders. (77)

Recent research further linked sleep deprivation (SD) with the development of Alzheimer's disease (AD), the most common form of dementia (50–75% dementia cases) worldwide, which is estimated by the World Health Organization (WHO) to affect affect 81.1 million people by 2040.

One systematic review and meta-analysis, involving 198,232 individuals in 12.14 ± 12.84 years of follow-up, found that subjects with sleep disturbances have a 1.49-fold increased risk of AD as compared to a baseline of no sleep disturbances. Patients with insomnia (risk ratio = 1.51), sleep-disordered breathing (risk ratio = 1.20) or other sleep disturbances (risk ratio = 1.76) were found to have higher risks of developing AD (Shi et al., 2017). (78, 79, 80)

A FEW TERMS:

Every year, research uncovers more and more information and insight into the complex domain of metabolic regulation which includes study of the Circadian Cycle.

First, a few terms:

Hypothalamus:
A region of the forebrain below the thalamus (hence the name "hypo" – "below" – the thalamus) which coordinates both the autonomic nervous system and the activity of the pituitary, controlling body temperature, thirst, hunger, and other homeostatic systems, and involved in sleep and emotional activity.

Suprachiasmatic Nucleus (SCN):
The suprachiasmatic nucleus or nuclei (SCN) is a tiny region of the brain in the hypothalamus, situated directly above the optic chiasm (hence the name "supra" – "above" – the optic "chiasm"). It is responsible for controlling circadian rhythms. The neuronal and hormonal activities it generates regulate many different body functions in a 24-hour cycle.

Master Clock:
A more general term for the SCN. The SCN (Master Clock) also contains receptors for melatonin, commonly termed "the sleep hormone." Neurons in the SCN fire in a 24-hour rhythm, reaching a peak at mid-day.

Central Pacemaker:
Another general term for the SCN.

"Local" or Biological Clocks:
Through a complex process of hormone secretion and changes in body temperature, the SCN synchronizes "local" clocks that operate independently of the master clock.

These gene-operated clocks are found in places such as the liver, connective tissue, lungs, and muscles. (7)

Neuroscientists suspect that almost every cell in the body contains a circadian clock. (8)

A LITTLE NEUROLOGY:

The suprachiasmatic nucleus (SCN) is a bilateral structure located in the anterior part of the hypothalamus. It is the central pacemaker of the circadian timing system and regulates most circadian rhythms in the body.

Multiple afferent (input sensory neurons) neuronal tracts project to the SCN. Its major tract is the retino-hypothalamic (eye-to-hypothalamus) tract originating from photosensitive ganglion cells of the retina. Efferent (output command neurons) projections from the SCN innervate structures such as the pineal gland, producing melatonin during the night for induction of sleep.

Disruptions in the SCN circadian system have been found to correlate with various mood disorders and sleep disorders. (6) Once the Master Clock (SCN) releases signals that trigger certain body functions, the Biological Clocks (Local Clocks) set the Circadian Rhythm in motion. The biological clock produces daily circadian rhythms, monitors their timing, and controls other cycles that occur seasonally and yearly. The biological clock controls these cycles while coordinating with the Master Clock to keep the circadian rhythm in sync with the surrounding environment. (9, 10)

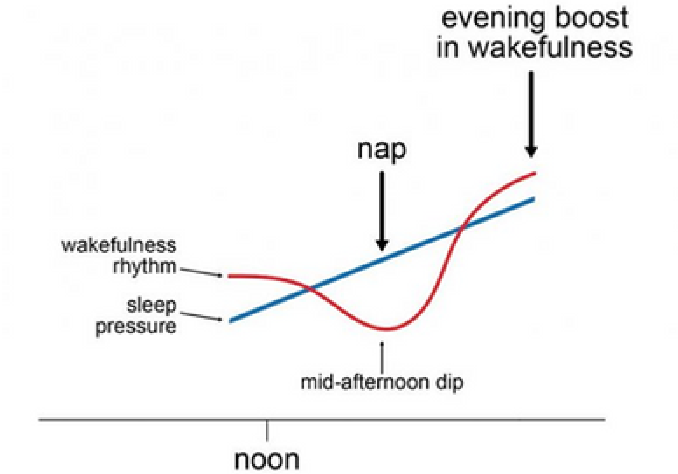
Examples of environmental cues that impact the circadian rhythm include:

- Daily changes in light when the sun rises and sets
- Temperature
- Humidity
- Activity levels
- Meal times

In addition to producing circadian rhythms through their interaction with the day/night cycle and internal clock, these environmental cues help stimulate essential functions in the body, such as digestion, body temperature, and melatonin release. (10, 11, 12)

THE BRAIN IS PHYSICAL JUST AS IS THE SOMATIC BODY. IT IS A MISTAKE TO CONSIDER THE BRAIN AS SEPARATE FROM THE BODY.

CIRCADIAN GRAPHIC OVERVIEW:



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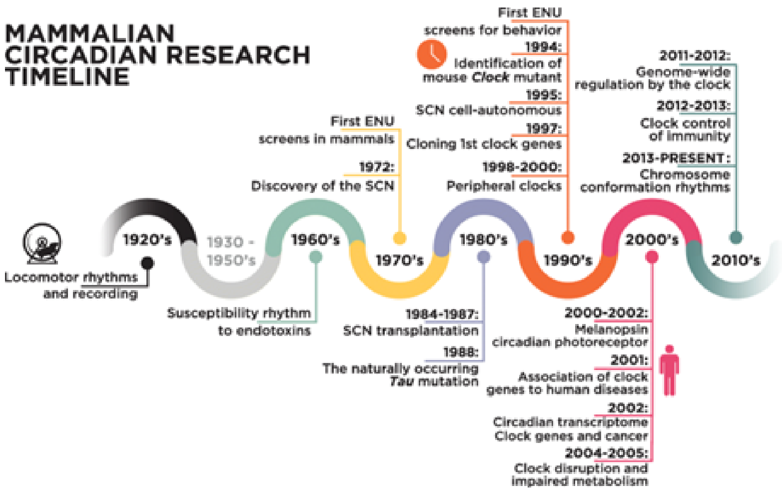

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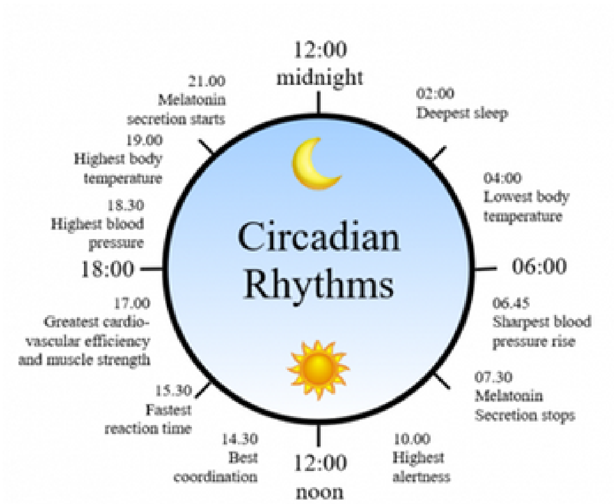

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CIRCADIAN BRAIN CHANGE:

As seen in the image above, our circadian based metabolic regulation is dynamic with a number of predictable shifts and changes in activity over every 24-hour period.Brain change is at the heart of this time sensitive regulation.

Broadly speaking, our brain activity is divided into two major stages:

1. Waking;
2. Sleeping.

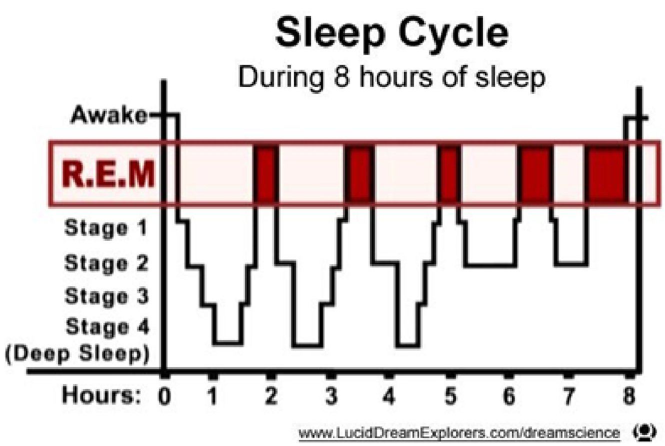
These two also each have their own subset:

1. Waking > Waking Dreams
2. Sleeping > Sleeping Dreams

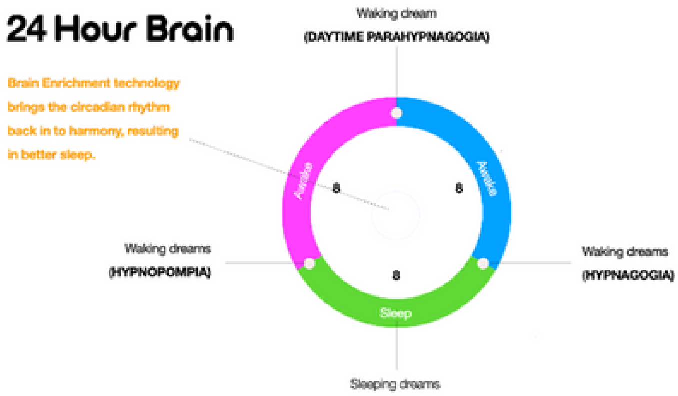
The conventional division of our 24-hour cycle is:

1. 16 hours of waking from 7:00 am to 11:00 pm;
2. These waking 16 hours are subdivided into 7:00 am to 3:00 pm (8 hours)and 3:00 pm to 11:00 pm (8 hours);
3. The 3:00 pm point is a deep drop in midday energy;
4. The sleeping period is 8 hours from 11:00 pm to 7:00 am.
5. One can see that our circadian cycle has basic periodicity of 8 hours.

Within the 8 hours of Sleep, we have a series of Sleeping Dreams (REM Sleep):



Within the 16 hours of Waking, we have periods of Waking Dreams.



These Waking Dreams are classically defined as Hypnagogia (occurs in the transition between Waking and Sleeping) and Hypnopompia (occurs in the transition between Sleeping and Waking).There is third period of Waking Dreams known as Parahypnagogia that occur at variable times during the day with a tendency towards the 3:00 pm zone when the circadian energy drops to a low point.

So, on a regular basis, our brain must be able to shift and change many times throughout the day at fundamental level of biological regulation. These shift/change dynamics are transitional periods and offer an opportunity to introduce various Circadian Cycle adjustments and influences.

Required transitional changes (following the classic biological model):

1. Transition from Sleep to Waking Dreams (Hypnopompia)
2. Transition from Waking Dreams to Awake
3. Transition from Awake to Midday Waking Dreams (Parahypnagogia)
4. Transition from Midday Waking Dreams (Parahypnagogia) to Awake
5. Transition from Awake to Waking Dreams (Hypnagogia)
6. Transition from Waking Dreams (Hypnagogia) to Sleep
7. Transition from Deep Sleep to REM/Sleeping Dreams and back to Sleep (repeatedly)

We repeat this fundamental series of macro-Changes in Brain States every 24 hour period of the Circadian Cycle. At the most basic biological level, our adult human brain must navigate through this series of Changes in order to maintain harmonious metabolic regulation. These macro dynamic changes are mediated by the "internal biological clock system". A challenge emerges when this internal processing must integrate with a wide variety and often unpredictable "external" stimulation.

The human sleep-wake cycle, that is periods of sleep during the night and wakefulness during the day, is one of the most prominent examples of a circadian behavioral pattern. It results from the interaction between two factors:

- the circadian drive for wakefulness (process C);
- the homeostatic sleep pressure (process S).

The interaction between this circadian "process C" and the homeostatic "process S" has been conceptualized in the widely known "two-process model of sleep", which accounts for the timing and intensity of sleep in many experimental settings. (46, 47)

INTERNAL/EXTERNAL CIRCADIAN REGULATION:

Artificial light decreases the amplitude of daily rhythms in human lifestyle principally by permitting activity and food intake to occur during hours of darkness, and allowing day-time activity to occur in dim light, indoors.

Endogenous circadian timing mechanisms that oscillate with a period of 24 h have evolved to ensure physiology is synchronized with the daily variations in light, food, and social cues of the environment. Artificial light affects the synchronization between these oscillators, and metabolic disruption may be one consequence of this.

By dampening the amplitude of environmental timing cues and disrupting circadian rhythmicity, artificial lighting might initiate metabolic disruption and contribute to the association between global urbanization and obesity. (73)

Above, we stated that it is important to appreciate that the Circadian Cycle is controlled by two interactive processes:

1. the complex endogenous (internal) biological "clock" system and
2. the variety of exogenous (external) environmental conditions and factors.

How can the hardwired "internal biological clock system" by influenced by the "external environmental conditions and factors"? Here we have a look at a process called "masking".

Masking:

Environmental cues (e.g., light-dark cycle) have an immediate and direct effect on behavior, but these cues are also capable of "masking" the expression of the circadian pacemaker, depending on the type of cue presented, the time-of-day when they are presented, and the temporal niche of the organism. Masking is capable of complementing entrainment, the process by which an organism is synchronized to environmental cues, if the cues are presented at an expected or predictable time of-day, but masking can also disrupt entrainment if the cues are presented at an inappropriate time-of-day.

Therefore, masking is independent of but complementary to the biological circadian pacemaker that resides within the brain (i.e., suprachiasmatic nucleus) when exogenous stimuli are presented at predictable times of day. Importantly, environmental cues are capable of either inducing sleep or wakefulness depending on the organism's temporal niche; therefore, the same presentation of a stimulus can affect behavior quite differently in diurnal vs. nocturnal organisms. (45)

The circadian rhythms observed in constant routine conditions will differ in their phase (timing) and amplitude between individuals, primarily as a result of their genetics, age, and sex. (24) With the addition of an unpredictable variety of personal habits (eg. caffeine, psychological stress, exercise), there is the strong likelihood of "phase shifts" in a person's circadian cycle.

When the timing of a person's circadian cycle is shifted out of the normal biological rhythms, the profile is then considered as their personal "diurnal cycle".A "diurnal cycle" can be considered as being "out of phase" with the normal biological timing of the human circadian cycle. Hence, in many cases, shifting a personal out-of-phase "diurnal cycle" back to a normal biological circadian cycle will be a therapeutic goal.

Seeking to identify and modify various exogenous/external factors that are pushing the circadian cycle out of phase and into a maladaptive diurnal cycle is a basic goal in a wellness.Furthermore, harnessing certain exogenous/external factors that may help pull the maladaptive diurnal cycle back into harmony with the endogenous/internal circadian cycle will certainly be key in enhancing wellness. Hence, skillful "masking" methods can be very meaningful when attempting to adjust the endogenous biological clocks of the circadian cycle.

Exogenous/external stimulation interacts with the endogenous/internal "biological clock systems".

In a study, in Pennsylvania, to assess consequences of prolonged sleep restriction (>5.6 h) for 3 weeks under control conditions, American subjects experienced decreased resting metabolic rate, and increased postprandial plasma glucose suggesting increased risk of obesity and diabetes. They took 9 days of recovery sleep to re-entrain and normalize. (71, 72)

The availability of artificial light marked a milestone in human evolution, facilitating manipulation of the daily light-dark cycle, illuminating feeding and social interactions, and extending waking hours into the night. Candlelight was progressively supplemented by gas lighting, and the early nineteenth century marked a turning-point in human light exposure when artificial lighting became both efficient and affordable, finally ending dependence on the light of the sun.

The year 1800 is taken as a turning-point in the development of human reliance on artificial light. This period marked the beginning of the industrial revolution, and also when artificial light provided by candles, gas, and finally electricity became efficient and affordable. (73)

In 1879, Thomas Edison announced one of the first electric light bulbs, which was indeed 'the best artificial light ever known quickly swamping all preceding exposure to man-made light and eliminating darkness from the human night. Electric light allowed humans to override the strong rhythmicity that had pervaded life for millennia. The times reserved for eating, sleeping, and exercising were now malleable. The rhythmicity of human lifestyle was eroded by artificial night-light, and it slipped away largely unrecorded. (73)

ADVERTISEMENT FOR EDISON ELECTRIC ILLUMINATING COMPANY OF BROOKLYN PRINTED IN THE BROOKLYN INSTITUTE OF ARTS AND SCIENCES BULLETIN, VOLUME 3, NO. 16, DECEMBER 25, 1909

One specific effect of artificial lighting was to consolidate the Winter night, shortening the hours of darkness to those of Summer and enabling evening-time activity. An immediate implication of this was the demise of a human biphasic sleep pattern which is thought to have been a common feature of the sleep patterns of medieval Europeans. The biphasic pattern of Winter sleep consisted of two sleep periods with an intervening 'quiet time' around midnight which medieval man reserved for reading by candlelight, thinking, or praying. (73, 74)

In addition to disruption of circadian rhythms, and termination of human seasonal sleep patterns, artificial light further affects photoperiodic timing of physiology by reducing overall light exposure. Work and leisure activities are increasingly based indoors, causing a reduction in day-time exposure to sunlight. Artificial lighting has created a modern photoperiod of relatively brighter nights and dimmer days, with a net effect of dampening the photic signal delivered to circadian timing centers. (73, 75)

Access to the internet and PCs has removed temporal boundaries to work and social interactions, so that even non-photic zeitgebers (circadian modifiers) are losing their restriction to daylight hours. For example, human social interaction is a non-photic timing cue which is affected by 'social media' (internet, twitter), which supports communication during sleeping hours, even with those in their waking hours on the opposite hemisphere.

Together with dampening of the photoperiodic signal, and erratic meal-timing, these factors converge in the urban environment to compromise the entraining signals to the human circadian clock. Therefore, any potential detrimental effects of night-light are likely not simply a consequence of shorter hours of darkness, but rather a general disruption of the temporal architecture of human life. (73)

In the Mapuches–an indigenous Native American population living in Chile–a 3-fold difference in insulin resistance has been observed between adults living traditional rural lifestyle and those living in cities, despite rural Mapuches having higher energy intakes and body mass indexes than their urban counterparts. (73, 76)

LIGHT, NEUROLOGY & YOUR CIRCADIAN CYCLE:

It is important to keep in mind that the retinal photoreceptors experience an altered version of the light relative to the cornea, the front surface of the eye. This is because the eye itself contains filters. In the center of the retina, this includes the macular pigment, which is present in the fovea but drops off in the peripheral retina. More importantly for ipRGCs, the crystalline lens and ocular media filter out short-wavelength light. This natural "blue-blocking" filter increases density with increasing age, with less and less short-wavelength light reaching the retina.

While the field of vision science has a long history (>150 years) in examining how different types of light stimuli are encoded, processed and perceived, we still remain largely in the dark about many aspects of the effects of light on the circadian clock. The discovery that the production of melatonin is suppressed in humans in response to light dates back to only 1980. Teasing apart how the different elements in the retina contribute to the effects of light on circadian rhythms, sleep and mood remains an important challenge. (40, 26)

Successful interaction between body and environment needs more than just a central clock; it also requires input pathways relaying information about the environment and the body to the SCN to achieve adequate entrainment as well as output pathways communicating timing information to the body to synchronize bodily processes with the circadian phase. (26)
Our circadian pacemaker, the suprachiasmatic nuclei (SCN) in the hypothalamus, is entrained to the 24-hour solar day via a pathway from the retina and synchronizes our internal biological rhythms.

Rhythmic variations in ambient illumination impact behaviors such as rest during sleep and activity during wakefulness as well as their underlying biological processes. Rather recently, the availability of artificial light has substantially changed the light environment, especially during evening and night hours. This may increase the risk of developing circadian rhythm sleep–wake disorders (CRSWD), which are often caused by a misalignment of endogenous circadian rhythms and external light–dark cycles. (26)

The most important "zeitgeber" (from German, something that "gives time") reaching the SCN is ambient light in the environment. In addition to processing visual stimuli in the environment, allowing us to see, the retina carries this photic information via the retinohypothalamic tract (RHT) to the SCN. (26)

The SCN also projects to the pineal gland, where the sleep-facilitating hormone melatonin is produced during the biological night, thereby modulating the diurnal variations between wakefulness and sleep. In addition to the pathway between retina and SCN, there is recent evidence from animal studies showing that also the habenula in the thalamus is innervated by retinal projections which may specifically mediate mood-related non-visual effects of light. (27, 28, 29)

Cones and rods are not the only photoreceptors in the retina. A small fraction of secondary neurons in the retina—the retinal ganglion cells (RGCs), which integrate information and send it to the brain via the optic nerve—express the photopigment melanopsin (30). Melanopsin is a short-wavelength-sensitive pigment with a peak spectral sensitivity near around 480 nm (31), rendering some RGCs intrinsically photosensitive (32).

These intrinsically photosensitive retinal ganglion cells (ipRGCs) are thought to mediate most effects of light on the circadian clock. However, ipRGCs are not independent of rod and cone input. Rather, they also receive information from these receptors, suggesting that ipRGCs indeed act as "integrators of information" regarding the light environment across a wide range of wavelengths and light levels. Surprisingly, the input from the S cones into the ipRGCs has a negative sign (33). In humans, this has the paradoxical consequence that increases in S cone activation lead to a dilation of the pupil (34, 35). which is also controlled by the ipRGCs.

It has long been thought that cones and rods mediate what is typically considered "vision" (seeing color, motion, spatial detail), and that melanopsin mediates the "other", non-visual effects of light, i.e. melatonin suppression, circadian phase shifting, and alertness. However, at second sight, this dichotomy breaks down. There is now converging evidence that melanopsin signals reach the primary visual cortex (V1) (36), where they may contribute to and modulate our visual perception (37, 38, 39).

USING LIGHT TO SHIFT YOUR CIRCADIAN CYCLE:

An example of a Phase Advance would be feeling sleepy earlier in the evening – feeling sleepy at 9:00 pm instead of 10:00 pm.
An example of a Phase Delay would be feeling sleepy later in the evening – feeling sleepy at 11:00 pm instead of 10:00 pm.
A second and very important light related circadian modulator is the suppression of melatonin. Melatonin (the "sleep hormone") natural secretion normally kicks in at 11:00 pm. Bright light exposure between 9:00 to 11:00 pm (and after 11:00 pm) normally suppresses melatonin secretion resulting in a Phase Delay of sleep onset.

So, the 2-hour period leading up to 11:00 pm in the normal circadian cycle is especially sensitive to bright light, especially in the white/blue wavelengths.

However, bright white/blue wavelength light exposure within the preceding 2 hours from 7:00 pm to 9:00 pm actually increases the sleepy feeling and sleep shifts at 11:00 pm. (41) So, the common belief that bright white/blue light in the evening is disruptive to sleep is only partially correct. It is disruptive in the 2 hours before the normal advent of melatonin induced sleep at 11:00 pm but actually beneficial for 11:00 pm sleep if the stimulation occurs between 7:00 pm and 9:00 pm. The phase shift effects of light can be achieved with as little as 5 minutes of exposure when applied at sensitive times, even with eyelids closed. (42)Furthermore, it has been found that very short pulses of intermittent light have a longer effect than continuous light. (43, 44)

Another light exposure method capable of phase shifting the circadian cycle is bright light early in the day. Early bright light exposure will result in a Phase Advance of the circadian cycle.For example, early bright light exposure will shift the sleepy feeling from 11:00 pm to 10:00 pm or even 9:00 pm.So, examples of using light exposure to help a person who cannot fall asleep until after 12:00 midnight would be:

- Bright light exposure before 12 noon;
- Bright light exposure between 7:00 pm and 9:00 pm.

Together, these actions should coax a Phase Advance that pulls back the sleep from after 12 midnight to the normal 11:00 pm time - and perhaps even earlier. This protocol could also include stress reduction methods between 12 noon and 7:00 pm along with the reduction of stimulants such as caffeine.

Light can affect mood in several ways: by directly modulating the availability of neurotransmitters such as serotonin, which is involved in mood regulation, and by entraining and stabilizing circadian rhythms, thereby addressing circadian desynchronization and sleep disorders, which are rather common in people suffering from mental disorders. Therefore, in the last decades, light as an intervention—light therapy—has found an increasingly widespread use for treating mood and other psychiatric disorders. (26).

MORE ABOUT WAKING DREAMS:

The foundation of health and wellness is the 24-hour physiological sequencing known as the Circadian Cycle. Above, the normal biological Circadian Cycle was divided and subdivided into four (4) basic Brain States:

- Waking (with the subset of Waking Dreams)
- Sleeping (with the subset of Sleeping Dreams).

A disruption of the Circadian Cycle and its multiple metabolic regulatory functions is the basis of numerous complaints and pathologies from the simple to the complex.Our Circadian Cycle does not just control wake/sleep cycles which are just the tip of the metabolic iceberg.Underneath the evident wake/sleep rhythms are an impressive number of critical processes such as hormones, blood pressure, body temperature, cardio-vascular efficiency, mood regulation and even muscle strength. Attempts to remedy the complaints/pathologies are typically frustrated as long as the circadian disruption remains in place.

Admittedly, the category of Waking Dreams is poorly understood and frequently not even recognized. Everyone knows that Sleep has two main aspects: Deep Sleeping and Sleeping Dreams.

Few people have the appreciation that Waking also has two main aspects: Clear Waking and Waking Dreams.

In contemporary science, Waking Dreams are typically labelled as:

1. Hypnagogia,
2. Para-Hypnagogia
3. Hypnopompia.

In ancient yogic literature and methods, the Waking Dreams were known as the Fourth State.

Before we go further into Waking Dreams and the Circadian Cycle, it is necessary to explore the word “dream” in this context since the term is used in both Sleeping Dreams and Waking Dreams.

ABOUT “DREAMS” IN GENERAL:

Our current culture has a common philosophy that is fundamentally rational, materialistic and reductionistic. This philosophy is considered indispensable to the scientific method of investigation and experimentation. Many scientists with this perspective consider “dreams” and even consciousness itself as an epiphenomenon of purely physical neurological brain activities.With this approach, “dreams” whether Sleeping Dreams and certainly Waking Dreams are given meager attention and exported away into a subjective psychological domain of interpretation. Ancient cultures however placed significant importance on dreams.

Dream incubation was a widespread practice across the Near Eastern civilizations of the ancient world. Egyptian, Mesopotamian, Greek and Hebrew texts all refer to some form of inviting the other world to send prophetic dreams.

The process was similar across the region: a person who wanted advice or a message from the gods would come to a temple or other holy place and offer a payment to the keepers of the temple. Most often, they would follow a ritual that might include offering a sacrifice, eating certain foods or drinks and/or fasting. This was followed by sleeping in the "presence of the gods" in the temple, usually in rooms set aside specifically for that purpose. In some places, the actual dreaming was done by an oracle or prophet. In others, the person seeking advice slept and dreamed beside the oracle, who would then interpret both of their dreams together. In ancient Egyptian times, the dream world existed between the land of the living and the world on the other side, a world inhabited by deities and the spirits of the dead. Dreams were communications from those entities. (60)

The Old Testament contains many stories about God speaking to leaders, seers and prophets through dreams. Like many other cultures in the region, the ancient Hebrews believed that sleep thinned the veil between the living world and the world of demons, angels and spirits, and that sometimes, God himself spoke to humans through their dreams. (60)

Like many other ancient peoples, many Native American cultures viewed the dream space as a sacred place, one where a person could step outside the bonds of mundane existence and connect with a more universal consciousness. Each tribe and culture had (or has) its own way of accessing this dimension along with the knowledge to be learned from the animal and ancestral spirits that inhabit it.

Researchers dedicated to studying the broad range of conscious experience including the dream states offer more impressive insights into the strong physiological and psychological purposes and benefits of dream states. Neuroscientific and psychological research suggests that dreams may help maintain our mental and emotional well-being by regulating our emotions and consolidating our memories during sleep. (48)

While dreams have long been a topic of intrigue in psychology, they weren't studied as neurological phenomena until the discovery of rapid eye movement (REM) sleep and non-rapid eye movement (NREM) sleep in the 1950s. Researchers used electroencephalograms (EEGs) to measure electrical activity in the brain during sleep and discovered that while NREM was a relaxed state with low mental activity, REM had high levels of mental activity that resembled waking states. (48)

A particularly useful method for studying brain activity during sleep is a positron emission tomography (PET) scan. PET scans involve the injection of a radioactively-labeled molecule into the bloodstream, which is detected via imaging. Higher concentrations of the radioactively-labeled molecule in certain regions of the brain are associated with higher levels of activity in those regions.

Studies using PET scans to analyze REM brain activity have found that the motor cortex, visual cortex, hippocampus, and amygdala, among many other brain structures, are active during REM; however, they do not activate REM sleep themselves. The activation of these brain structures potentially corresponds to different features of dreams. For instance, the visual cortex and motor cortex may contribute to visual and motor hallucinations, while the hippocampus, normally involved in memory processing, may insert familiar scenes into dreams.

Additionally, the amygdala may be responsible for the emotional nature of dreams, stemming from its normal function in emotional regulation. The inactivation of certain brain structures can be telling as well; for instance, a major region of inactivity during REM is the dorsolateral prefrontal cortex (DLPFC). As the DLPFC is a center of cognitive control and reasoning, its inactivation is often associated with the bizarre narratives of dreams as well as the inability to distinguish dreams from reality.

Understanding brain activity during sleep and how it may affect the nature of dreams provides major insight into the possible functions of dreaming. In particular, the activation of the amygdala and the hippocampus during REM inspired two major dream theories: the emotional regulation theory and the memory consolidation theory. (48, 49, 50, 51, 52)

HYPNAGOGIA (AKA – WAKING DREAMS):

The hypnagogic state can be defined as "spontaneously appearing visual, auditory and kinesthetic images; qualitatively unusual thought processes and verbal constructions; tendencies towards extreme suggestibility; symbolic representations of ongoing mental and physiological processes; and so on". (58)

The single term "hypnagogia" is frequently used as a "catch all" designation for the three interrelated states of hypnagogia (between waking and sleeping), para-hypnagogia (various periods of relaxation in the daytime waking state with prevalence at the midday 3:00 pm drop in circadian energy) and hypnopompia (between sleeping and waking).

These states seem not to be limited to the transitional phases between wakefulness and sleep, but may also occur during the day. (59)

It is very important to understand that it is possible to develop the skill of inducing the para-hypnagogic state by practicing midday deep conscious relaxation methods as well developing lucidity in the hypnagogic and hypnopompic states.

Hence the concept here of "Waking Dreams" applies to all three (3) states of hypnagogia, para-hypnagogia and hypnopompia.

Sleep onset hypnagogia is the twilight state of human consciousness, marking the transition from waking to sleep. It occurs regularly and spontaneously in healthy humans, and allows researchers to study potential shifts in cognitive functions while waking consciousness fades into sleeping consciousness. (55)

The transition to sleep is described as a continuous series of changes in (brain) physiology rather than an abrupt state change - it has therefore proven difficult to define one point in time at which sleep begins. As a person falls asleep, slow electroencephalographic waves first occur locally towards the end of wakefulness. As a person transitions further into sleep, slow waves become global and merge into large, synchronized networks. As the level of cholinergic (arousal promoting) neuromodulators decreases, cortical neurons enter an on-off mode of firing, first locally and then globally. These global on-off periods occur synchronously, producing a global low-frequency synchronization of neuronal activity. Accordingly, during sleep onset, the variability of resting state networks decreases (55, 56, 57).

The global shifts in brain function that occur during sleep do not reverse immediately upon awakening. The properties of the preceding sleep stage linger, leaving participants in a hypnopompic wake state that maintains some of state's physiology. Upon awakening, blood flow is rapidly re-established in the brainstem, thalamus, and anterior cingulate cortex, but it can take up to 20 minutes to be fully re-established in dorsolateral prefrontal cortex, which may contribute to heightened suggestibility (82).

A recent proof-of-principle study, led by Noreika, intensively studied a single individual as he repeatedly transitioned into sleep while the brain's electrical activity was recorded using EEG scalp electrodes. The would-be-sleeper was asked to press a button when he experienced an intrusive thought or image, and to verbally report it to the sleep researchers. The descriptions were pleasantly bizarre: "putting a horse into a sort of violin case and zipping it up," "the phrase learning to consume consciously from a master," "visual image of a curled-up music manuscript." (53, 54)

The electrical activity of the brain became steadily more predictable the longer the person lay still—something that's entirely normal for sleep entry. Unexpectedly though, the hypnagogic intrusions were preceded not by sudden bursts of complex brain activity, like sparks in a fading candle, but by sudden changes to a more orderly brain state. Noreika is working on the hypothesis that when we enter sleep, the brain steadily dismantles the models and concepts we use to interpret the world, leading to moments of experience unconstrained by our usual mental filters. (53, 54)

The difficulty that people have detecting the strangeness of these experiences prompted psychologists Clemens and Jana Speth, both at the University of Dundee, to examine reports of hypnagogic intrusions. As Clemens says, the two were hoping "to develop a timeline that shows what elements of consciousness decline or emerge as people drift into sleep."

Applying linguistic analysis to data from a sleep lab, they found evidence that reflective thought—the ability to evaluate ongoing experience—declined quickly during the hypnagogic state while thoughts about physical interaction with the imaginary world increased, indicating a change in the structure and not just the content of conscious thought.

ALL TERMS ARE DERIVED FROM THE GREEK – "HYPNO" FOR SLEEP, "GOGIA/AGIEN" FOR TO LEAD TOWARDS AND "POMPIA/PEMPIEN" FOR TO LEAD AWAY.

Similarly, by comparing the hypnagogic state to REM dreaming, a 2013 study by the same researchers confirmed the long-noted observation that while dreams often feel fully immersive, hypnagogia tends to be experienced as if we were passive observers—with the hallucinatory thoughts and images occurring as a projection on our existing sense of reality. (In a famous passage on hypnagogia in Oliver Twist, Dickens wrote of "the visionary scenes that pass before us.")

The fact that our sense of immersion and reflective distance from our own experience do not always co-occur during sleep may suggest they also have different roles in waking consciousness. (55)

Francesca Siclari, a sleep and consciousness researcher at the University Hospital of Lausanne, in Switzerland, also hopes this new wave of interest will result in more practical benefits. "The transition to sleep provides a unique opportunity, as one can study how changes in consciousness relate to changes in brain activity," she says. "This process is not only fundamental to the study of consciousness it may also shed light on sleep disorders that are associated with an abnormal transition to sleep." (53)

Hypnogogic Waking Dreams appear to act as possible regulatory compensation for inadequate or disturbed sleep patterns including those with deficient REM Sleeping Dreams. Furthermore, the effects of psychogenic stress including PTSD may also be compensated for by increased Hypnagogic Waking Dreams. Accordingly, the tendency of Hypnagogic Waking Dreams to access past memories as a passive and unemotional observer may promote revisiting the challenges in a state with a dissipation of charge and easier resolution.

Indicators of insomnia, such as difficulties falling asleep, maintaining sleep, early awakening, difficulties maintaining sleep and an overall non-restorative sleep, as well as daytime sleepiness, were reported to be associated with a higher likelihood of reporting hypnagogic states. This influence of sleep quality further appears to be moderated by stress, with more hypnagogic states occurring in stressed individuals when their overall sleep quality is poor. Moreover, the quality of hypnagogic states was reported to increase in dream-like qualities when individuals were deprived from REM sleep prior to entering the hypnagogic state. As such, we would emphasize the role of sleep in the emergence and quality of hypnagogic states. (61, 62, 63, 64)

Further, the suppression of thoughts and the susceptibility to intrusive thoughts seem to be associated with hypnagogic states.

When instructed to suppress a specific thought content during the day, subjects reported more target thoughts when falling asleep than controls, an effect that has been demonstrated in dreams. Similarly, auditory hypnagogic experiences were associated with the tendency to undertake thought suppression and the self-reported susceptibility to intrusive thoughts. (61, 65, 66, 67)

It is plausible that the increase in the Waking Dreams of hypnagogia may serve the purpose of counter-balancing the Circadian Cycle disruption created by sleep disturbances, unresolved emotional experiences and the suppression of thoughts related to incomplete psychological processing.
Accordingly, hypnagogic experiences are more likely to occur in individuals with PTSD as intrusive thoughts are a hallmark of PTSD and are more likely following traumatic events. controls. (61, 68, 69, 70)

The hypothesis is that this liminal period between wakefulness and sleep is a fount of creativity that is usually lost in the ocean of sleep. The thinking is that if you're able to descend into that stage of sleep and return to consciousness without descending deeper into sleep, you will benefit from the intensely associative thinking that characterizes the strange micro-dreams experienced during the transition to sleep.

What is certain, however, is that hypnagogia is a natural phenomenon that almost all of us encounter on a nightly basis. Unlike other sleep states that allow for awareness, such as lucid dreaming during REM sleep, hypnagogia doesn't require special training to induce its effects. It's a common phenomenon that is a natural part of the circadian rhythm.

THOMAS EDISON TAKING A HYPNAGOGIC NAP.

These strange experiences explain why hypnagogic consciousness has been coveted by some of the most brilliant scientific and artistic minds in history. Thomas Edison, Edgar Allen Poe, Vladimir Nabokov, Mary Shelley, Albert Einstein, Salvador Dali, August Kekule, and Richard Wagner all expressed their fascination with hypnagogia and claimed that their experiences in this twilight zone of the mind resulted in sudden bursts of creativity or mental clarity. The idea that "conscious access to underlying, unconscious forces" is at the root of creativity was also echoed and reformulated in a more scientifically rigorous way by the Nobel biophysicist Eric Kandel in the 90s. (81)

"All these major thinkers write beautifully about this state of mind where the world starts dissolving, but you still have awareness of your descent into unconsciousness and memories mixing with hallucinations."

"Ideas were not coming from me, they were just passing through my head," one subject reported. "I felt I was nowhere really, in this kind of nowhere space where all of these ideas exist, and it made so much sense that all these ideas existed in this nowhere space." (81)

Sleep researchers now suggest that Edison might have been on to something. A study published recently in Science Advances reports that we have a brief period of creativity and insight in the semi-lucid state that occurs just as we begin to drift into sleep, a sleep phase called N1, or nonrapid-eye-movement sleep stage 1. The findings imply that if we can harness that liminal haze between sleep and wakefulness —known as a hypnagogic state—we might recall our bright ideas more easily. (83, 84)

Inspired by Edison, Delphine Oudiette of the Paris Brain Institute and her colleagues presented 103 participants with mathematical problems that had a hidden rule that allowed them to be solved much faster. The 16 people who cracked the clue right away were then excluded from the study. The rest were given a 20-minute break period and asked to relax in a reclined position while holding a drinking glass in their right hand. If it fell, they were then asked to report what they had been thinking prior to letting go.

Throughout the break, subjects underwent polysomnography, a technology that monitors brain, eye and muscle activity to assess a person's state of wakefulness. This helped to determine which subjects were awake rather than in N1 or if they were in N2—the next, slightly deeper phase of our sleep.

After the break, the study subjects were presented with the math problems again. Those who had dozed into N1 were nearly three times more likely to crack the hidden rule as others who had stayed awake throughout the experiment—and nearly six times more likely to do so as people who had slipped into N2. This "eureka moment," as the authors call it, did not occur immediately. Rather it happened after many subsequent attempts to solve the math problem, which is consistent with previous research on insight and sleep. (83, 84)

Oudiette hopes not only to confirm her findings in future research but also to determine if focusing on our hypnagogic state might help solve real-world tasks and problems by harnessing the creative potential of that liminal period between sleep and wakefulness. Additionally, she and her group are considering the potential of brain-computer interfaces to precisely identify brain-wave patterns associated with the onset of sleep, allowing the precise identification of when people should be woken up during their moments of putative insight. (83, 84)

"We could even teach people how to reach this creative state at will," Oudiette envisions. "Imagine playing sounds when people are reaching the right state and other sounds when they are going too far into sleep. Such a method could teach them how to recognize the creative state and how to reach it." (83, 84)

"In order to acquire continuity of consciousness, unaffected by lapses into unconscious states, you must hold yourself at the junction of all the states, which constitutes the links between sleeping, dreaming, and waking: the half-sleep or Fourth State". - 10th century Tantric text (over 1,000 years ago) (85)

"The new results suggest there is a creative sleep sweet spot during which individuals are asleep enough to access otherwise inaccessible elements but not so far gone the material is lost." (83)

"The reason you get these different ways of processing information is because you don't have the same brain at sleep onset," Horowitz told me. "You lose a lot of frontal function which means you're hyper-associative, you have a loss of sense of self, a loss of sense of time, a loss of sense of space, and people have a much easier time with divergent thinking, which is tightly tied to coming up with innovative and weird solutions that you would ignore if you're fully awake." (81)

FOURTH STATE DEFICIENCY SYNDROME – THEORY:

Modern psychology combined with our fast-paced urban life style has practically erased any recognition and appreciation of hypnagogia or the Waking Dreams of "half-sleep". Here the Waking Dream is also known as the Fourth State of Consciousness with Clear Wake, Sleep and Sleeping Dreams constituting the other three more commonly recognized states.

The premise of the Fourth State Deficiency Syndrome theory is simple and straight forward. We have a normal biological Circadian Cycle that functions with a combination of internal regulation and external influences. This biological cycle includes regular periodic transitions through four different complementary states.

If the person is deprived of any one of these four biological states, the organism will suffer a disruption in many levels of metabolic regulation. This fact has been repeatedly confirmed in numerous animal and human studies.

The theory then states that a sufficiently reduced time of lucid experiences in the Waking Dreams of hypnagogia will result in a disruption in a multitude of Circadian Cycle moderated metabolic functions. As a syndrome, these multiple dysfunctions will manifest indirectly in a variety of ways. The theory further states that the most common and evident symptom of this circadian disruption is in the Sleep element of the 24-hour cycle. It is also likely to express itself in daytime Waking State mood and cognitive activities requiring sustained attention and creative problem solving.

Lastly, the theory states that with the "dim daytime light and bright nighttime light" and a lack of deep conscious relaxation common in urban lifestyle, a Fourth State Deficiency Syndrome may present a pervasive epidemic that is destabilizing health and frustrating numerous otherwise effective therapeutic strategies.

CONCLUSION:

The human Circadian Cycle has a profound influence on a broad range of metabolic regulatory functions.

The Circadian Cycle is managed by a combination of internal biological clocks and external environmental influences.

This Circadian Cycle has a highly predictable and repeatable 24-hour series of biological states complete with unique transitional periods.

Interference with these states and transitional periods is disruptive to the Circadian Cycle as a whole and manifests in a variety of complaints and disorders.

A process known as "masking" can influence the periodicity and phases of the Circadian Cycle.

A negative "masking" process interferes with the phasic characteristics of the Circadian Cycle and contributes to a range of associated complaints and disorders including Sleep problems.

A positive "masking" process acts to adjust and fortify the normative characteristics of the Circadian Cycle back into biological metabolic harmony.

The theory of a Fourth State Deficiency Syndrome is presented here in this paper.

The theory then specifically states that a sufficiently reduced time of lucid experiences in the Waking Dreams of hypnagogia will result in a disruption in a multitude of Circadian Cycle moderated metabolic functions.

The theory further states that the most common and evident symptom of this circadian disruption is in the Sleep element of the 24-hour cycle.

The theory also recognizes that other factors may also be disruptive to the Circadian Cycle either independently or interdependently of the Fourth State Deficiency Syndrome.

Evidence is conclusive that external Light can act as either a positive or negative "masking" factor in relation to the Circadian Cycle.

In a positive "masking" process Light can be used to interact with the Circadian Cycle for the purpose of harmonizing the cycle and reducing and/or remedying the circadian disruptions such as Sleep disturbances.

A person who falls to sleep past the circadian/melatonin 11:00 pm time can use a positive "masking" to create a Phase Forward effect by exposure to bright light early in the day – such exposure acts to phase shift the sleep period to earlier in the evening and closer to the biological norm.

Additional positive "masking" processes using Light can be integrated in periods during the day and especially at the circadian low energy 3:00 pm period that assist in reducing the compounding of stress that can build during the day and interfere with the natural descent of metabolic energy in the early evening.

A person can help ensure a feeling of sleepiness and longer sleep at the circadian 11:00 pm time by exposure to bright Light between 7:00 pm and 9:00 pm – while also avoiding exposure to bright Light between 9:00 pm and 11:00 pm.

Bright Light exposure in positive "masking" processes can reach an effect in as little as 5 minutes of exposure.

The positive "masking" using bright Light has an effect even with eyelids closed.

The positive "masking" using bright Light has a longer effect when the Light is micro pulsed as compared to continuous Light.

It is possible to design the bright Light, eyes closed, pulsing experience so as to help induce a hypnogogic-like state in the person hence supplementing the deficiency proposed in the Fourth State Deficiency Syndrome theory presented in this paper.

In addition to the hypnogogic-like Waking Dream Fourth State, it is possible to design the pulsing bright light signals to induce various brain wave based "probability states" congruent with stress reduction, sleep "letting go" training and sleep related deep relaxation.

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