# Biotemporal Dissonance: An Integrative Analysis of Chronobiology, Cognition, and Speculative Realities

## Introduction: Defining Biotemporal Dissonance

The human organism is a temporal entity, forged by the relentless cycles of a rotating planet. Its physiology is not a static system but a dynamic orchestra of rhythms, a biological clockwork that anticipates the rising and setting of the sun. Concurrently, the human mind constructs its own experience of time, a subjective flow that can stretch and compress in response to attention, emotion, and context. In the modern era, and even more so in the speculative futures imagined by science fiction, a fundamental conflict has emerged: a growing misalignment between the body’s innate temporal programming, the mind’s perception of time’s passage, and the objective or technologically-mediated reality an individual inhabits. This report introduces the term **Biotemporal Dissonance** to define and analyze this state of psychophysiological conflict.

The neologism is constructed from three core components. **"Bio-"** refers to the organism's endogenous biological rhythms, governed by a genetically encoded, self-sustaining internal clock system that operates on a near-24-hour cycle.1

**"-temporal"** pertains to the multifaceted experience of time, encompassing both the objective, physical passage of moments and the subjective, malleable perception of duration, a faculty known as chronoception.3 Finally,

**"Dissonance"** is drawn directly from Leon Festinger's seminal theory of cognitive dissonance, which describes the state of psychological discomfort and motivational stress that arises when an individual holds two or more contradictory cognitions, or when their behavior conflicts with their beliefs.5

Biotemporal Dissonance, therefore, is the psychological and physiological stress that results from the contradiction between an organism's internal temporal framework and its experienced temporal reality. It occurs when the fundamental, often unconscious, cognition "My body operates on an intrinsic, evolutionarily determined ~24-hour cycle" is in direct conflict with the experiential cognition "My reality—whether dictated by a work schedule, a virtual environment, or travel across spacetime—operates on a completely different and incompatible temporal framework." This conflict is not merely a philosophical inconvenience; it generates measurable psychological tension and, when chronic, precipitates a cascade of physiological pathologies.

This report will argue that Biotemporal Dissonance manifests across a spectrum, from the widespread, low-grade stress of modern life to the profound, identity-shattering conflicts explored in speculative fiction. This spectrum can be categorized into distinct types, each defined by a unique core conflict and explored through the dual lenses of scientific research and fictional thought experiments. The following typology serves as a conceptual map for the analysis that follows.

| Type of Dissonance | Core Conflict | Primary Scientific Domain | Key Fictional Tropes | Primary Effects |
| --- | --- | --- | --- | --- |
| **Internal (Chronodisruption)** | Misalignment between internal clocks and external *zeitgebers* (time-givers). | Chronobiology & Public Health | N/A (Real-world phenomenon) | Metabolic syndrome, cancer, cardiovascular disease, mood disorders. |
| **External (Temporal Displacement)** | Misalignment between the organism's biological age and objective chronological time. | Relativity & Cryobiology | Cryosleep, Time Dilation (near-light speed travel). | Social alienation, identity crisis, existential loss of connection, anachronism. |
| **Paradoxical (Causal Inconsistency)** | Contradiction between the organism's biological existence and its causal history. | Theoretical Physics & Logic | Time Travel Paradoxes (e.g., Grandfather Paradox). | Existential paradox, logical threat to selfhood, potential physical trauma. |
| **Virtual (Perceptual Dislocation)** | Discrepancy between perceived time in a simulation and the body's real-time physiological state. | Neuropsychology & Human-Computer Interaction | Immersive Virtual Reality, Cyberspace. | Time compression, dissociation from objective reality, neglect of biological needs. |

By establishing this framework, this report will systematically deconstruct the biological, psychological, and existential dimensions of Biotemporal Dissonance. It will begin by detailing the robust and ancient machinery of the body's internal clocks, then explore the subjective and constructed nature of time perception, and finally explain the psychological mechanism of cognitive dissonance that drives the felt experience of this conflict. These foundational sections will then be applied to analyze both the real-world crisis of chronodisruption and the speculative crises of time travel, cryosleep, and virtual immersion, revealing Biotemporal Dissonance as a unifying concept for understanding a critical challenge of our time and a profound theme in our imagination of times to come.

## The Rhythmic Organism: Foundations of Chronobiology

To comprehend the "Bio-" component of Biotemporal Dissonance, one must first appreciate the profound and deeply embedded nature of the body's internal timekeeping system. Life on Earth evolved under the constant, predictable rhythm of the 24-hour light-dark cycle, a product of the planet's rotation.7 In response, virtually all life forms, from cyanobacteria to humans, have developed an endogenous, self-sustaining biological clock.2 This system, the subject of the field of chronobiology, is not a passive responder to environmental cues but an active, predictive mechanism that allows an organism to anticipate daily changes and organize its physiology accordingly, granting a significant evolutionary advantage.2 The disruption of this ancient and fundamental system is the biological root of dissonance.

### The Master Clock and its Genetic Machinery

In mammals, the central pacemaker of the circadian system is a pair of tiny, densely packed clusters of neurons in the anterior hypothalamus known as the suprachiasmatic nuclei (SCN).7 The SCN functions as the body's "master clock," generating a coordinated circadian signal that is transmitted to the rest of the brain and peripheral organs.8 The critical role of the SCN has been unequivocally demonstrated through animal lesion studies; when the SCN is destroyed, the organism's 24-hour rhythms of sleep-wake, hormone release, and body temperature are obliterated.8 Remarkably, the oscillatory properties of the SCN are so intrinsic that individual SCN neurons, when removed from the brain and kept in culture, continue to exhibit a 24-hour rhythm of activity, demonstrating that this timekeeping ability is a fundamental property of the cells themselves.8

The molecular basis for this remarkable timekeeping lies in a complex, autoregulatory feedback loop of specific "clock genes".1 The discovery of these genes, beginning with the

*Period* (*Per*) gene in fruit flies in 1971, revolutionized chronobiology.8 In mammals, the core mechanism involves a set of transcriptional regulators, including proteins encoded by the

*CLOCK* and *Bmal1* genes, which activate the transcription of other clock genes like *Period* (*Per*) and *Cryptochrome* (*Cry*).1 The PER and CRY proteins then accumulate in the cell's cytoplasm, eventually re-entering the nucleus to inhibit the activity of CLOCK and BMAL1, thus shutting down their own production. Over time, the PER and CRY proteins degrade, releasing the inhibition and allowing the cycle to begin anew.1 This entire transcriptional-translational feedback loop takes approximately 24 hours to complete, forming the genetic gearwork of the biological clock. This genetic foundation underscores the non-negotiable, deeply evolved nature of our internal time; it is as much a part of our biological inheritance as the structure of our DNA.

### The Role of Zeitgebers and the Federation of Clocks

While the circadian clock is endogenously generated, it must be synchronized, or entrained, to the external 24-hour day to remain accurate. This synchronization is achieved through environmental cues known as *zeitgebers*, a German term meaning "time-givers".7 The most powerful

*zeitgeber* for the mammalian SCN is light.7 Light information is transmitted from specialized photosensitive cells in the retina directly to the SCN, allowing the master clock to reset itself daily and stay aligned with the solar cycle.7

However, the SCN is not the only clock in the body. Research has revealed that nearly every organ and tissue, from the liver and pancreas to the gut and adipose tissue, possesses its own peripheral clock, driven by the same molecular machinery as the SCN.7 This creates a "federation of clocks," where the SCN acts as the central conductor, coordinating the timing of the peripheral oscillators primarily through neural and hormonal signals, such as the circadian release of melatonin from the pineal gland.7 These peripheral clocks, in turn, are highly sensitive to weaker

*zeitgebers*, most notably the timing of food intake.10 This hierarchical yet distributed system ensures that the entire body's physiology is temporally organized. For example, the liver's clock anticipates periods of feeding by upregulating genes for metabolism, while the gut's clock prepares for digestion.10 For optimal health, all these clocks must be synchronized with each other and with the external environment. A lack of synchrony between the central SCN and the peripheral clocks is a key mechanism of chronodisruption and a primary source of internal Biotemporal Dissonance.7

This system's design reveals a crucial characteristic: it is fundamentally anticipatory. The circadian system does not merely react to events as they happen; it enables the organism to *prepare* for them.2 Cortisol levels rise before waking to promote alertness and mobilize energy stores. Body temperature drops in the evening to facilitate sleep. Insulin sensitivity is highest in the morning in anticipation of the first meal of the day.10 This predictive function is what makes its disruption so physiologically devastating. When a powerful

*zeitgeber* like a meal arrives at a biologically inappropriate time—for instance, at 3 AM for a diurnal human—the body is caught unprepared. The pancreas is not primed for a robust insulin response, the digestive system is in a state of rest, and the metabolic machinery is not configured for efficient energy processing. Therefore, the harm from chronodisruption is not simply a scheduling mismatch; it is a state of chronic "anticipation failure," where the body is constantly subjected to metabolic surprise. This repeated violation of its predictive capacity leads to inefficient physiological processing, systemic stress, and, over the long term, the development of chronic disease.

Finally, it is important to recognize that there are genetically influenced individual variations in this system. The concept of "chronotype" describes an individual's natural inclination for sleep and wakefulness, ranging from early types ("larks") to late types ("owls").1 This trait has a biological basis and reflects differences in the intrinsic period and phasing of an individual's circadian clock. Significant health consequences arise when social schedules, such as early school start times or standard 9-to-5 workdays, are misaligned with an individual's innate chronotype, creating a chronic state of dissonance between their internal time and societal time.1

## The Subjective Clock: The Psychology of Time Perception

While the biological clock ticks with relentless, genetically programmed regularity, the human mind experiences time in a far more fluid and subjective manner. This faculty, known as chronoception, is not a faithful recording of objective reality but a complex cognitive construction that can stretch, compress, and warp depending on a host of internal and external factors.3 This malleable "subjective clock" introduces a second potential layer of conflict, creating the possibility for dissonance not only between our biology and the environment but also between our biology and our own conscious experience. Understanding the psychology of time perception is therefore essential for grasping the "-temporal" aspect of Biotemporal Dissonance in its entirety.

### The Brain's Distributed Timekeeping System

Unlike the five primary senses, which are associated with specific sensory organs, time perception is not localized to a single brain region. Instead, it is handled by a highly distributed system involving the coordinated activity of the prefrontal cortex, the cerebellum, and the basal ganglia.4 This distributed nature helps explain why our sense of time is so easily influenced by other cognitive and emotional states. The brain does not passively receive temporal information; it actively constructs an experience of duration.12

Influential psychological models, often referred to as "internal clock" or "pacemaker-accumulator" models, propose a hypothetical framework for this process. They posit a neural pacemaker that emits regular pulses or "ticks." An accumulator counts these ticks during a given event, and this count is then compared to a reference memory of durations to form a judgment about how much time has passed.3 While a simplification, this model provides a useful heuristic for understanding how various factors can distort time perception by altering the rate of the pacemaker or the way ticks are accumulated and interpreted.

### The Malleability of Subjective Time

Numerous factors have been shown to modulate this constructive process, leading to significant distortions in our perception of time's flow.

* **Cognition, Attention, and Memory:** The allocation of attentional resources has a profound effect on our experience of duration. Time often seems to fly when we are deeply engaged in a task and to drag when we are bored or idle. This is sometimes explained by the "processing principle," which suggests that perceived time is positively related to the amount and ease of information processing.14 When we are engaged, our cognitive resources are focused on the task, not on tracking time, leading to an underestimation of its passage. Conversely, when we are unoccupied, more attention is available to monitor the internal clock, leading to an overestimation. Memory also plays a role; looking back, a period filled with novel and memorable experiences (like a vacation) often seems longer in retrospect than a monotonous, routine period of the same objective duration.
* **Emotion and Arousal:** Our emotional state is one of the most powerful modulators of time perception. Intense emotions, particularly fear, awe, or the experience of a traumatic event, can trigger a neurological condition known as tachypsychia, in which time appears to slow down dramatically.4 This phenomenon is commonly reported during life-threatening situations like car accidents or physical assaults. The evolutionary rationale for this effect is likely that a perceived slowing of time enhances one's ability to process information and make rapid, critical decisions for survival. This state is associated with elevated levels of epinephrine (adrenaline), which increases overall brain activity.4 The feeling of awe, characterized by an experience of perceptual vastness, has also been shown to expand one's sense of time availability.4
* **The Psychological Present:** The brain's construction of time is also evident at the micro-level of the "psychological present." This refers to a brief temporal window, typically lasting no more than a few seconds, within which successive events are perceived not as discrete, isolated moments but as a single, unified perceptual sequence.12 For example, when a metronome ticks two or three times per second, we hear a coherent rhythm. If the interval between ticks is extended to three or more seconds, the perception of sequence breaks down, and each tick is experienced as an isolated event. This demonstrates that our seamless experience of the "now" is an active cognitive binding of discrete sensory inputs into a coherent temporal whole.

The existence of this subjective, malleable clock creates the potential for a three-way conflict, moving beyond the simple binary of biology versus environment. A person's biological clock (Clock A) is a rigid, ~24-hour oscillator. Objective, physical time (Clock B) is a constant, unvarying standard. Psychological, perceived time (Clock C) is a fluid and context-dependent construction. While Clock A is normally entrained to Clock B, a situation can arise where all three are desynchronized. Consider an individual suffering from depression exacerbated by long-term social isolation.15 Their biological clock (A) may become disrupted and fragmented due to irregular sleep-wake cycles and lack of exposure to strong

*zeitgebers*.15 Simultaneously, their psychological perception of time (C) may slow to a crawl, with days feeling empty and interminable due to boredom and lack of novel stimulation. Both of these internal temporal states are now profoundly out of sync with objective clock time (B), which continues its relentless march. This creates a multi-layered and particularly distressing form of Biotemporal Dissonance. The individual feels a mismatch not only with the external world's schedule but also with their own internal sense of pace, energy, and the subjective flow of experience, a state that likely magnifies the feelings of alienation and hopelessness characteristic of depression. The feeling of being "out of sync" becomes both a literal, biological reality and a deeply felt psychological one.

## The Dissonant Mind: Cognitive Dissonance and the Drive for Consistency

The "Dissonance" in Biotemporal Dissonance is not a passive state of misalignment but an active, psychologically uncomfortable condition that motivates a resolution. The engine driving this discomfort is cognitive dissonance, a foundational theory in social psychology proposed by Leon Festinger in 1957.6 The theory posits that human beings have a fundamental need for internal psychological consistency and that a state of inconsistency generates a motivational drive to restore consonance.17 This framework provides the crucial link between a biological or environmental state of temporal misalignment and the resulting psychological stress and behavioral responses.

### Festinger's Foundational Theory

Festinger's theory begins with the concept of "cognitions," which are defined as any elements of knowledge—beliefs, ideas, values, or perceptions about oneself, one's behavior, or one's surroundings.18 Two cognitions can be related in one of three ways: they can be irrelevant to one another, consonant, or dissonant.18 Two cognitions are consonant if one follows from the other (e.g., "I believe in protecting the environment" and "I diligently recycle"). They are dissonant if the obverse of one cognition follows from the other (e.g., "I believe in protecting the environment" and "I drive a gas-guzzling SUV").19

The core tenet of the theory is that the existence of dissonance is psychologically uncomfortable.19 This discomfort is not a minor irritation but a powerful motivational state, akin to hunger or thirst, that impels the individual to reduce the dissonance and achieve a state of consonance.6 The magnitude of the dissonance, and thus the pressure to reduce it, depends on the number and importance of the dissonant cognitions relative to the number and importance of the consonant ones.19 A conflict involving a core belief or a central aspect of one's self-concept will generate far more dissonance than one involving a trivial matter.20

### Mechanisms for Dissonance Reduction

When faced with this uncomfortable state, individuals employ several strategies to reduce the tension and restore internal consistency. Since it is often difficult or impossible to change a behavior that has already occurred, people frequently resort to changing their cognitions.21 The primary mechanisms for dissonance reduction are:

1. **Changing a Dissonant Cognition:** An individual can alter one of the conflicting beliefs to make it consistent with their behavior. For example, a smoker who believes smoking is harmful might start to question the validity of the medical evidence ("The link between smoking and cancer is not as strong as they say").19
2. **Adding New Consonant Cognitions:** A person can add new beliefs that support their behavior, effectively outweighing the dissonant elements. The smoker might rationalize their habit by adding cognitions like, "Smoking helps me manage stress, and stress is also a major health risk," or "I exercise regularly and eat a healthy diet, which offsets the negative effects of smoking".19
3. **Decreasing the Importance of Dissonant Cognitions:** An individual can trivialize the conflict, thereby reducing its psychological impact. The smoker might conclude, "The risks are minimal, and life is short anyway. We all have to die of something".19
4. **Changing Behavior:** While often the most difficult path, an individual can resolve the dissonance by bringing their behavior in line with their beliefs (e.g., the smoker quits smoking).21

These strategies are not always conscious or rational; they are often automatic psychological defense mechanisms aimed at protecting one's self-concept and reducing mental stress.

### The Neurological Correlates of Dissonance

Modern neuroscience has begun to uncover the neural underpinnings of this psychological process, lending it further empirical weight. Studies using electroencephalography (EEG) have found that making a difficult choice—a classic dissonance-inducing paradigm—triggers a specific negative frontocentral brain response that peaks shortly after the decision is made.22 This signal is remarkably similar in its timing and location to "error-related negativity" (ERN), a brain signal typically generated when a person makes a performance error, like pressing the wrong button in a task.22 This suggests that the brain's general performance-monitoring circuitry, centered in areas like the posterior medial frontal cortex (pMFC), treats cognitive inconsistency as a kind of error that needs to be corrected.22

Furthermore, the amplitude of this ERN-like signal is correlated with the magnitude of subsequent preference change. In the "free-choice paradigm," individuals who make a difficult choice between two equally preferred items will later rate the chosen item as more desirable and the rejected item as less desirable.5 This "spreading of alternatives" is a classic method of dissonance reduction. Neuroimaging studies have shown that this choice-induced preference change is reflected in the brain's reward circuitry, such as the striatum.5 The act of choosing literally changes the neural representation of the items' value to align with the decision, thus providing strong evidence that dissonance reduction is a tangible neurocognitive process, not just a psychological abstraction.

This powerful drive for consistency can create a dangerous feedback loop when applied to chronodisruption, a phenomenon that can be termed the "justification of chronodisruption." Consider an individual, such as a nurse or factory worker, whose job requires them to work night shifts. This person is likely to hold two conflicting cognitions. The first cognition (A) is the knowledge, whether explicit or intuitive, that this lifestyle is unnatural and unhealthy: "I know that being awake all night, sleeping during the day, and eating at 3 AM is bad for my body".23 The second cognition (B) is the knowledge of their own behavior: "I am choosing to continue working this job and live this way." The direct conflict between A and B generates cognitive dissonance, a state of psychological discomfort.21

To reduce this discomfort, the individual is motivated to change one of the cognitions. Changing the behavior (quitting the job) may be impractical due to financial or personal reasons. Therefore, the path of least resistance is often to modify the dissonant beliefs. The individual might add new, consonant cognitions, such as "The higher pay from the night shift is essential for my family's well-being," or "This job provides me with a sense of purpose that I wouldn't have otherwise." They might also reduce the importance of the dissonant health information: "I'm young and resilient, I can handle it," or "The health risks are probably exaggerated by scientists." This act of justification serves to reduce the immediate psychological stress. However, in doing so, it reinforces the chronodisruptive behavior, making it psychologically easier to continue the pathogenic lifestyle. This creates a feedback loop where the psychological need to reduce dissonance actively undermines the motivation to adopt healthier temporal habits. It helps explain why simply providing public health information about the dangers of shift work is often insufficient to produce behavioral change; the individual's mind is actively working to justify the behavior to maintain internal consistency.

## Chronodisruption: The Internal Manifestation of Biotemporal Dissonance

The principles of chronobiology, time perception, and cognitive dissonance converge in the real-world phenomenon of chronodisruption, which can be understood as the primary internal manifestation of Biotemporal Dissonance. It is a chronic state of conflict between the body's deeply ingrained temporal programming and the relentless demands of the modern, 24/7 environment. This misalignment is not a benign scheduling issue but a potent source of physiological and psychological stress, leading to a wide array of pathologies that represent some of the most significant public health challenges of our time.

### Causes of Modern Chronodisruption

In contemporary society, several factors systematically sever the connection between our internal clocks and the natural environmental cycles that are meant to entrain them.

* **Shift Work and Artificial Light at Night (ALAN):** These are arguably the most powerful and direct causes of chronodisruption. Shift work forces individuals to be active during their biological night and attempt to sleep during their biological day, placing their behavior in direct opposition to the signals generated by the SCN.23 This is compounded by exposure to artificial light at night (ALAN), which directly suppresses the nocturnal production of melatonin, a key hormonal signal for darkness, and confuses the SCN's ability to distinguish between day and night.11 The health implications are so severe that the International Agency for Research on Cancer has classified shift work involving circadian disruption as a probable human carcinogen.7
* **Mistimed Eating:** As established, food intake is a powerful *zeitgeber* for peripheral clocks in metabolic organs like the liver, pancreas, and gut.10 When eating occurs at a biologically inappropriate time (e.g., late at night), these peripheral clocks can become desynchronized from the central SCN, which is primarily entrained by light. This internal desynchrony leads to metabolic chaos. Animal studies have shown that mice fed a high-fat diet only during their normal inactive period gain significantly more weight and suffer worse metabolic consequences than mice fed the exact same number of calories during their active period.23 This demonstrates that  
  *when* we eat can be as important as *what* we eat, a central tenet of the emerging field of chrononutrition.10
* **Social Jetlag:** A pervasive and often overlooked form of chronodisruption is "social jetlag," defined as the discrepancy between an individual's sleep schedule on workdays versus free days.23 For many people, particularly those with a late chronotype ("owls") forced into an early-start work or school schedule, this can mean a weekly cycle of sleep deprivation followed by "catching up" on weekends. This constant shifting of the sleep-wake cycle is akin to flying across one or two time zones every weekend and is associated with an increased risk of obesity and metabolic syndrome.23

### Pathophysiological Consequences

The chronic state of Biotemporal Dissonance induced by these factors has profound and wide-ranging consequences for human health.

* **Metabolic Syndrome:** Chronodisruption is strongly linked to an increased risk of obesity, type 2 diabetes, and insulin resistance. This is due to multiple factors, including impaired glucose tolerance and reduced insulin sensitivity during the biological night, and mistimed release of appetite-regulating hormones like leptin (satiety) and ghrelin (hunger), which can promote overeating.23
* **Cardiovascular Disease:** The risk of hypertension, myocardial infarction (heart attack), and atherosclerosis is significantly elevated in populations with high levels of chronodisruption, such as shift workers.10 This is related to the disruption of the normal circadian rhythms of blood pressure, heart rate, and endothelial function.10
* **Cancer:** A growing body of evidence links chronodisruption to an increased risk of several types of cancer, particularly hormone-sensitive cancers like breast and prostate cancer, as well as colorectal cancer.23 The proposed mechanisms include the suppression of melatonin's oncostatic (anti-tumor) properties by ALAN and the impairment of clock-gene-controlled pathways involved in DNA damage repair and cell cycle regulation.23
* **Neurodegenerative and Mood Disorders:** The circadian system is deeply intertwined with brain health. Circadian disruptions are a common feature of neurodegenerative disorders like Alzheimer's and Parkinson's disease, and may even contribute to their development.1 Furthermore, a strong link exists between chronodisruption and mood disorders, including major depression, bipolar disorder, and seasonal affective disorder (SAD), highlighting the importance of a stable internal rhythm for maintaining mental well-being.26

### Case Study: Long-Term Isolation and the "Bunker Experiments"

To understand the fundamental nature of the internal clock and its relationship with the environment, researchers in the mid-20th century conducted a series of landmark "bunker experiments." In these studies, human volunteers were placed in complete isolation from all external time cues (*zeitgebers*)—no sunlight, no clocks, no knowledge of the time of day—for weeks at a time.27

These experiments provided the first definitive proof of the existence of an endogenous human circadian clock. Deprived of external cues, the subjects' bodies did not descend into temporal chaos. Instead, they settled into a self-sustained "free-running" rhythm of sleep and wakefulness.27 Critically, this free-running period was consistently found to be slightly longer than 24 hours, typically around 25 hours on average.27 This demonstrated that the internal clock is not simply a passive response to the environment but an innate oscillator that must be actively entrained by

*zeitgebers* like light to remain synchronized with the 24-hour solar day.

These isolation studies also revealed a profound form of Biotemporal Dissonance that arises from the *absence* of environmental conflict. As the subjects' internal 25-hour "day" began to drift out of sync with the external 24-hour world, their subjective perception of time became dramatically distorted. In one extreme case, a subject who had spent five weeks in the bunker was convinced that only three weeks had passed, having lived through a circadian cycle of nearly 50 hours at times.27 This highlights the critical role of environmental entrainment in anchoring not only our physiology but also our psychological sense of time's passage. While modern chronodisruption involves a conflict between our internal clock and a misaligned environment, the bunker experiments show that a complete lack of entrainment leads to a different, more isolating form of dissonance, where the individual's entire temporal reality becomes detached from the shared reality of the outside world. This has direct parallels to the effects of long-term social isolation, which is known to disrupt sleep quality and exacerbate depression, creating a vicious cycle of physiological and psychological distress.15

## Speculative Realities: Exploring the Extremes of Biotemporal Dissonance in Science Fiction

While chronodisruption represents the most prevalent form of Biotemporal Dissonance in our current reality, science fiction serves as a vast cultural laboratory for conducting thought experiments on more extreme and technologically mediated forms of this conflict. The genre's narratives of interstellar travel, cryosleep, time paradoxes, and virtual immersion push the concept to its logical and existential limits, exploring the profound psychological, biological, and philosophical consequences of radical temporal manipulation. By examining these speculative scenarios, we can gain a deeper understanding of the fundamental human relationship with time and the potential for its catastrophic disruption.

### The Trauma of Temporal Displacement: Time Dilation and Cryosleep

A recurring theme in space-faring science fiction is the challenge of traversing vast interstellar distances. Two primary tropes, time dilation and cryosleep, are often employed to solve this problem, but in doing so, they introduce a severe form of external Biotemporal Dissonance: the trauma of temporal displacement. The core conflict arises from the radical decoupling of the traveler's personal, biological time from the objective, chronological time of the universe they left behind. The central dissonant cognitions become: "According to my body and my memories, I have only lived for 30 years" versus "The society, culture, and all the people I once knew ceased to exist a thousand years ago."

* **Time Dilation:** Grounded in Albert Einstein's theory of special relativity, time dilation is the phenomenon where time passes more slowly for an observer moving at a significant fraction of the speed of light relative to a stationary observer.28 A journey of one year at near-light speed might correspond to ten, a hundred, or even thousands of years passing on Earth.29 Fictional works like Joe Haldeman's  
  *The Forever War* and L. Ron Hubbard's *To the Stars* masterfully explore the psychological toll of this effect.29 The returning astronaut is not a hero but an anachronism, a living fossil. Their skills are obsolete, their language is archaic, and their emotional connections have turned to dust. They experience a profound social and existential alienation, forever out of sync with the world they sought to serve. This is a form of cognitive dissonance on an existential scale, where the very foundations of one's identity are rendered meaningless by the relentless, asymmetrical passage of time.
* **Cryosleep and Suspended Animation:** This trope offers a biological rather than a relativistic solution to long-duration travel, positing a technology that can halt or dramatically slow the body's metabolic processes for extended periods.31 While often depicted as a simple "pause button," narratives like the film  
  *Idiocracy* use it to explore the same themes of social displacement and anachronism.33 Beyond the social consequences, these stories also frequently introduce the intrinsic biological risks of the procedure itself. The complex process of freezing and thawing a human body without causing irreversible cellular damage from ice crystal formation is a monumental challenge.34 Fictional depictions often explore the potential side effects: imperfect reanimation leading to brain damage, memory loss, impaired cognitive function, personality shifts, chronic pain, and severe psychological trauma.34 In this case, the Biotemporal Dissonance is twofold: an external conflict with a changed society and an internal conflict with a body and mind that have been damaged and altered by the very process of temporal suspension.

These narratives force a confrontation with the idea of the "self" as a temporal construct. If personal identity is defined not just by a continuous stream of consciousness but also by a web of relationships, cultural context, and shared history, then the temporally displaced individual experiences a form of identity death. The cryo-sleeper who awakens after a millennium is a biological continuation of their former self but an existential stranger in a foreign land. The dissonance is no longer just about a mismatched schedule; it is about the fundamental definition of personhood. The conflicting cognitions become "I am me" versus "The entire world that created and defined 'me' is gone." This is perhaps the most profound psychological expression of Biotemporal Dissonance.

### The Paradox of Self: Time Travel and Biological Causality

If temporal displacement represents an external conflict with history, then time travel into the past introduces the ultimate form of Biotemporal Dissonance: a paradoxical conflict where an individual's biological existence becomes logically and causally inconsistent with the timeline they occupy. This is not merely a feeling of being out of place; it is a state of being a logical impossibility. The core dissonant cognitions are the most fundamental imaginable: "My body exists here and now" versus "The necessary causal chain required for my body's existence has been severed."

* **Consistency Paradoxes:** The most famous of these is the "Grandfather Paradox." In this scenario, a time traveler goes to the past and kills their own grandfather before he can meet their grandmother, thereby preventing the conception of their parent and, consequently, themselves.36 This creates an irresolvable contradiction: if the traveler was never born, they could not have gone back in time to commit the act in the first place.38 The traveler's biological presence in the past becomes a paradox. The dissonance is an ontological clash between being and non-being. Fictional explorations of this often posit that the universe has a self-correcting mechanism, where any attempt to create such a paradox is thwarted by circumstance, or that changing the past creates a new, divergent timeline (the many-worlds interpretation).38
* **Bootstrap Paradoxes:** Also known as an ontological paradox, this involves an object, piece of information, or even a person existing in a closed causal loop with no discernible origin.37 The object is "pulled up by its own bootstraps." A classic example is a time traveler giving a young William Shakespeare a copy of his complete works, which Shakespeare then copies and publishes, becoming the source of the very works that were given to him. When applied to biology, this can lead to a person who is their own ancestor, as explored in Robert A. Heinlein's short story "—All You Zombies—," where the protagonist, through a complex series of events involving time travel and a sex change, becomes their own mother and father.37 The Biotemporal Dissonance here is a crisis of origin and identity: the individual's biological existence is a self-contained, un-caused loop, a profound violation of the linear progression of life.

In fiction, this state of logical paradox is often translated into visceral, physical trauma. A character attempting to alter their own past might experience nosebleeds, seizures, intense pain, or a complete psychological breakdown, as if their body is physically struggling to exist in a state of causal violation.40 Some narratives propose that time travel itself is an inherently biological process, perhaps tied to a rare genetic disorder or a specific genetic modification, making the traveler's body the literal site and vessel of the temporal paradox.41

### The Virtual Uncanny: Simulated Realities and Perceptual Dislocation

Biotemporal Dissonance is not confined to the grand scales of interstellar or chronological travel. It can also manifest in the intimate space between mind and body, a conflict driven by immersive technologies that decouple subjective experience from physiological reality. This "virtual dissonance" represents a new, technologically mediated form of chronodisruption that is rapidly moving from the realm of science fiction to everyday life. The core conflict is between the body's real-time homeostatic state and the mind's distorted perception of time within a compelling virtual environment. The dissonant cognitions are: "My body has been sitting motionless in a chair for three hours, its muscles are stiffening and it is signaling a need for food and water" versus "My mind, fully engaged in this virtual world, perceives that only 30 minutes have passed."

* **VR-Induced Time Compression:** A growing body of research and widespread anecdotal reports from users and developers confirm that time appears to pass more quickly while immersed in virtual reality (VR).42 In one study, perceived five-minute intervals in VR were found to contain 28.5% more actual, objective time than perceived five-minute intervals spent on a conventional monitor.42 This "time compression" effect is a measurable form of Biotemporal Dissonance, where the subjective clock (chronoception) becomes radically desynchronized from both objective clock time and the body's biological time. The immersive nature of VR, which occupies the entire visual field and can reduce bodily awareness, likely contributes to this powerful perceptual distortion.42
* **Dissociation and Presence:** Beyond time compression, VR has been shown to induce dissociative states, such as depersonalization (a feeling of detachment from one's own body) and derealization (a feeling that the external world is unreal).43 It creates a powerful sense of "presence"—the feeling of actually being inside the virtual scene—which can, in turn, lessen the sense of presence in objective reality.43 This creates a profound dissonance between the mind, which feels fully present and embodied in the virtual world, and the physical body, which remains inert in the real one.

Science fiction has long served as a prescient guide to these themes. Early stories like Stanley G. Weinbaum's 1935 "Pygmalion's Spectacles" imagined immersive sensory experiences that blurred the line between reality and illusion.44 The cyberpunk genre, pioneered by William Gibson's

*Neuromancer*, took this concept further, depicting "console cowboys" who would "jack in" to cyberspace, a "consensual hallucination," while their physical bodies (derisively termed "the meat") were neglected and left vulnerable.44 More contemporary works, such as the television series

*Black Mirror*, relentlessly explore the disturbing psychological, social, and physical consequences of this technologically induced mind-body split, where virtual identities and experiences begin to supersede physical reality.47

This analysis reveals that immersive technologies are acting as powerful new vectors for chronodisruption. VR headsets, and to a lesser but still significant extent, conventional video games, smartphones, and other engaging screen-based media, function as potent technological *zeitgebers*. However, unlike the natural *zeitgebers* of light and dark, they do not entrain our biological clocks. Instead, they entrain our *subjective perception* of time, pulling it powerfully out of sync with our fundamental biological needs for movement, nutrition, and rest. This represents a novel and increasingly widespread form of Biotemporal Dissonance, one that does not require a spaceship or a time machine, but merely a headset and a comfortable chair.

## Distinctions and Boundaries: Differentiating from Sensory and Spatial Conflicts

To further refine and clarify the concept of Biotemporal Dissonance, it is crucial to distinguish it from related but fundamentally different conditions that can arise in extreme environments. A prime example for comparison is Space Adaptation Syndrome (SAS), a well-documented ailment affecting astronauts. While both SAS and the circadian disruptions experienced in spaceflight are challenges of adapting to an extraterrestrial environment, their underlying causes and mechanisms are distinct. This comparison serves to highlight that Biotemporal Dissonance is specifically a *temporal* conflict, not a generalized sensory or spatial one.

### Defining Space Adaptation Syndrome (SAS)

Space Adaptation Syndrome, also commonly known as space sickness, is a condition that affects up to 70% of space travelers, typically during the first two to three days of a mission in microgravity.48 The symptoms are similar to terrestrial motion sickness and can range from mild disorientation and headaches to severe nausea and vomiting.50 The most extreme reaction recorded was that of Senator Jake Garn, whose severe symptoms led NASA to informally use the "Garn scale" as a measure of space sickness severity.48

### The Sensory Conflict Hypothesis

The prevailing explanation for SAS is the sensory conflict hypothesis.48 On Earth, the brain integrates information from multiple sensory systems to maintain spatial orientation and balance. The visual system provides information about where the body is in relation to its surroundings, while the vestibular system in the inner ear detects gravity and acceleration, providing a sense of motion and up-down orientation. In the microgravity environment of space, this integration breaks down. The visual system sees the interior of the spacecraft as a stable, stationary reference frame, while the vestibular system, no longer sensing the constant pull of gravity, sends signals to the brain that are confusing or absent. The brain receives contradictory information: the eyes say "I am not moving," while the inner ear says "I don't know where 'down' is, and my sense of motion is gone".48 This sensory mismatch is believed to be the root cause of the nausea and disorientation of SAS. The condition is, in essence, the opposite of terrestrial motion sickness (e.g., seasickness), where the vestibular system

*feels* motion while the eyes see a static environment (like the inside of a cabin).48

### The Key Distinction

By comparing the underlying mechanisms, the distinction between SAS and space-induced Biotemporal Dissonance becomes clear.

* **Space Adaptation Syndrome (SAS)** is a **sensory-spatial conflict**. It is fundamentally a problem of *where* and *how* the body is oriented in three-dimensional space. The conflict is between different sensory inputs—primarily visual and vestibular—providing contradictory information about motion and orientation. SAS is an acute condition; it typically resolves within a few days as the brain neuroplastically adapts to the new microgravity environment, learning to down-weight the confusing signals from the vestibular system and rely more heavily on visual cues.49
* **Biotemporal Dissonance (in spaceflight)** is a **chronobiological-temporal conflict**. It is a problem of *when* physiological processes should occur. It arises not from microgravity's effect on the senses, but from the disruption of the body's internal timing system by the unique space environment. Factors include the lack of a robust, terrestrial 24-hour light-dark cycle (on the International Space Station, astronauts experience 16 sunrises and sunsets per day), the demanding operational workload, confinement, and altered sleep architecture.51 This leads to circadian misalignment, sleep disorders, and hormonal dysregulation. Unlike SAS, this is a chronic health risk that persists throughout a long-duration mission and does not resolve on its own. It requires active countermeasures such as precisely timed light exposure, exercise regimens, and carefully managed work-rest schedules to mitigate its negative effects on health and performance.51

In conclusion, while an astronaut on their first mission may suffer from both SAS and circadian disruption simultaneously, these are distinct physiological challenges. SAS is the body's acute struggle to adapt its spatial orientation system to the absence of gravity. Space-induced Biotemporal Dissonance is the body's chronic struggle to maintain its internal temporal organization in an environment devoid of the reliable terrestrial *zeitgebers* that have shaped its evolution for millennia. This distinction reinforces that Biotemporal Dissonance is a specific class of conflict rooted in the dimension of time.

## Conclusion: Synthesis and Future Implications

This report has introduced and elaborated upon the concept of Biotemporal Dissonance, defining it as a state of psychophysiological conflict arising from a misalignment between an organism's innate biological rhythms, its subjective perception of time, and the objective or technologically-mediated temporal reality it inhabits. By integrating principles from chronobiology, psychology, and neuroscience, and applying them to both real-world health crises and speculative fictional narratives, a comprehensive framework emerges. Biotemporal Dissonance is not merely a state of being "out of sync"; it is an active condition driven by the powerful psychological stress of cognitive dissonance acting upon a biological system with ancient, non-negotiable temporal requirements. It manifests across a spectrum, from the chronic internal dissonance of chronodisruption caused by modern lifestyles, to the profound external and paradoxical dissonances of temporal displacement and causal inconsistency imagined in science fiction.

The contemporary relevance of this concept cannot be overstated. We are living in an age of escalating Biotemporal Dissonance. The 24/7 global economy, the ubiquity of artificial light, frequent jet travel, and the constant engagement with digital screens are systematically decoupling human physiology and psychology from the natural 24-hour cycles that governed our evolution. The pathological consequences—metabolic syndrome, cardiovascular disease, cancer, and mood disorders—are not niche problems affecting only shift workers, but are among the most significant public health crises of the 21st century. The analysis of chronodisruption as a form of internal Biotemporal Dissonance provides a powerful lens for understanding that these conditions are not just diseases of diet or lifestyle in the conventional sense, but are, at their core, diseases of time.

Looking to the future, the challenges posed by Biotemporal Dissonance will only become more acute. As humanity stands on the precipice of becoming a multi-planetary species, with long-duration missions to Mars and beyond on the horizon, understanding and mitigating the effects of profound circadian disruption in an environment devoid of terrestrial *zeitgebers* will be a critical, mission-defining challenge for astronaut health and performance.51 Failure to do so will jeopardize not only the success of these missions but the very well-being of the explorers who undertake them.

Simultaneously, the rapid development of terrestrial technologies raises new ethical considerations. Immersive virtual reality and future brain-computer interfaces hold the potential to engineer experiences that intentionally or unintentionally induce a state of virtual Biotemporal Dissonance. The documented phenomena of time compression and dissociation in VR are early indicators of a future where subjective experience can be radically unmoored from biological reality.42 This raises profound questions about the long-term psychological and physiological consequences of living bifurcated lives, where the mind inhabits a timeless digital space while the body remains subject to the inexorable ticking of its biological clock.

Finally, the resonance of these themes in speculative fiction speaks to a deep-seated human anxiety. The stories of the temporally displaced cryo-sleeper, the paradox-ridden time traveler, and the cyberspace-addicted deck-jockey are powerful because they tap into fundamental fears of alienation, the loss of identity, and the irreversible passage of time. They are thought experiments that explore the fragility of the self when its temporal anchors are removed. The concept of Biotemporal Dissonance gives a scientific and philosophical name to this narrative intuition: the pervasive fear that we might one day become irrevocably out of sync with our world, our bodies, and ultimately, ourselves. Understanding this dissonance is therefore not just a matter of public health or technological ethics; it is a critical part of understanding the human condition in an increasingly complex and temporally fragmented world.

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