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Biological and psychological rhythms: An integrative approach to rhythm disturbances in autistic disorder

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ABSTRACT

Biological rhythms are crucial phenomena that are perfect examples of the adaptation of organisms to their environment. A considerable amount of work has described different types of biological rhythms (from circadian to ultradian), individual differences in their patterns and the complexity of their regulation. In particular, the regulation and maturation of the sleep–wake cycle have been thoroughly studied. Its desynchronization, both endogenous and exogenous, is now well understood, as are its consequences for cognitive impairments and health problems. From a completely different perspective, psychoanalysts have shown a growing interest in the rhythms of psychic life. This interest extends beyond the original focus of psychoanalysis on dreams and the sleep–wake cycle, incorporating central theoretical and practical psychoanalytic issues related to the core functioning of the psychic life: the rhythmic structures of drive dynamics, intersubjective developmental processes and psychic containment functions. Psychopathological and biological approaches to the study of infantile autism reveal the importance of specific biological and psychological rhythmic disturbances in this disorder. Considering data and hypotheses from both perspectives, this paper proposes an integrative approach to the study of these rhythmic disturbances and offers an etiopathogenic hypothesis based on this integrative approach.

1. Introduction

Biological rhythms are perfect examples of the adaptation of organisms to their environments. The endogenous variations in physiological activity reflect adaptations to sequences of the regularly changing conditions of geophysical cycles, such as tides, the lunar cycle, the day–night cycle and seasons. Biological rhythms can be understood as an organism's incorporation of a time program that allows it to be prepared for changes in the environment. From a phylogenetic perspective, biological rhythms reflect a very old heritage; some traces of these rhythms can be found in invertebrate species. The periodicity of activities applies to all biological, physiological and psychological functions. Recently, the science of biological rhythms, chronobiology, has emerged with its own theory and methods, with considerable implications for medicine, psychiatry, pharmacology, sleep science, education, industry and transportation.

The essential theoretical assumptions of psychoanalysis propose a central role of rhythmicity in the functioning of the psychic apparatus, particularly in Freudian and post-Freudian works on the drives, the birth of thought, the development of intersubjectivity and the function of the therapeutic framework.

Starting with an overview of the basic characteristics of biological rhythms and the main psychoanalytical conceptions of rhythmicity, this paper proposes to reconcile the data obtained from each of these two heterogeneous perspectives and to apply this integrative approach to the study of infantile autism.

2. Overview of biological rhythms

2.1. Definition

Over the last 50 years, a considerable amount of research has been conducted in an effort to understand the properties and implications of biological rhythms. Chronobiology has paved the way for several new fields of research in psychology (chronopsychology), medicine (chronotherapy) and pharmacology (chronopharmacology). The resulting research has implications both for basic knowledge and for industrial applications (e.g., night and shift work).

Biological rhythms comprise three families of rhythms that differ in their endogenous periods:

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- Circadian rhythms refer to cycles that occur once in 20–28 h. Examples of circadian rhythms are the sleep–wake cycle, body temperature and metabolic processes.
- Ultradian rhythms occur with a greater frequency in the range of seconds, minutes or hours (e.g., EEG, EKG and the breath cycle).
- Infradian rhythms correspond to the longest cycles and occur with a lower frequency weekly, monthly (e.g., the menstrual cycle) or seasonally (e.g., hibernation).

These rhythms are endogenous; they persist in the absence of temporal cues, such as the light–dark cycle. Circadian rhythms have been observed in temporal isolation studies where subjects were isolated from all time cues for several weeks (Wever, 1979). Approximately 15 days after the start of such experiments, a shift in the phase of the cycle can be observed, with an increase of the period that corresponds to the intrinsic period of the rhythm (i.e., around 25 h). This shift is known as free running. Under normal situations, external time cues play the role of time givers (Zeitgeber) that permanently reset the biological rhythms to a period of 24 h. These intrinsic rhythms have been identified in every organism from unicellular to human and in all functions, including physiological, enzymatic and psychological.

2.2. Regulation of biological rhythms

These rhythms are under the control of a "master" pacemaker located in the suprachiasmatic nuclei of the hypothalamus. The synchronization to the external light–dark cycle occurs via retinal light input that controls daily rhythms of sleep and alertness as well as rhythms of core body temperature and the secretion of melatonin from the pineal gland and the secretion of cortisol from the adrenal glands. These inputs are provided through a direct and specialized retinohypothalamic tract (Murakami et al., 1989). Melatonin is known as the hormone of darkness because its secretion is inhibited by light and favored by darkness. Secretion of melatonin and its concentration in the blood peak in the middle of the night and gradually fall during the second half of the night. It is well established that melatonin plays a major role in the regulation of the sleep–wake and temperature cycles.

Recent studies have identified non-visual circadian photic input through the melanopsin in ganglion cells (Berson et al., 2002; Hattar et al., 2002). Valdez et al. (2009) showed in GUCY1 chickens, birds carrying a null mutation that causes blindness at hatch, both the pupillary light reflex and the entrainment of feeding rhythms to a 12:12 h light–dark cycle. These novel non-visual circadian photoreceptors, which contain the photopigment melanopsin, are most sensitive to blue wavelength light.

Based on this mechanism, a very large amount of applied research has shown that exposure to bright light can rapidly induce large-magnitude phase shifts of the melatonin rhythm and thereby entrain the circadian rhythms (Czeisler and Gooley, 2007). These findings have both clinical and industrial applications because bright light can be used to help workers adjust to shift work or to help travelers transition between time zones. Furthermore, circadian oscillators can be found in every organ and in every cell (Schibler et al., 2003), and each organ is sensitive to specific time givers.

2.3. Interindividual differences in biological rhythms

The phases of biological rhythms vary between individuals; some individuals have an early phase (morning type), whereas other show a late phase (evening type). This individual characteristic can easily be determined based on the individual's sleep–wake cycle or with a standardized questionnaire, such as the morningness–eveningness Questionnaire (Horne and Ostberg, 1976) or, most recently, the Munich Chronotype Questionnaire (Zavada et al., 2005). Over the last decade, a growing number of genetic studies have traced circadian variability in humans to polymorphisms or mutations of the recently identified "clock genes" that generate circadian cycles. From these studies, evidence has emerged for a genetically determined period of the intrinsic circadian rhythm that defines morningness or eveningness. Furthermore, the process of aging interacts with morningness–eveningness. Morningness represents the majority of elderly people (75%) but a minority of young adults (Duffy et al., 1998; Yoon et al., 1999). The trend towards morningness appears around the age of 50. A recent explanation for this impact of age is a weaker transduction of the circadian signal downstream (Munch et al., 2005) rather than a general advancement of the circadian system.

2.4. The ultradian rhythms

Circadian rhythms have been studied most often, although a growing research interest in ultradian rhythms has been noted because of their implications for the sleep–wake cycle. In 1963, Kleitman was the first to hypothesize a Basic Rest Activity Cycle, a fundamental cycle of approximately 90 min in duration that produces the nocturnal non-REM/REM sleep cycle and a similar waking periodicity in motor performance, sensory acuity and a variety of visceral functions in human and animals.

Lavie (1986) described another ultradian rhythm, a 12-h cycle of sleep propensity. This cycle shows a bimodal distribution of sleepiness: a major nocturnal sleepiness peak and a secondary mid-afternoon sleepiness peak, respectively known as the primary and secondary sleep gates. These two gates are separated by a "forbidden zone for sleep" (the late afternoon) during which the sleep propensity tends to be significantly lower.

2.5. Regulation of the sleep–wake cycle

Regulation of the sleep–wake cycle has been studied extensively. Borbely (1982) was the first to propose a model of the sleep–wake cycle including two separate processes: a homeostatic process related to time awake and amount of prior sleep (process S) and a circadian component (process C) representing the effect of the biological clock. This first model essentially addressed sleep regulation. Folkard and Åkerstedt (1987) further developed this model to predict alertness by adding a third process known as W, which relates to sleep inertia. Sleep inertia is "a transitional state of lowered arousal occurring immediately after awakening from sleep and producing a temporary decrement in subsequent performance" (Tassi and Muzet, 2000). This period can last from a few minutes to several hours depending on the sleep stage during which the individual was awakened (Tassi and Muzet, 2000). Several mathematical models have been developed over the last 20 years to predict sleepiness and/or alertness with the aim of optimizing work performance (Mallis et al., 2004).

2.6. Cognitive performance rhythms

The rhythm of cognitive performance has been investigated extensively because of its practical implications. One of the difficulties in the study of the time-of-day effects on cognitive performance is discriminating the effect of the homeostatic process (S) from the effect of the circadian process (C). In fact, in normal day/night conditions, these two processes are synchronized. Several techniques have been developed to separate the effects of these two processes. In the forced desynchrony protocol (Czeisler et al., 1990), subjects are exposed to an artificial sleep/wake cycle with a shorter or longer day than the normal 24-h day for a period