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# DESYNCHRONISED TIMES? CHRONOBIOLOGY, (BIO)MEDICALISATION AND THE RHYTHMS OF LIFE ITSELF

Simon J. Williams<sup>1</sup>, Robert Meadows<sup>2</sup> & Catherine M. Coveney<sup>3</sup>

*Institutional Affiliations:* <sup>1</sup> Department of Sociology, University of Warwick, UK; <sup>2</sup> Department of Sociology, University of Surrey UK; <sup>3</sup> Social and Policy Studies, School of Social Sciences and Humanities, Loughborough University, UK.

## Abstract

This paper takes a critical look at the role of chronobiology in society today, with particular reference to its entanglements with health and medicine and whether or not this amounts to the (bio)medicalisation of our circadian rhythms. What we have here, we show, is a complex unfolding storyline, within and beyond medicine. On the one hand, the promises and problems of these circadian, infradian and ultradian rhythms for our health and wellbeing are now increasingly emphasised. On the other hand, a variety of new rhythmic interventions and forms of governance are now emerging within and beyond medicine, from chronotherapies and chronopharmacology to biocompatible school and work schedules, and from chronodiets to the optimisation of all we do according to our ‘chronotypes’. Conceptualising these developments, we suggest, challenges us to think *within* and *beyond* medicalisation to wider processes of biomedicalisation and the biopolitics of our body clocks: a vital new strand of chronopolitics today indeed which implicates us all in sickness and in health as the very embodiment of these *rhythms of life itself*. The paper concludes with a call for further research on these complex unfolding relations between chronobiology, health and society in these desynchronised times of ours.

**Keywords:** Chronobiology, Time, Body Clocks, Rhythms, Medicalisation, Biomedicalisation, Biopolitics.

## Introduction

Chronobiology is a rising biological science in society today in these ‘desynchronised’ times of ours. From Nobel Prize winners to discussions and debates about more biocompatible school start-times and work schedules, and from chrono-medicine and chrono-nutrition to new ways to optimise all we do according to our chronotypes, chronobiology’s time now seems to be coming in more ways than one, some more surprising than others.

Engagements with chronobiology in the social sciences so far however (see for example Cambrosio and Keating 1983; Young 1988; Rifkin 1989; Adam 1990, 1992; Nordgren 2016), have yet to critically examine, in an in-depth sociological fashion, the role of this science in society, its entanglements with health and medicine, its implications for the optimisation of ourselves, and the extent to which this is resulting in the (bio)medicalisation of these rhythms of life. The same indeed may be said of engagements with rhythms in the social sciences to date, with or without reference to chronobiology *qua* science as such (see for example Zerubavel 1985; Lefebvre 2013[1992]; Henriques et al 2014; Edensor 2016, Lyon 2019).

As for sleep matters, while recent studies in the sociology of sleep have discussed the partial and problematic medicalisation of sleep problems and pointed to important dynamics occurring beyond medicalisation (Williams et al, 2013, Williams et al, 2017; Hislop and Arber, 2003), there is little in this growing corpus of work, which engages directly, in a critical and sustained fashion, with chronobiology; beyond that is general references to sleep science or sleep medicine. Chronobiology after all is about more than simply sleep matters.

This paper therefore seeks to fill this gap in the literature. Located at the intersections of the sociology of health and medicine and science and technology studies (STS), we critically examine the social and political life of chronobiology in society, with particular reference to the *circulation, translation, popularisation,*

*institutionalisation* and *politicisation* of these rhythmatised forms of power, knowledge and expertise beyond the lab and their implications for our bodies, our health and the optimisation of all we do. A key aspect of our analytical strategy here, as alluded to above, is to think both *within* and *beyond* medicalisation as and where necessary with these chronobiological matters in mind. Hence our use of the term (bio)medicalisation (Clarke et al, 2010) given recent debates as to whether or not we need to go ‘beyond’ medicalisation when it comes to matters of health, medicine and technoscience today (see for example Busfield, 2017; Williams et al, 2017, Williams et al, 2013; Coveney et al, 2011). Whilst medicalisation, on these counts, denotes the making medical of some hitherto non-medical matter (Conrad 2007), biomedicalisation signals shifts of more technoscientific kind from the ‘control’ to the ‘customisation’ of bodies (Clarke et al. 2010), with related terms such as biopower and biopolitics bringing to the fore the productive intersections of biology, power and politics, including the ways we come to know, govern and optimise ourselves in a ‘biological age’ (Rose 2004).

A few words on methodological matters are also in order here at the outset.

Following Williams et al (2015) and Pickersgill (2019a) we interrogated a range of sources to explore how the ‘problems, prospects and possibilities’ (Williams et al 2015: 1041) of chronobiology in society were being expressed. Specifically, we (i) searched PubMed using the key term ‘chronobiology’, mapped the number of papers (self)relating to chronobiology and coded paper titles into themes; (ii) searched apps stores (google play) to identify applications which made reference to chronobiology; and (iii) used google searchers to further identify how, where and why chronobiology is being invoked beyond the lab.

The claims made in this paper therefore are based on a *preliminary* scoping of these rhythmic matters *in the making*. In the making that is to say, in the sense of being a newly emerging problem space in society today. Preliminary too however, given the need for further research on any and all the chronobiological issues raised in

the paper at “various levels and scales of complexity” (Williams et al 2015). This paper therefore forms one part of this wider endeavour.

In the first part of the paper, we briefly say a little more about what chronobiology is exactly and why its time now seems to be coming in the biological sciences today. The remainder of the paper is then devoted to a more critical exploration of the role of chronobiology in society today, including the problems, promises and prospects of these chronobiological matters for our health and the forms of rhythmic governance this entails in these desynchronised times of ours.

### **What is Chronobiology?**

Characterising chronobiology, beyond simple definitions such as the ‘biology of time’ or the ‘science of biological rhythms and the temporal dimensions of life’, is no easy matter. Any attempt to do so indeed, as Pickersgill similarly comments in the case of the neurosciences, risks not only simplifying but rendering as ‘unified’ what is in fact ‘highly heterogeneous’ (2013: 324). To the extent furthermore, as we shall see, that chronobiology is relevant to and intersects with many if not most other branches of the biological and biomedical sciences today, including the neurosciences, then this further underlines these complexities.

Clues to this complexity can be traced through the history of chronobiology or *historiæ* in the plural to be precise -- including official histories, personal histories, histories of discovery and so forth -- as Rose and Abi-Rached (2013) rightly remind us with the histories of the brain sciences once again in mind. A detailed analysis of these histories is beyond the scope of the present paper. Suffice it to say for our purposes however, that whilst a number of historical precursors may be pointed to here -- from de Mairan’s observations in 1729 of the rhythmic opening and closing of plant leaves (*mimosa pudica*) in the absence of light to Curtis Richter’s early animal studies of rhythmic behaviour in the 1920s and 30s, and from Linnaeus’ development of the flora clock in 1748 to the founding of the Society for Biological Rhythms in 1937 – the 1960s are commonly seen to be the years in

which chronobiology was officially birthed, named and christened. Much is made on these counts of the Cold Spring Harbour Symposium of 1960 as a critical moment in the emergence of what was yet to be named ‘chronobiology’: a symposium where a number of key figures in the field of biological rhythms research gathered together, including Colin Pittendrigh and Franz Halberg (Foster and Kreitzman 2004). This nevertheless proved to be a difficult birth, as Cambrosio and Keating (1983) note, given subsequent disputes between Pittendrigh, Halberg and their followers over the very name ‘chronobiology’, its domains and methods of study, and its future direction of travel. For Pittendrigh, for example, who himself disliked the term ‘chronobiology’ and considered himself a ‘circadian physiologist and an evolutionary biologist’ (Foster and Kreitzman 2004: 235), the path ahead was seen as one of moving beyond the multitude of observation of biological rhythms in a variety of organisms, through the establishment of endogenous clocks, to the gradual uncovering of the biological mechanisms of the clock. For Halberg in contrast, who coined the term ‘circadian’, the agenda was far wider and more medically focused from the start. At stake here for Halberg then, as Cambrosio and Keating succinctly put it, was ‘a process of synthesis which, with the help of statistical methods, cuts across many domains in the biomedical sector’, and therefore included ‘not only biologists but gerontologists, paediatricians and, in general, medical practitioners’ (1983: 330).

As for developments since this time, according to chronobiology’s own chronology of itself, these broadly speaking may be regarded a complex mixture of both the above agendas, albeit more bio still than biomedical. On the one hand, for example, in keeping with Halberg and his followers’ agenda, chronobiology has pursued a strategy of increasing ‘disciplinization’ over time (Cambrosio and Keating, 1983), with expanding links to the biomedical sciences and medical practice now too (of which more shortly), including attention to matters such as ageing, nutrition and chronotherapy, themselves studied through what Halberg termed ‘chronomics’ – i.e. the mapping of time structures within and around us.

On the other hand, Pittendrigh's 'clock' based vision for future biological research also appears to have well and truly materialised. This for example, includes the hunt for and location of the 'master' mammalian clock in a tiny cluster of around 20,000 cells (the so-called suprachiasmatic nuclei (SCN)) in the brain, the shift to more genetic and molecular understandings of this biological clockwork, and the increasing emphasis now placed on circadian *systems* or *networks* rather than just mechanical clocks and negative molecular feedback loops (Roenneberg and Merrow 2001).

Here we glimpse then another critical way of characterising chronobiology in terms of the *visions of life* at stake here in these foregoing circadian developments and debates. It is no longer simply a case, on these counts, of life rhythmatised in these – *circadian* (around a day), *infradian* (more than a day) or *ultradian* (less than a day) -- ways, important as that is. Time itself, or timing to be precise, has now become *internalised, localised, geneticised, molecularised, individualised* and *personalised* in chronobiological ways too. Time, that is say, as something *endogenous* that 'ticks' away *inside us*. Time localised and spatialized in the anterior region of the hypothalamus as the central circadian pacemaker. Time distributed throughout the peripheral clocks found in the cells, tissues and organs of the body. Time geneticised and molecularised in terms of the 'protein "tick" and the RNA "tock"' (Foster and Kreitzman 2004) of these biological clocks of ours. Time individualised and personalised though in the shape of our chronotypes, or our 'morningness' and 'eveningness' propensities to you and me. As for these body 'clocks' of ours, this of course is a metaphor, a powerful and potent one indeed (Aviram and Manella 2020). Metaphors abound in chronobiology, particularly those of musical kind for obvious reasons with these rhythms in mind.

It is not just this internal or interior gaze which characterises chronobiology however but its *outward* gaze too. A gaze that is directed to and trained upon the relations, or 'interactions' as they are frequently called, between these 'endogenous'

rhythms of life and the *environments* within which they occur. Hence the notion of *entrainment* and related terms such as *zeitgebers* (or time-givers) to capture and convey these internal-external, endogenous-environmental interactions, with daylight seen as the primary environmental influence or circadian cue here. Hence too the increasing emphasis within chronobiology today on the clash, conflict, tensions or misalignment between ‘biological’ and ‘social’ time -- of which more shortly.

As Graph 1 and Table 1 show, chronobiology is a science whose time does indeed now seem to be coming if not already arrived. A science which has grown exponentially in recent decades with a rising number of papers since the late 1950s on a wide variety of topics. A science, despite echoes still of these past divisions and debates, which now spans physiology, biochemistry, behavioural genetics, molecular biology and the neurosciences not to mention evolutionary biology, ethology, ecology, even ergonomics, with many others now working on applications in fields as diverse as agriculture, horticulture, medicine, sport, the military, even space travel (Foster and Kreitzman 2004).

### **Graph 1 and Table 1**

With respect to the figure and table above, previous research has suggested that North America has the highest number of biomedical publications per year (Rahman and Fukui 2003), with “at least twice the productivity of either Asia or Europe” (Monge- Nájera and Nielsen 2005: 1), which raises the possibilities of spatial limitations to the analysis and discussion presented here - a point we shall return to later.

How then, exactly, does all this translate into matters of health and illness? Can particular forms of chronobiological intervention or governance now be pointed to



within and beyond medicine? And does this amount to the (bio)medicalisation of these rhythms of life? It is to these matters that we now turn in the remainder of this paper.

## **Rhythmic Health: Promises and Problems**

Our starting point here concerns the growing number of links now made between these biological rhythms of life and health. Chronobiology, on these counts, faces both ways so to speak.

On the one hand, health becomes envisaged and understood through recourse to these biological rhythms of life. Health, that is to say, as a symphony of rhythms, orchestrated by these molecular ‘clocks’ of ours which ensure the correct timing and sequence of all our vital life processes. Living in tune, harmony or sync with these rhythms of life therefore becomes a critical public health matter (Lewis et al 2018), with important implications for our mental as well as our physical health, and the optimisation of anything and everything we do according to when we do it. Health, consequently, becomes both *rhythmatised* and *temporalised* in these circadian ways as vital matter for us all, whether we know it or not.

On the other hand, the problems and perils of living our lives out of synch with these bodily rhythms is also now increasingly emphasised, as the other face of chronobiology today, including links to a wide and growing range of health conditions as Table 1 shows.

It is in this context that the notion of ‘*circadian disruption*’ looms large – a term which includes both endogenous and exogenous factors and which also goes by the names of *circadian misalignment*, *circadian desynchrony* or *chronodisruption* (Vetter 2018). Many features of modern-day life and living, on this exogenous or environmental count, are now seen to be disruptive of these circadian rhythms, from work to what we eat when, and from travel across the globe to alcohol

consumption and other forms of drug taking, all of which disrupt our body clocks and adversely affect our health and well-being. This disruption may be short-term (transient) or long-term (chronic), with a variety of negative impacts either way. It is also however, as Foster (2017) stresses, ‘a feature shared by some of the most challenging diseases of our time’, including mental disorders such as depression, bipolar and schizophrenia, neurological conditions such as multiple sclerosis, stroke and Alzheimer’s, developmental disorders such as autism, and serious eye disorders too. Research now points to the critical importance of these circadian rhythms and ‘clock machinery’ in the processes and problems of ageing, with ‘the promise of interventions to extend health lifespans’ (Cornelissen and Otsuka 2017: 118). Even the symptoms of many conditions are known to vary in both appearance and intensity according to these circadian rhythms, disrupted or otherwise, from asthma to rheumatoid arthritis and from allergic rhinitis to osteoarthritis, thereby raising important questions about the optimal timing of treatments – of which more shortly.

Three critical issues in particular, for our purposes, are important to stress here on these circadian counts.

First, the translation of our problems falling asleep, staying asleep and waking up too early into so-called circadian rhythm disorders, or sleep-wake cycle disorders as they are sometimes known. Let us leave for now the merits of naming these ‘disorders’ as such and the broader questions this raises as to what normal sleep is in the first place, for whom, when and where. Suffice it to say at this juncture that these circadian disorders now come in a variety of shapes and sizes, ranging from so-called ‘delayed sleep-wake phase’, ‘advanced sleep-wake phase’, ‘irregular sleep-wake rhythm’ and ‘non-24 hour sleep-wake rhythm’ to ‘jet lag’ and even shift work too, as in ‘shift work sleep disorder’ (SWSD). Viewing adolescent sleep through a chronobiological lens likewise suggests that the problems teenagers face in getting up in the morning for school are due to an age-related shift in circadian rhythms during puberty where it is then considered ‘natural’ for teenagers to stay awake

later into the night and get up later in the morning: a case of so-called ‘adolescent circadian delay’ or ‘delayed sleep phase syndrome’ (Crowley et al, 2007) in other words.

A second critical issue here concerns the sociologically intriguing notion of ‘social jet lag’ (Roenneberg 2012), a common form of circadian disruption which produces the jet lag-like effects many of us are said to be suffering from when our body clocks are out of synch with social time. This misalignment or mistiming, it is claimed, has implications for our sleep, our physical and mental health, including our mood and cognitive functioning (Roenneberg, 2012), as well as our safety, productivity and performance within and beyond the workplace (Kelley with Griffiths 2018).

Here we arrive at a third critical issue, which concerns the findings of recent research, in collaboration with sociologists, that those with an ‘evening chronotype’ are more likely to experience ‘disadvantage for a lifetime’, starting with the problems experienced in school as a consequence of ‘mistiming’ which ‘continue into adult life’ leading to ‘increased risks to health, mood and even lower performance in their jobs.’ (Kelley with Griffiths 2018: 191).

In these ways then, to summarise, chronobiology straddles both the powers and promises, problems and perils of these circadian rhythms for our health and our well-being in contemporary society, including the elaboration of a variety of *at-risk states* and *susceptibilities* associated with *circadian disruption*. Further examples include a recently published comic book aimed at those aged 13 and above – *Enlighten your body clock: How your body tells the time* (Weinzaepflen and Spitschan 2021). We ‘ignore our circadian rhythms at our peril’, as Foster (2017) succinctly puts it. It is not simply a case of the *framing* of our circadian rhythms in these ways, however, but of the variety of circadian (and ultradian/infradian) *solutions* now forged and fashioned in response to these promises and problems in society today. It is to these matters that we next turn.

## **Rhythmic Solutions: Practices and Prospects**

A growing number of high and low tech circadian, ultradian and infradian interventions may now be pointed to within and beyond the clinic; where concerns with matters of health and well-being are now becoming ever more entangled with the aims and aspirations of optimising all we do according to when we do it. These solutions, broadly speaking, may be grouped in the following ways according to both the types of interventions in question and their domains of application.

### *(i) Biocompatible schedules? School, Work and the ChronoCity...*

School and work may prove stubborn domains to reschedule, for practical let alone other reasons. A number of examples nevertheless may be pointed to where circadian interventions are starting to gain traction and move things in a more biocompatible direction in the interest not simply of sleep, health and wellbeing, but of performance and productivity too.

In the US for example, calls for later school start times are based on a growing body of scientific evidence about the incompatibility of early middle and high school start times with adolescent circadian rhythms and sleep patterns, given the shifts they undergo during puberty (Owens et al (2010)). Many bills have also been introduced along these lines at state level since the 1990s, with California the first state to mandate such changes in 2019.

The careful scheduling of time in this context has many benefits, it is claimed, including health as well as improved performance and grades. This, in turn, economically speaking, translates later down the line in to higher life-time earnings and other economic benefits that far outweigh the costs associated with such measures (Hafner et al 2017). A particularly vocal exponent of this such measures in the UK is the sleep, circadian and memory neuroscientist Dr Paul Kelley, whose interests lie in teaching and learning innovation. Based on his own time as a

headteacher and his collaborative research on both school and university timetables, the evidence for later start times, Kelley argues, resoundingly points in the direction of improvements all round, from improvements in concentration and mood to reduced sickness absence and better exam results (Kelley with Griffiths 2018). A study is also now underway, by the Oxford Sleep and Circadian Neuroscience Institute, to evaluate the effectiveness of both a school-based education programme (Illingworth et al 2020) and a shift from a 9.00am to a 10.00am start for A-level college students (TeenSleep 2019).

Debates continue nevertheless as to the merits of any such measures, questioning whether the scientific evidence stacks up and the practicalities of doing so even if it does. A key issue here concerns debates, amongst experts themselves, as to whether these problems are best tackled through wider institutional start-time changes of these kinds or changes to behaviour at the individual level such as reductions in light exposure, particularly light of the blue-wave kind from computers, laptops and other mobile devices (Skeldon et al. 2017).

A number of circadian interventions have also been proposed in the workplace. These include, for example, the implementation of circadian principles to optimise shift work schedules, the use of bio-mathematical models (BMMs) to calculate fatigue risks of employees arising from shift patterns and to justify the scheduling of 'safe' work based on these models (Dawson et al. 2017), and the use of circadian light technologies (Arendt, 2010). Taking into account the latest scientific research on chronotypes, this also includes calls for more flexible forms of employment that enable employees to work and sleep in ways which are more in tune or synch with their body clocks and circadian rhythms. The extent to which workers requests for flexible working based on their chronotype are, or will be, legitimated by employers is however questionable to date (Gilmer 2018) and hence part and parcel of the on-going politics of any and all such interventions.

Mention should also be made here of companies specialising in chronobiological solutions to issues of fatigue management and optimal performance in the workplace. Examples here are Circadian® -- a company founded in 1983 by Dr. Martin Moore-Ede – who according to its website specialise in ‘24/7 workforce performance and safety solutions for businesses that operate around the clock’, including industries as diverse as energy, manufacturing, emergency services, aviation and other transport sectors to help companies ‘improve their competitiveness in the global 24/7 economy’ (Circadian ® 2020). Further examples include BLUE ZONES®, whose website includes articles on using the “science of ultradian rhythms to boost productivity, energy and willpower” (BLUE ZONES® 2021).

It is not just a case of the classroom or the workplace however, but of the ChronoCity project too: an urban design project headed up by the chronobiologist Dr. Thomas Kantermann in the German spa town of Bad Kissingen (ChronoCity 2020). The aim here, we are told, is to restructure the town’s civic life along chronobiological lines so that it better harmonises with its citizens’ body clocks and circadian rhythms. Measures here include things such as improved urban lighting, changing school and work times, improving overall conditions for shift workers and hospital patients, to name but a few. Bad Kissingen, on these counts, is the first ChronoCity of its kind, and a concrete example indeed of the circadian principles in action in civic life, whatever we make of them.

In these ways then, as we can see, chronobiology is now becoming entangled with the educational and occupational spheres, as well as civic life as a whole, including how best to optimise health and wellbeing, academic outcomes and workplace productivity and performance based on circadian/ultradian interventions of various kinds. All organisations indeed, it is claimed, should allow people to work and study at the hours that suit their personal biological rhythms, thereby enabling them to be more productive and healthy (Kelley with Griffiths 2018).

*(ii) Timely Medicine? Chronopharmacology, Chronotherapeutics and Beyond...*

Here we arrive at largely circadian interventions within the institution of medicine itself which present a somewhat mixed picture to date.

On the one hand, relations between chronobiology and medicine remain somewhat partial and problematic. In part this has to do with chronobiology's own past direction of travel, which as we have seen has tended to be more bio than biomedical. This in turn however, as Foster and Kreitzman (2004) note, is compounded by 'paradigm problems' within medicine itself, whereby homeostatic understandings of bodily processes prevail over those of a changeable yet predictable and rhythmic kind. Add to this that medical training in these circadian matters is still quite limited (Selfridge et al. 2015, Smolensky 1998), and one could be forgiven for thinking this is pretty much a non-starter.

On the other hand, times may well be changing given the critical importance of chronobiology and these biological rhythms of life to any and all branches of medicine. Soon, it is optimistically claimed, we will see 'chrono' attached to every form of medicine (Gamble, 2016.).

Two key issues are particularly important to note here for our purposes with these medical matters in mind.

First, on the therapeutic count, a range of so-called 'chronotherapies', of both the pharmaceutical and non-pharmaceutical kind, may now be pointed to for the treatment of medical problems. This for example, on the non-pharmaceutical count, includes interventions such as the manipulation of sleep and the use of light therapy to reset our body clocks. It also, on the pharmaceutical count, includes the use of existing sleep medicines, such as melatonin, Z-drugs and orexin receptor agonists for the treatment of circadian rhythm disorders, and as well as the use of wakefulness promoting drugs such Provigil in the US for the treatment of sleep

disorders associated with shift work. The hunt for new body clock drugs also continues, including those that potentially ‘enhance’ our circadian rhythms and protect against metabolic syndrome (He et al 2016). *Synchronicity Pharma* for example, as its website states, is ‘focused on exploiting the burgeoning understanding of the body clock and its role in treating a variety of diseases’ (Synchronicity Pharma 2020). It is not simply a case of the hunt for new drug developments here, but of the potential *repurposing* of existing drugs too with these circadian matters in mind. A recent high throughput chemical screen of existing drugs for circadian clock modulation, for example, found approximately 5% of drugs screened altered circadian period (Tamai et al. 2018). Research has also highlighted how cortisol replacement therapy fails to replicate ultradian rhythmicity of plasma cortisol and why this issue of ‘pulsatility’ may be important (Kalafatakis, et al 2018) for chronotherapeutics.

Second, on the timing count, recourse to these circadian principles also, it is argued, has implications for the timing of other drug treatments too according to our body clocks and biological rhythms, thereby providing optimal times to take medicines of any and all kinds. Chronopharmacology and other chronotherapeutic interventions, in this respect, have the potential to effect a more or less radical shift in the timings and temporalities of medicine according to these circadian principles. Conditions already treated in these ways include not just the aforementioned circadian rhythm sleep-wake disorders, but other conditions too such as major depression (both seasonal and non-seasonal), bipolar disorder as well as asthma, allergic rhinitis, arthritis, peptic ulcers, hypertension, cardiovascular disease and cancer (Smoelensky & Peppas, 2007; Zaki et al, 2019). Chemotherapy for example, as Roberts (2016) states, ‘could work twice as well if given at the right time.’

This also has potentially profound implications for the timings of clinical drug trials. And for other medical interventions too such as cardiac surgery which appears to be time-critical. A recent study for example found that the risk of



complications from heart surgery were significantly lower when operations were performed in the afternoon rather than the morning (Kelley 2017).

Whilst many challenges still remain to the uptake of chronopharmacology more widely within medicine, not least challenges and problems of a practical nature in rescheduling treatments in these ways, a number of rhythmic solutions of the chronotherapeutic and chronopharmacological kind may now be pointed to; including those with the potential to more or less radically transform the practice of medicine in future through recourse to the circadian or ultradian timing of treatments. In doing so they add important new dimensions to what Adam appositely refers to as the range of other ‘time-slowing strategies’ within medicine, health and healing today: strategies to ‘counteract’ our contemporary ‘time-diseases’, including ‘meditation, biofeedback, imagery, hypnosis and autogenic training’ (1992: 163). To the extent moreover that future research further unravels the role of circadian timing and clock genes in a variety of disorders such as cancer, then this may result in something akin to a paradigm shift in this circadian direction within medicine itself. Foster’s (2017) comments are instructive here, with circadian disruption in mind: ‘The future of circadian rhythms research’, he suggests, ‘is to understand how this disruption comes about, and, based on that knowledge, *develop new drugs and treatments that will help regulate internal time across the health spectrum.*’

(iii) *Optimising Ourselves? Chronotypes, Self-Improvement and the Extremes of Human Endeavour...*

Here we arrive at a final set of issues for our purposes to do with the improvement or optimisation of ourselves in these rhythmic ways far beyond the school, the workplace and the clinic. This is evident in the following ways.

First, the upcoming field of so-called chrono-nutrition which, as the name suggests, adds important new circadian dimensions to nutritional science, dietetics

and our wider cultural concerns with the food we eat and weight loss. Perhaps most importantly for our purposes, with the improvement and optimisation of ourselves in mind, this is now translating into a series of chronobiological recipes for action in contemporary culture and society in which what we eat when and when we eat what – or meal times, calories distribution and feeding/fasting windows of the 8:16 hour kind to be precise -- is increasingly emphasised as another vital dimension of our health, weight, well-being and longevity. Hence the appeal, in books such as Roizen and Crupain's *What to Eat When* (2019), to the 'when way' as a way of helping you, the reader, achieve your 'health goals' and allowing you to be 'your best self'. Hence too the appeal, in other books, blogs, articles, videos on these circadian matters, to weight loss through meal scheduling as a way of synchronising our eating patterns to our biological clocks. In these ways then, chronobiology is now becoming entangled in the quest to improve our health and optimise ourselves by eating in line with our circadian rhythms. Weighty circadian matters in short, based on clocking our eating, quite literally.

These circadian concerns with when to eat what in turn feed into a wider series of cultural directives today to not simply 'know' but to 'hack' these body clocks, chronotypes and biological rhythms of ours. You don't on these counts need to be a biohacker to do so, despite the evident interest (Asprey n.d.). On the contrary, invitations, instructions and indeed imperatives of this kind extend to us all, whether we take them up or not. Take Breus's 2016 best-selling book *The power of when*, for example, which not only extends and popularises these chronotypes, including the elaboration of personality traits associated with them, but encourages us to find out the best time to do everything depending on which of these chronotypes we are. Hence the 'power of when', from when to have your first cup of coffee in the morning, to when to work, exercise and even when to have sex. The *Circadian Code* likewise, continuing in this popular science meets self-help vein, invites you to 'lose weight, supercharge your energy and sleep well every night', by showing how the timings of our day are 'more crucial than we ever

thought before’ and how, if your ‘schedule is out of sync with your circadian rhythms, you can fix it.’ (Panda 2018).

Smart technologies too are now getting in on the act. From *Lumos* smart sleep masks – which include light pulse therapy to help adjust your body clock while you sleep – to apps such as *TimeShifter*, *Solar Clock: Circadian Rhythm* and *MyCircadianClock*, a variety of smart ways to track and target these body clocks and circadian rhythms may be pointed to. Not just *circadian* rhythms however, but infradian, monthly, cycles too, such as *Moody Month*, which goes beyond period tracker apps to help women ‘better understand their cycles, moods and emotions’ (Moody Month 2017).

To these examples, moving further afield, we may add some of the other more elite and extreme feats of human achievement, endurance and endeavour where chronobiology has again played and continues to play its part, from elite sport (Simpson et al, 2018) to the military (Guo et al 2020), and from polar expeditions (Arendt, 2012) to space travel (NASA 2019).

Here then, once again, we see the translation and integration of chronobiological forms of knowledge and expertise into a wide variety of potential or prospective projects to improve or optimise our bodies, our health and ourselves, from the mundane realms of everyday life and the desire to lose weight, through the competitive fields of elite sport where every second counts, to the quite literally out-of-this-world realms of space travel and the quest to go where no one else has gone before.

## **Discussion**

Where then does this leave us, particularly as far as the (bio)medicalisation of these rhythms of life is concerned?

The answer, unsurprisingly perhaps, is far from simple or straightforward: a complex if not contradictory unfolding circadian story line indeed.

On the one hand, as we have seen, relations between chronobiology and medicine remain somewhat underdeveloped to date for a variety of reasons -- from historical divisions of the bio vs medical kind which still linger today to the aforementioned 'paradigm problems' and limited medical training in rhythmic matters. If we add to this the fact the public too have yet to fully wake up to the importance of body clocks and circadian rhythms for our health and wellbeing, including '...the potential dangers of abusing one's internal clock' (Lewis et al. 2018), then it is hard to see, by any stretch of the sociological imagination, how this amounts to 'medicalisation' as such of any degree or kind.

On the other hand, like Busfield (2017) has recently argued elsewhere, medicalisation remains a useful sociological concept in exploring significant aspects of the role of medicine in society today. In our case, the concept directs attention to the formation of new circadian rhythm disorders, new medical interventions of the pharmaceutical and non-pharmaceutical kinds for regulating, restoring or resynchronising our body clocks, and potentially new forms of circadian patienthood too. It is hard indeed to think of a more relevant sociological concept than medicalisation when it comes to conditions such as SWSD: the medicalisation of a social problem surely if ever there was one. Here then we return to the governance of sleep times in these circadian ways according to prevailing models and mantras of what 'normal' sleep is, past as well as present (Ekirch 2004, Wolf Meyer 2012). At stake here indeed are two interrelated forms of medicalisation. First, the rendering of bodies which do not conform to these vital circadian normativities and prevailing sleep norms as 'disordered' or 'pathological' (e.g. delayed or advanced sleep phase disorder, irregular sleep-wake rhythm disorder). Second, the medicalisation of social problems due to the misalignment of biological and social time (e.g. jet lag, shift work sleep disorder) in these circadian ways.

It is not simply a case of these circadian rhythm sleep 'disorders' though, as we have seen, but of the potentially far wider ranging links now forged between

circadian rhythm ‘disruption’ of various kinds and a host of other *already medicalised* conditions and disorders, from type 2 diabetes and obesity to bipolar disorder and depression. All in all then, what this suggests, are *partial degrees* of medicalisation to date regarding these circadian rhythms of ours, at the *conceptual*, *institutional* and *interactional* levels (Conrad, 2007).

What then of biomedicalisation? Can this shed any further light on these circadian matters, beyond medicalisation? Again, the answer it seems is a partial or qualified yes. Much like Pickersgill’s (2019b) comments on psychological therapy, it is clear that different facets reflect back depending on how chronobiology catches analytic light. Alongside professional control over medical knowledge production, medical profession led initiatives and normalization of disordered bodies as noted above, these developments are resulting in new genetic and molecular understandings of these chronobiological matters and new technoscientific ways to manage or modify these rhythms of life within and beyond medicine (Clark et al 2010). These chronobiological developments also include an emphasis on the elaboration of new *at-risk susceptibilities* and an intensified focus on *health* and well-being, as well as productivity and performance. Further, they take us beyond simply the normalisation or renormalisation of ‘disordered’ bodies to the optimisation if not *customisation* of our bodies (Williams et al, 2013; Coveney et al, 2011), including new ways of ‘hacking’ our body clocks and circadian rhythms in the quest for optimisation. Here then, we may arguably speak of biomedicalisation of these rhythms of life beyond medicalisation. Biomedicalisation beyond medicalisation, that is to say, in the sense that recourse to both concepts remains useful for thinking these issues through (Williams et al, 2017), as older forms of medicalisation frequently coalesce with newer forms of biomedicalization in precisely the ways discussed above.

If (bio)medicalisation however can only take us so far here what other concepts may we turn to with these chronobiological matters in mind? Biopolitics we suggest, is one such concept which denotes the politics of life itself in a ‘biological

age' (Rose 2004) thereby covering both the *bio* and the *biomedical* in question here. To the extent, for example, as we have seen, that chronobiology is still more *bio* than *biomedical*, and to the extent that these rhythms of life are becoming increasingly problematized and *politicised* in these desynchronised times of ours, then we may indeed speak of a newly emerging strand of biopolitics or chronopolitics in the twenty-first century. A vital new politics of the *rhythms of life itself* that is to say, which implicates us all, in sickness and health as the very embodiment of these chronobiological matters. When time, for example, is problematised and politicised in these rhythmic ways, when new circadian forms of individual and institutional governance may be pointed to, embryonic or otherwise, and when we are now increasingly encouraged to understand and optimise ourselves in these circadian ways, then we may indeed speak of a nascent bio or chronopolitics of our body clocks and the rhythms of life itself. A chronopolitics which adds vital new circadian dimensions to existing chronopolitical agendas – of the 'time in politics', 'politics of time', 'politicised time' kinds (Becker 2019). And a chronopolitics which resonates with a wide variety of other movements today – from the slow movement to the environmental and holistic health movements – who each in their different ways are committed to a more biocompatible time order.

Two further critical matters are important to address here in closing, themselves implicit in the foregoing discussion. First, the relationship between chronobiology and capitalism which is equally complex if not contradictory. Whilst chronobiology, on the one hand, rarely if ever mentions capitalism as such, and whilst this science itself of course harbours its own divisions, it is nevertheless possible to characterise its stance here as broadly critical given the problems of the prevailing time order under capitalism. And whilst the solutions proposed here seem to have more to do with reforming capitalism than they do with its revolutionary overthrow, they are still nevertheless about the brokering of a new more biocompatible time order. On the other hand, it can hardly escape our notice

that many of these chronobiological solutions seem to be couched in neoliberal terms through appeals to productivity, performance and the optimisation of all we do in life. Better fitting shift workers to shift work on these circadian counts, or optimising the timing of all we do when based on our chronotypes, may sound and feel like progress but it also affords capitalism even more purchase on our bodies and these rhythms of life itself: part and parcel of a newly emerging phase and form of *chronobiocapitalism* perhaps, including *circadian* body projects (cf. Shilling 2016), or *body clock projects* if you prefer, in line with prevailing neoliberal mandates and motifs. Whilst it is impossible to say that our analysis is biased towards a particular global region – committees of the international society for chronobiology, for example, include members from Brazil, India, Australia, China, Turkey, USA, France, Japan, Israel and Germany - the potential for inequalities here still should not be forgotten not least under *global* capitalism where countries with cheap outsourced labour but incompatible time-orders are forced to fit. Nor should we forget, despite appeals to these ‘ancient’ body clocks and ‘natural’ rhythms of ours, that chronobiology is itself of course a technoscience which is busy colonising these rhythms of life in various ways that render them ever more amendable to reordering and regulating if not resetting in future in the interests of enterprise, efficiency and enhancement. As for developments of the ChronoCity kind, well this in part at least, as Reiss wryly observes, amounts to ‘repairing sleep with some of the tools that broke it: alarm clocks, all-seeing screens, hovering experts, mountains of data and advice, concerns about productivity and new rules and reasons to obsess.’ (2017: 174)

This in turn brings us to the second critical matter as to whether or not these developments signal more synchronised times ahead? The answer it seems is a definite maybe at this particular point in time. To the extent, for example, that chronobiology continues to make progress on these counts in future then it is indeed possible to envisage more synchronised times ahead. To the extent

furthermore that the global coronavirus pandemic we are all currently living through has enabled some at least, albeit temporarily, to reconnect if not resynchronise with these rhythms of life, then this again may work in chronobiology's favour going forward as something to build if not capitalise on in future. To the extent, however, that many obstacles and challenges remain, and to the extent that the pace and tempo of life in post-pandemic times returns to if not exceeds pre-pandemic levels in the quest to 'bounce back better', then any such gains will be short-lived with future progress achieved in a largely piecemeal fashion as before. The shift in societal attention to focus on all things viral in current times may also provide an opportunity for more sustained attention going forward into the intersections of chronobiology and medicine. For example, through expansion of research which already links circadian phase to the severity of viral infection and points to the role of circadian rhythms in our immune response (Mazzoccoli et al, 2020), including responses to Covid -19 infection (Barone et al, 2020; Curtis 2021). Moreover, it has recently been hypothesised that the efficacy of vaccination is under circadian control (Sengupta et al, 2020). If so, this could have far reaching implications for health policy and the temporal organisation of medical services, for example, on the effectiveness of 24 hour vaccination programmes for Covid -19 that have been proposed in the UK (see Williams et al 2021 for further discussion).

Either way these circadian matters are likely to become more not less visible and vital in the aftermath of the pandemic, as part and parcel of the politics of our post-pandemic futures and what they could or should look like in the decades to come.

The sociology of health and medicine then, to conclude, is clearly well placed to contribute to these more critical sociological agendas regarding chronobiology *in* society, including further research of the kind addressed in this paper on the (bio)medicalisation of these rhythms of life and the associated biopolitical or chronopolitical issues this raises. More theoretically-informed empirical work in



particular is needed here on the salience and significance of these chronobiological matters in institutional and everyday life, including the class, gender, age or intersectional nature of these developments. These matters indeed will be particularly important to consider in the aftermath of the pandemic and the politics of our post-pandemic futures. To the extent this paper provides a critical catalyst or spur for future engagements of this kind, in medical sociology and beyond, then it will indeed have served its purpose. Time will tell...

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### **Address for correspondence**

Professor Robert Meadows, Department of Sociology, University of Surrey, Guildford GU2 7XH, Surrey, UK, Tel: 00-44-(0)1483-686984, Email: [R.Meadows@surrey.ac.uk](mailto:R.Meadows@surrey.ac.uk)

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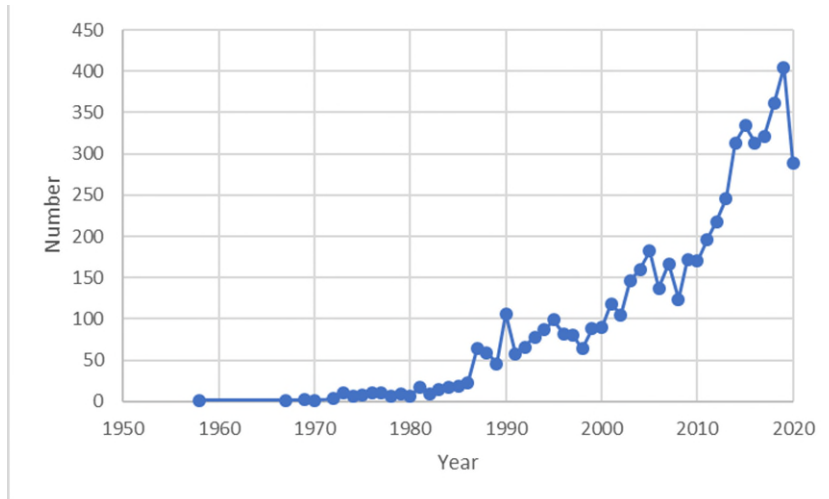


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## Figures and Tables

Figure 1: PubMed search results per year (search term: chronobiology)



\*The downward trajectory for 2020 is likely an artefact, in part at least. The search was carried out in September and therefore did not cover the full year. The COVID-19 pandemic is also likely to have had an impact on academic outputs. A filter was applied to include papers where an abstract was available. The PubMed 'Results by Year' timeline counts publication dates differently from the search function and total n across figure 1 and table 1 will therefore differ slightly.

Table 1: Summary of PubMed search (search term: chronobiology. n=4479)

Topic covered	Frequency	Topic covered	Frequency
Addiction	23	Fatigue Syndrome	21
Age and later life	79	Hair	8
Alcohol	21	Headache	26
Alzheimer	25	Light exposure	219
Analgesia	19	Melatonin	174
Arthritis	4	Menstrual - maternal-foetal	37
Asthma	19	Metabolomics/metabolic/microbiome	18
Basic/Animal (not otherwise coded)	586	Method	132
Blood pressure/hypertension	223	nocturia/noise/odour	14
Brain (general)	89	Nutrition/Obesity	170
Cancer	186	Orexin	14
Cardiology	164	Other Chono-word used	12
Chronodisruption (not otherwise coded)	45	Overview/Position/Review	208
Chronomics	28	Pain	25
Chronopharmacology	6	Parkinson	13
Circadian rhythm disorders/dysfunction used	21	Psychiatry/mood/mental wellness	302
Clock/ Genetics/Genome/Genomics	331	Reproduction	2
COVID	7	Shift (not otherwise coded)	83
Critical Care Medicine/critical illness/specific disease	97	Sleep	571
Dementia	10	Social, jet lag, environment	123
Desynchrony (not otherwise coded)	12	Space/aviation/military	26
Diabetes	15	Sport/Performance	78
Drug/Chronotherapeutics (general)	95	Stroke	11
Endocrinology/Hormone (general)	51	Teeth	1
Epilepsy/seizures	35		

\*The search was carried out in September 2020. Each paper was given a single code based on title/abstract. Where papers touched upon a range of themes a code was chosen which reflected the dominant keyword in the title (such as 'clock'). These codes were then grouped as in the table above. A further search of the google app store (search term: chronobiology) returned 254 apps; some of which are discussed further below.