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A chronobiological evaluation of the risks of cancelling Daylight Saving Time*

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The long term impact of seasonal regulation of clocks (Daylight Saving Time) is analyzed showing that it helped to mitigate the advance of the phase of human activity during the 20th century and the exposition to the hours of the dawn winter.
The increased risks induced by circadian misalignment around transition dates are balanced by a better alignment of social clocks to the natural day in summer and in winter.

Keywords: DST; summer time; latitude; sleep deprivation; spring transition; Europe; insolation; season; motor vehicle accidents

1. INTRODUCTION

Many recent studies have brought the attention to the impact of Daylight Saving Time (DST) regulations —the seasonal changes of clocks, the shift from winter time to summer time in spring, and back to winter time in autumn— on a myriad of societal issues[1; 2; 3; 4; 5]. The spring transition —when clocks are advanced and, thereafter the phase of human activity also advances— often shows the highest increased risks because circadian misalignment and sleep loss meet. These risks push for cancelling the regulation[6; 7] for the sake of "the health and safety of the citizens", even though they can be mitigated by a circadian pre-adaptation[8] to the clock change, since the transition dates are predictable.

In this Letter I bring the attention to a most challenging question. Can we evaluate the risks of abandoning the seasonal changes of clocks? The answer to this question is paramount to balance appropriately the overall risk induced by the transitions and the risks of a human activity tied to a rigid, non-seasonal time discipline.

It must be noted that the practice of seasonal clock changing sets up the natural experiment from which measurements and statistical analyses lead to the observations unveiled in the mentioned studies. On the contrary there is no natural experiment for evaluating the risks of not practicing the seasonal regulations of clocks. Instead a retrospective look into the history of clock changing can give us a hint.

2. DST PREVENTED THE PHASE OF HUMAN ACTIVITY FROM ADVANCING IN WINTER

Germany and Great Britain are separated by 15 degrees longitude or one time zone. Germany lays in the second half of UTC+01; Great Britain, on the second half of UTC+00. Except for Scotland and Bayern, both share a common latitude of 50°. At this level of latitude the sunrise time and the sunset time drift some four and a half hours from winter to summer; correspondingly the photoperiod (and the scotoperiod) changes by nine hours during one year. At 40° of latitude, where New York City locates, people experience a change of six hours in the photoperiod, which translates into three hours in the sunrise time and sunset time. Compared to these variations the human activity in modern societies synchronized by clocks is largely insensitive to the seasonal cycle[9; 10] even if the seasonal regulations of clocks, sized only one hour, are taken into account.

The role played by DST regulations in setting the phase of human activity can be understood recalling the cases of Germany and Great Britain, where the first two seasonal advance of clocks occurred in April (Germany) and May (Great Britain) 1916, amid World War One. The onset of seasonal clock changing evidences that by 1915 societies were already following a rigid time discipline with little seasonality. This may have been specifically the case of the

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urban population. With the impact of artificial light only incipient, the onset of human activity should have been dominated by the winter sunrise time, a powerful synchronizer[11; 12]. By late April, the sunrise time had advanced three hours and a half relative to the winter sunrise time. Therefore the advance of clocks by one hour —resulting in the apparent delay of sunrise, solar noon and sunset times, and the subsequent advance of the phase of human activity— was mild enough so as not to bring human activity into the hours of the dawn.

Since then the seasonal regulations of clocks drifted apart in both countries. Great Britain has never stopped using them —except for the year 1941 and 1968–1970, in both cases extending summer time year round— while Germany cancelled them at the end of World War One, only resumed the regulation during World War Two and until 1949 when the practice was abandoned for thirty years until 1980, amidst the energy crisis. Ireland, Portugal and the major cities of the United States followed a path similar to the British regulation of time, save for minor differences. The rest of European countries followed path similar to Germany albeit for some significant differences: France, Spain and the Benelux also abandoned DST regulations at the end of World War Two but in the permanent summer time mode. Italy resumed DST regulations in 1965, fifteen year earlier than Germany.

Does any fingerprint of these different regulations persist in the 21st century?

Time Use Surveys help to understand and compare human activity across different countries by inspecting daily rhythms: the fraction of population doing an activity at an hour of the day. Figure 1 shows the daily rhythm of sleep and personal care (top), and working/studying (bottom) in Germany and Great Britain. The x-axis displays the hour of the day in local time format and the shades show the winter scotoperiod (blueish) and the winter photoperiod (yellowish). The source is the Harmonized European Time Use Survey (HETUS), a collection of surveys by 15 European national statistics organizations compiled by Statistics Finland and Statistics Sweden [13]. The surveys were collected at the end of the 20th century and the beginning of the 21st century.

Figure 1 shows that daily rhythms in Germany were advanced respect to the corresponding British daily rhythm. In the figure a thin line visualizes the British daily rhythm shifted by 30 minutes (sleep and personal care) and 40 minutes (working/studying). Generally speaking German workers wake up some 30 minutes earlier than British workers, and start working some 40 to 50 minutes earlier than British workers. Thus Germans are more prone to experience activity in the hours of the winter dawn compared to Britons: the solar elevation angle in winter z_w at the onset of the labor activity is $z_w = -8°$ —nautical twilight— in Germany and $z_w = 0°$ —sunrise— in Great Britain[11, Table 2].

The rationale that links this observation to the history of DST regulations albeit speculative and elusive runs as follows. During the critical period of time 1950–1980, when the economic activity was reborn the British time zone was advanced by one hour during half of the year, or by thirty minutes on a year average. This advance was offset by an equivalent delay of the average human activity which is observed in Figure 1.

From another point of view, at that time Germany and Great Britain —and indeed the vast majority of the European continent— shared UTC + 01 time zone in summer. With Germany placed 15° degrees to the East, earlier German summer sunrises favoured an earlier onset of human activity. The increased uses of artificial light, the appetence for closing hours earlier than the winter sunset, and the appetence for a rigid, non-seasonal time discipline favoured the survival of this advance to the following winter. As a result, the human activity in Germany ended colonizing the hours of the winter dawn (see the color shades in Figure 1).

Meanwhile in Britain the spring shift eased the necessity of advancing human activity in summer as perceived in local time format. Later the autumn shift eased the necessity of delaying it in winter. That way the seasonal clock changing helped to keep the onset of human activity in line with the winter sunrise. In summary DST regulations helped to prevent the risks associated with human activity in the hours of the winter dawn, and helped to keep the link between social clocks, body clocks and the natural day.

Likewise, since World War One the major cities of the US ($\sim 40°$ latitude) shared clock regulations similar to those of Great Britain. The standard wake up time in the US for workers is nowadays 6am as revealed by the American Time Use Survey. This comes 1h20m before the winter sunrise in New York City. Americans do some personal care and start working at 7am or 8am mostly avoiding the hours of the winter dawn: the onset of the labor activity sees in winter a solar elevation angle equal to 1°[11, Tables 2 and 3]. Had clocks not been regulated seasonally 6am would have come after sunrise for half of the year. While this is perfectly fine from a chronobiological point of view, many working classes could not have afforded that. Again the seasonal regulation of clocks helped to keep the onset of human activity in line with the winter sunrise.

Unlike the risks of seasonal clock changing, faced by Britons and Americans, which are limited to a few days after the spring transition, the risks of transferring human activity towards the dawn, faced by Germans, continuously happen for weeks, if not months, from November to February.

It is not easy to assess whether the advance of German daily rhythm relative to British daily rhythm was only induced by DST regulations or some other preferences, including cultural, played a role. Either case the rationale

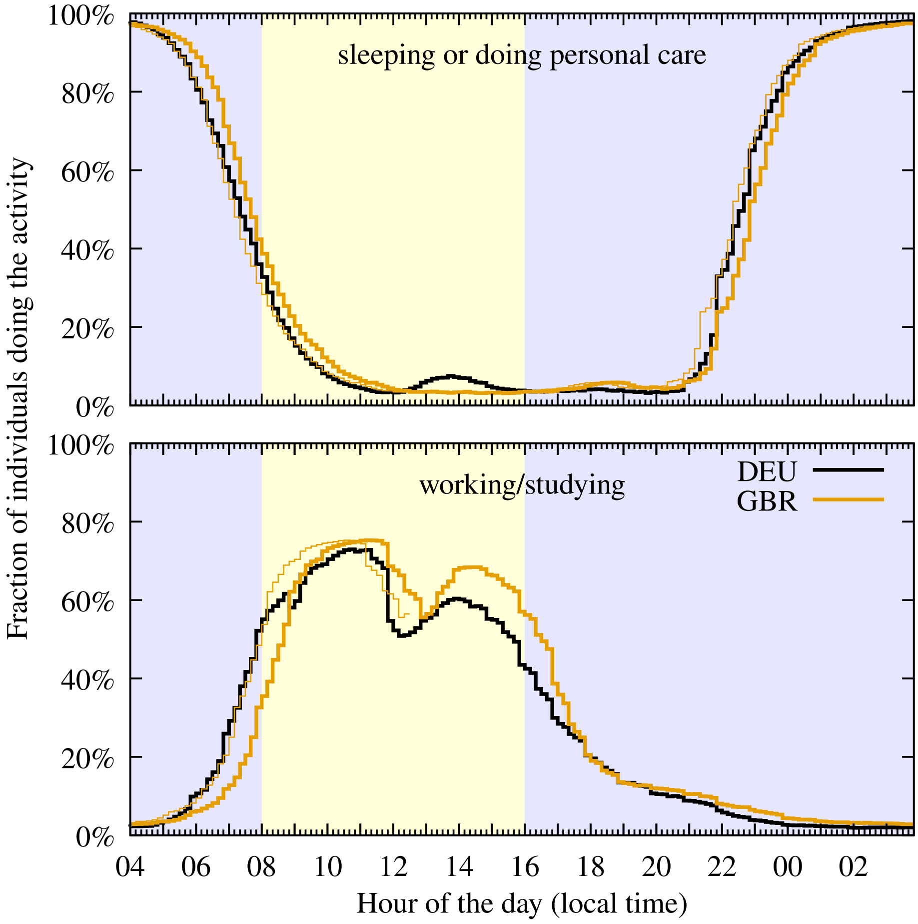

Figure 1 The sleep and personal care daily rhythm (top) and the work/study daily rhythm (bottom) in Germany (black) and Great Britain (orange) as per the Harmonized European Time Use Survey (HETUS). The rhythms were extracted from $N = 22\,597$ (Germany) and $N = 14\,810$ (Great Britain) surveys. The work/studying rhythm is computed over the fraction of individuals that reported having done the activity: 43 % (Germany) and 48 % (Great Britain). The hours of the day are expressed in local time. The thin line displaces the British daily rhythm by 30 minutes (top) and 40 (bottom) to match with the German daily rhythm at 6am (top) and before 8am (bottom). The yellowish shade signals the winter photoperiod, also the region of permanent daylight. The blueish shade signals the winter scotoperiod.

here developed could arise again if the seasonal regulations of clocks were cancelled anywhere and the winter time prevailed, as demanded frequently[6].

The call for a permanent winter time is, at the present time, equivalent to a call for delaying human activity in summer, when the sun rises the earliest. A plausible social reaction to this action could be a preference for advancing the onset of human activity as dictated by clocks, just in order to mitigate the action. This advance would be triggered by apparent earlier summer sunrise times after the winter time prevailed year round. If the advance of the onset of human activity were seasonal —for instance if a seasonal regulation of summer opening hours becomes popular— then the society would still be reproducing DST regulations and their risks, albeit by other means. The cancellation of DST regulations would have been then futile. If the advance were non-seasonal then slowly but surely human activity would drifting towards the hours of the winter dawn along with the risks associated to this.

3. CONCLUSION

Many societal and geographical issues or, generally speaking, preferences impact the decisions that accommodate the human activity to the seasonal cycle of light and dark in modern societies tied to clocks. They include the preference for practicing seasonal clock changing and the preference for translating human activity toward the winter dawn. No hard rule covers every single topic that populate these preferences.

Latitude is doubtless key property to understand the issue. Below the 47° circle of latitude the Tropical, the hazardous summer insolation and the gentle winter photoperiod push for a seasonal regulation of human activity. On the contrary, above 50° latitude the delay in winter sunrise times and the challenging shortening of the winter photoperiod pushes for transferring human activity to the winter dawn, which eases the necessity of a seasonal regulation of the activity.

The important thing to note is that no choice is exempt of the risks and hazards that seasons bring to mid-latitudes. Weighing all in, a seasonal regulation of human activity in modern, mid-latitude societies, synchronized by DST transitions, may not be a bad choice if it comes at the price of a brief, slight and preventable increase of hazards while it is able to stabilize preferences during one hundred years and to keep the onset of human activity in line with the winter sunrise.

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