The Biological Clock, Sleep, and the Debate about Daylight Saving Time

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What Is Daylight Saving Time?

At 2 AM on the first Sunday of each November (which in 2020 falls on November 1), clocks are set back 1 hour as we "fall back" to standard time (ST). ST lasts until 2 AM the second Sunday of March, when clocks are set 1 hour later as we "spring forward" to daylight saving time (DST). This twice-yearly switch to and from DST is related to seasonal changes in the time of sunrise and the number of hours of daylight, with more daylight hours in summer and fewer hours in winter. DST was first introduced in the United States more than 100 years ago to help save energy. In the summer, it is already light outside when most people wake up in the morning, so shifting to DST does not change morning sun exposure or energy usage. In the evening, though, DST has the benefit of shifting sunset time an hour later, meaning that we have an extra hour of natural daylight and can turn on lights later. However, using DST year-round would mean that in the winter, when sunrise is later, it would still be dark when most people wake up and possibly even during their commute to work. By shifting back to ST in the winter, people are less likely to wake up and start their day in darkness. The 1-hour advance of DST is similar to the seasonal change in wake-up times in societies without electricity, where wake-up time is more closely related to the time of sunrise than to sunset or the time on the clock.

What Does Biology Have to Do with Daylight Saving Time?

A part of the brain called the suprachiasmatic nuclei or "biological clock" keeps track of the time of day and keeps the organs in our bodies working together on a coordinated, 24-hour rhythm. The biological clock influences the timing of sleep and wake, so that sleep occurs mostly at night and wakefulness during the day. Proper timing of sleep and wake is important for metabolism, heart function and blood circulation, immune responses to infection, and other biological processes that are essential for good health. Proper timing of sleep and wake is also critical for the brain to perform at its best, for people to be efficient, effective, and safe.

Night and day alternate every 24 hours because the Earth rotates around its axis, which causes the sun to change its position in the sky. The sun is hidden from us between sunset and sunrise, which results in darkness – that is, night. However, because the Earth's axis is tilted, how long the sun is visible or hidden varies as the Earth orbits around the sun, which is why we have seasons. In the northern hemisphere, this effect is greater the farther north you go, making the seasons more distinct. In the northernmost part of the contiguous United States (for example, in the state of Washington), the difference between the longest and shortest nights of the year is more than seven hours. In response to these seasonal changes, the biological clock shifts its 24-hour rhythm so that when sunlight is available, we are likely to be awake.

The biological clock shifts its 24-hour rhythm based on morning and evening exposure to light. When we are exposed to light in the morning, the biological clock *advances*, making us wake up earlier the next day. When we are exposed to light in the evening, the biological clock *delays*, making us go to sleep later the next day. Minor day-to-day variations in light exposure, such as on a partially cloudy day, usually do not have much effect on the biological clock's rhythm. However, steady changes in exposure to light – especially morning light – across the seasons can shift the clock earlier in summer and later in winter. Yet, the seasonal differences in light exposure are diminished by exposure to artificial, electric light. In urban locations, where artificial light is especially common, the biological clock does not change much with the seasons.

A study conducted in Washington, D.C., found that the 24-hour rhythm of the biological clock shifted only an hour earlier in summer compared to winter, even though sunrise there is about 2.5 hours earlier in summer than in winter. The 1-hour difference in the rhythm of the biological clock matched the 1-hour difference between DST and ST, indicating that the biological clock synchronized with the twice-yearly change in clock time rather

than the seasonal changes in natural daylight. Another important finding from this study was that when study participants were allowed to sleep without an alarm clock, they woke up a little after sunrise in both summer and winter. This suggests that the biological clock itself is not the main reason why people get up in darkness during the winter months. Social factors, such as having to go to work or school, require many of us to get up early, before our biological clock tells us it is time to wake up.

What Are the Concerns with Switching between Daylight Saving Time and Standard Time?

Although DST adjusts the time of day to match better with the seasonal changes in the time of sunrise, the twice-yearly switching between ST and DST is associated with several issues related to safety and health. These issues are particularly noticeable in March, when we "spring forward" from ST to DST and we may lose an hour of sleep if we have to get up at a set time the next morning. For example, if we go to bed at 11 PM and set an alarm to wake up at 6 AM, we only get 6 hours of sleep instead of 7, because 2 AM suddenly becomes 3 AM. It may take the biological clock a couple of days to adjust to the new time, and some people may continue to lose a little sleep for a week or longer. This has negative effects on alertness, mood, well-being, work and school performance, traffic safety, and health during those days. For example, during the week following the change to DST, more people have heart attacks or suffer from stroke. There is also an increased risk of immune disorders and disorders involving the digestive system. The days right after the change to DST show an increase in cyberloafing (wasting work time on the Internet), traffic accidents, and workplace accidents. Healthcare workers report an increase in incidents related to patient safety. And records from nearly 50 years in Vienna, Austria, show a 3% increase in the daily number of people dying after the spring change to DST.

In November, when we "fall back" from DST to ST, we gain an extra hour at night that may be used for sleep. This offers some short-term advantages, such as improved mood and reduced risk of infectious and inflammatory diseases. There are also some disadvantages, such as an increase in symptoms for some people with depression. All in all, the benefits of gaining an hour of sleep in November do not appear to make up for the downsides of losing an hour of sleep in March. People also find it inconvenient to change the clock twice a year and adjust their schedules and routines. Because of these issues, there has been increasing discussion about whether to keep or abandon the twice-yearly switch to and from DST.

If Not Switching Between Daylight Saving Time and Standard Time, Then What?

If the United States should eliminate the twice-yearly change to and from DST, the question remains whether it should be replaced with year-round DST or year-round ST. Having DST all year would make winters in the United States similar to the current situation in much of western Europe, where the time zone is such that sunrise happens relatively late in the morning even in winter. By contrast, having ST all year (as is already the case in Hawaii and most of Arizona) would allow most parts of the United States to enjoy sunlight in the morning almost every day of the year. The difference would be most noticeable in winter on the western side of each time zone, where sunrise is nearly an hour later than on the eastern side. See **Figure 1**.

Exposure to sunlight in the morning matters, because for most people the biological clock has a tendency to shift a little later each day. Exposure to artificial light in the evening (from indoor lights, televisions, smartphones, etc.) increases this tendency to delay. Sunlight in the morning can help to counter these effects and keep the biological clock synchronized to the 24-hour day. Morning light may be less effective at synchronizing the biological clock after short nights of sleep, which are common in our widely sleep-deprived society. Even so, the importance of daylight exposure in the morning is used by scientists as a core argument to keep ST year-round.

What Else Should Be Considered?

There are many other considerations that should be part of the discussion about whether the United States should continue to switch between ST and DST each year or should implement either ST or DST year-round. While DST used to help save energy, some research has found that this may no longer be the case. Yet, many people tend to be in favor of adopting DST year-round because it would mean longer daylight in the evenings. This may have advantages with regard to crime and public safety, evening traffic accidents, outdoor sports and

recreation, and people spending money on activities in the evening hours. However, if DST were adopted year-round, it would mean waking up and leaving for work or school (or waiting for the school bus) in darkness during the winter in many parts of the United States. This would cause the biological clock to delay and would create "social jet lag" – having to get up earlier on work or school days than what would be natural based on the biological clock – which leads to sleep loss, reduced alertness, and health issues. Also, when Russia adopted DST year-round between 2011 and 2014, there was an increase in the number of people who suffered from seasonal affective disorder (SAD), a mood disorder that appears to be related to getting less sunlight in winter. On the other hand, if ST were adopted year-round, evening-type individuals ("night owls"), whose biological rhythms are somewhat delayed, would end up getting less exposure to daylight. Being an evening-type individual is particularly common among adolescents and young adults, so even a person's age can be relevant in the debate about DST.

Abandoning the twice-yearly change of the clock and adopting ST or DST year-round would, at first, also cost money. This includes the cost of updating hardware or software for billions of electronic systems with built-in clocks, such as computers and navigation systems, and the cost of providing information to the public about the change. Clearly, the DST debate involves considering many possible benefits and risks, and it is not obvious what the best choice is. The debate about DST has not been settled, and more research is needed to inform the discussion.

Another Point of View

A problem with almost all the evidence in favor of year-round ST or DST is that it is based on unproven assumptions. One critical assumption is that the advantages and disadvantages of ST in winter would also hold up in summer; and likewise, that the advantages and disadvantages of DST in summer would also hold up in winter. However, other differences between summer and winter must be taken into account, such as differences in weather and temperature, school enrollment, and recreational activities. Another critical assumption is that a modest delay in the biological clock is problematic, even though this is common in both modern and traditional societies. However, it can be argued that a delay of the biological clock is only problematic when people have to get up early to make it to work or school. Importantly, shifting to or from DST is just like going to work or school 1 hour earlier or later. Thus, instead of changing the way we deal with DST, we could achieve the same results (for example, not having to get up in darkness) by changing work and school start times.

The time at which most people have to report to work or school is a choice made by society, which has been driven by an unproven belief that getting up early is good for productivity, health, and well-being. Starting the day a little later can be beneficial, as has been shown by recent delays in school start times in parts of the country, as well as increased flexibility in work hours due to the COVID-19 pandemic. Therefore, while waiting for further research to inform the discussion about DST, we may also want to investigate whether changing work and school start times as one alternative would be worth pursuing. It is possible that delaying work and school start times would make the debate about DST less crucial and less complicated.

Recommended Readings

1. Roenneberg T, Winnebeck EC, Klerman EB. Daylight saving time and artificial time zones - A battle between biological and social times. Front Physiol. 2019;10:944.
2. Britannica ProCon.org: Top 3 Pros and Cons of Daylight Saving Time (https://www.procon.org/headlines/top-3-pros-and-cons-of-daylight-saving-time/).

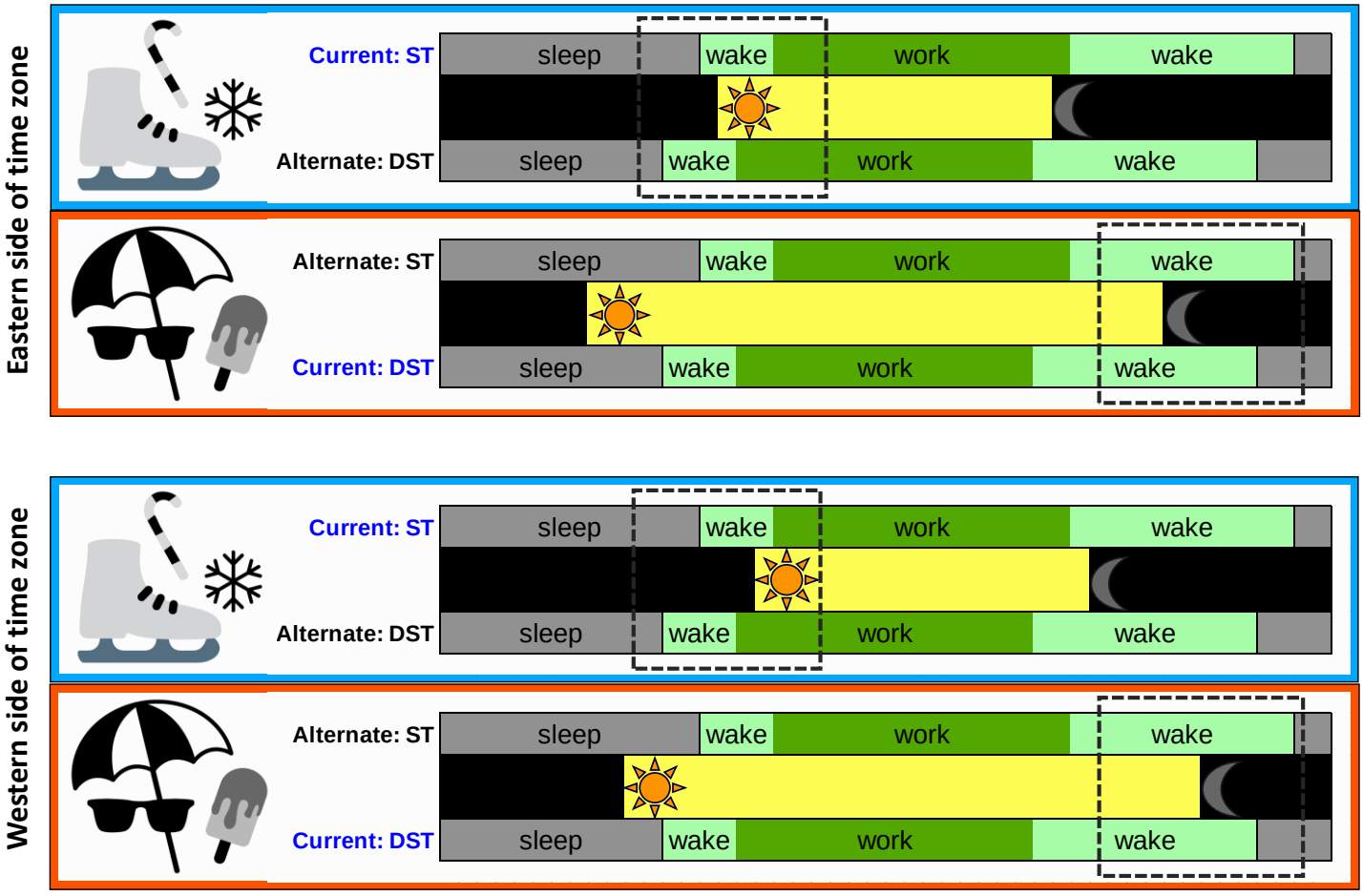

Figure 1: Illustration of the effects of ST and DST. Assuming a sleep period from 11 PM until 7 AM and a work period from 9 AM to 5 PM, the panels show the effects of ST and DST on the timing of sleep, wake, and work relative to sunrise and sunset – in winter (light blue) and summer (dark orange) – in the north of the contiguous United States. The top panels show the effects on the eastern side of a time zone, and the bottom panels show the effects on the western side. In winter, ST allows people to get some sunlight before they go to work, especially on the western side of a time zone; in summer, using ST or DST does not make a difference in that regard. In both seasons, and especially in summer, DST allows people to get more sunlight after work, which is particularly helpful on the eastern side of a time zone. The benefits of ST and DST depend on the season, where people live, their work or school schedules, and many other factors, which is why it is so difficult to resolve the DST debate.