


Longitudinal Location Influences Preference for Daylight Saving Time

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Abstract The chronobiology community advocates ending the biannual practice in many countries of adjusting their clocks to observe Daylight Saving Time (DST). Many governments are actively considering abandoning this practice. While sleep and circadian experts advocate the adoption of year-round standard time, most jurisdictions are instead considering permanent DST. In guiding advocacy, it is useful to understand the factors that lead governments and citizens to prefer the various options. In October 2021, the Canadian province of Alberta conducted a province-wide referendum on adopting year-round DST, in which more than 1 million valid votes were cast. As this referendum was tied to province-wide municipal elections, the results of the referendum were reported at the community level, allowing a geospatial analysis of preference for permanent DST. While the referendum proposal was narrowly defeated (49.8% in favor), a community-level analysis demonstrated a significant East-West gradient, with eastern communities more strongly in favor and western communities more strongly opposed to the year-round DST. Community size and latitudinal position also contributed to preference, with smaller and more northern communities showing more preference for year-round DST. These findings help identify how geospatial location can influence how citizens feel about the various time options and can further help guide public advocacy efforts by the sleep and circadian communities.

Keywords longitude, latitude, daylight saving time, standard time

Prior to the adoption of time zones and Universal Coordinated Time, societies organized their days around local solar cues. Coordinated time and time zones facilitate the interactions between communities within the same time zone as well as locations across the globe in different time zones. In 1886, Sanford

Fleming (1889) proposed a system of 24 global time zones relative to the prime meridian passing through Greenwich, England. Each time zone would be centered around meridians spaced in 15° increments relative to the prime meridian. When ideally applied, jurisdictions would optimally experience the middle

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of their solar day ± 30 min of 1200 h. While the current system is largely similar to the system originally proposed by Fleming, time zones are determined by local governments and often follow regional borders rather than the optimal location. This leads to some locations experiencing a mismatch between the solar day and their clock time. In addition, the adoption of biannual clock changes to observe Daylight Saving Time (DST) further influences how populations experience daylight relative to their social schedules. During DST clock time is advanced, delaying dawn and dusk to maximize evening light during seasons with longer days.

A large body of evidence has highlighted the deleterious effects of these biannual clock changes for health (e.g., Janszky and Ljung, 2008; Sipilä et al., 2016) and safety (e.g., Coren, 1996; Barnes and Wagner, 2009). Many jurisdictions are now contemplating abandoning this biannual clock change tradition. In many cases, governments are considering the move to permanent DST (pDST; Roenneberg et al., 2019a; Clark and Cunningham, 2020; Rishi et al., 2020). However, populations that have later sunsets, a phenomenon experienced during DST, exhibit less sleep, poorer health, and higher rates of obesity, heart disease, diabetes, and cancer (Gu et al., 2017; VoPham et al., 2018; Giuntella and Mazzonna, 2019; Cartanyà-Hueso et al., 2021). This is likely due in large part to social jetlag (Wittmann et al., 2006): the mismatch between our social schedules that dictate the start of work and school, and our biological rhythms that follow solar cues. For this reason, professional societies, such as the Society for Research on Biological Rhythms, have been advocating for the more natural option of permanent Standard Time (pStdTime; Roenneberg et al., 2019b; Rishi et al., 2020).

In 2019, the government of the province of Alberta, Canada, held an online survey from 19 November to 10 December to ask citizens whether they wanted to “Continue the practice of changing our clocks twice a year” or “Adopt year-round observance of daylight saving time.” Of the 141,000 responses, 91% favored the pDST option, although the option for pStdTime was not included (Herring, 2020). Based on these results, the provincial government initiated a referendum tied to municipal elections in Alberta on 18 October 2021, which asked, “Do you want Alberta to adopt year-round Daylight Saving Time, which is summer hours, eliminating the need to change our clocks twice a year?” The question was framed this way as provincial legislation around referendums allows only “Yes/No” answers. Again, the option for pStdTime was omitted.

A large media campaign was initiated by our group to educate the public on the consequences of the two choices, which were framed as a bad choice

(“No” to keep the clock change tradition) and an even worse choice (“Yes” to adopt pDST). This recommendation was made in large part because of how Alberta already follows time. Alberta extends between the 49th and 60th parallels. Alberta’s eastern border is at longitude 110°W. Its western border in the northern half of the province is at longitude 120°W, while the border in the southern half of the province follows the continental divide formed by the Rocky Mountains. Alberta follows Universal Coordinated Time (UTC)-7 in the late fall and winter and follows UTC-6 during DST for the balance of the year. Because UTC-7 is defined by the meridian at 105°W and would optimally extend from 97.5°W to 112.5°W, much of Alberta, including its two most populous cities (Edmonton and Calgary), lies outside the ideal location for UTC-7 (Figure 1a). As such, solar noon in Calgary, Alberta, can occur as late as 1250 h during StdTime and as late as 0145 h during DST. Effectively, the province experiences DST-like hours when observing UTC-7 in the winter and double-DST-like hours when observing UTC-6 in the summer. Adoption of the referendum proposal would have effectively moved much of Alberta to permanent Double DST. Due to most of Alberta’s population being located much further north than in other Canadian provinces (the city of Calgary is at 51°N, while the provincial capital, Edmonton, is at 53°N, Figure 1b), most Albertans experience very short days (<8 h of daylight) during the winter. Following UTC-6 in the winter would mean that major cities in Alberta would not experience sunrise until after 0930 h in December, while some western communities would not see sunrise until as late as 1020 h. In fact, during the winter on pDST, Calgary and Edmonton would be most offset of all major Canadian cities (populations >100,000, Figure 1b) from the time meridian that they follow. The public education efforts highlighted the detrimental aspects of such late sunrises for drivers, workers, and students, as this situation would create considerable social jetlag due to the social clock requiring many people to awaken much earlier than their circadian clock would be ready for (Roenneberg et al., 2019a, 2019b; Rishi et al., 2020).

Relevant to the context of what clock to follow are the time practices of Alberta’s neighboring provinces. To the east, most of the province of Saskatchewan (SK) follows UTC-6 year-round. A small portion of SK near Lloydminster, AB (53.3°N, 110°W), follows the same clock as Alberta, including the use of DST. To the west, much of the province of British Columbia (BC) follows UTC-8 in the winter and UTC-7 in the summer. The government of BC has passed legislation to adopt UTC-7 year-round, but only once do the three Pacific US states to the south (Washington,

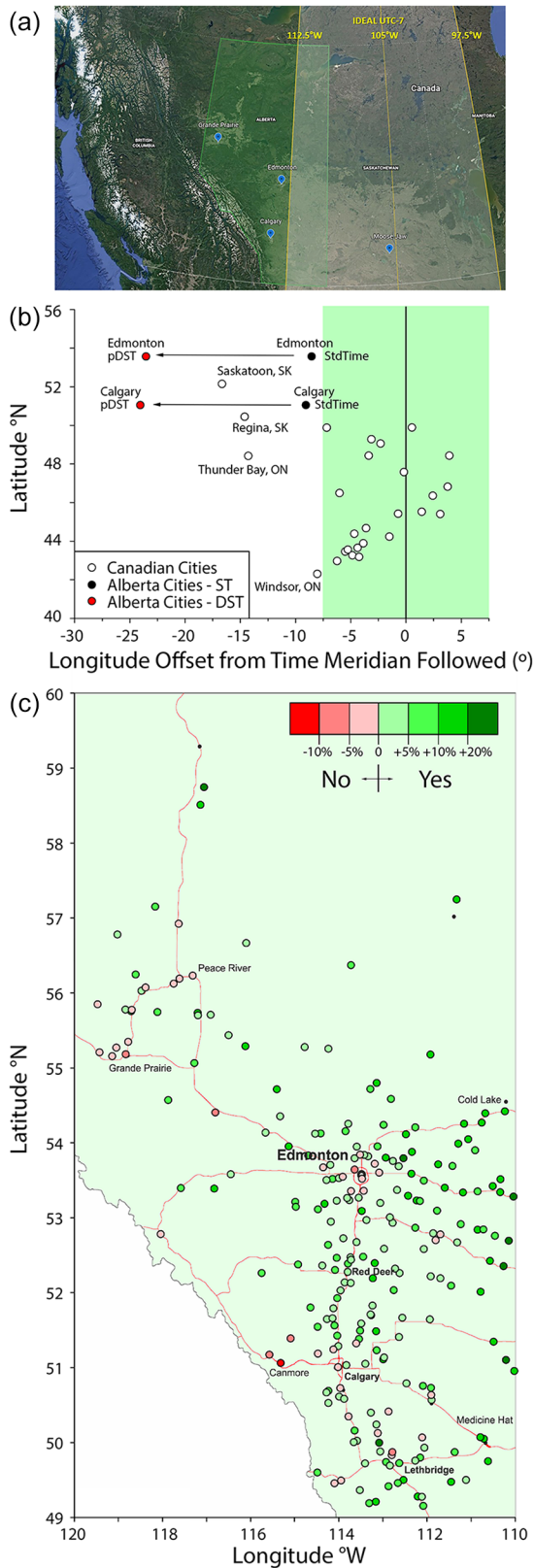


Figure 1. (continued)

Canadian cities from the time zone they follow when on Std-Time. Longitude location was subtracted from the meridian that defines the time zone followed (i.e. 52.5°W, 60°W, 75°W, 90°W, 105°W, 120°W for UTC-3.5, UTC-4, UTC-5, UTC-6, UTC-7, and UTC-8, respectively). Green shading represents offsets where solar noon occurs ± 30 min of 1200 h. Communities outside this range are named, and Alberta communities are shaded. Black-filled circles represent Alberta communities when following StdTime, while red-filled circles represent these same communities if following pDST. (c) The geographic location of the communities and their color-coded votes in the 2021 DST referendum. Green represents communities where $>50\%$ of voters were in favor of pDST, while red represents communities where $<50\%$ of voters were in favor of pDST. Abbreviations: UTC=Universal Coordinated Time; pDST=permanent Daylight Saving Time; DST=Daylight Saving Time.

Oregon, and California) do the same. Some parts of northeastern BC follow UTC-7 year-round, while some parts of southeastern BC follow the same clock as Alberta, including the use of DST.

The provincial referendum received 1,068,656 valid votes (about 38.7% of the eligible voters), with 535,874 (50.24%) votes against the referendum question. As this referendum was tied to municipal elections, results were reported by Elections Alberta at the municipality level (<https://officialresults.elections.ab.ca/orResultsReferendum2021.cfm?MODE=exProv&EventId=68&QUESTIONNO=2>). This allowed us to conduct a regression analysis based on geographic location within the province. The longitude and latitude location for communities was determined based on information from the Municipal Affairs website. Large municipal districts were assigned a geographic center at the intersection of two diagonal lines best representing the axes of the region. Results were obtained from 289 geographically definable voting districts. The percentage of votes for “Yes” (to adopt pDST) was calculated for the analysis. Communities that recorded fewer than 100 votes ($n=53$, 18.3% of voting districts) were excluded from the analysis, as a small number of votes could disproportionately influence a region’s percent votes for an option (e.g., one community with only 20 voters had 80% in favor, while another with only 18 voters have 22.2% in favor). These excluded districts accounted for 0.25% of the total vote (2755 votes, 1573 votes in favor). This left 236 voting districts for the analysis (Figure 1c). A community-based analysis was employed, rather than a voter-level analysis, as over half the votes came from the province’s two major metropolitan areas (Calgary and Edmonton). A multiple linear regression analysis was conducted to predict the percent votes in favor of pDST based on both longitude and latitude location. A significant relationship was detected ($F_{2,235} = 35.148$,

Figure 1. (a) Geographic location of the province of Alberta relative to the ideal location of the time zone it follows during StdTime (UTC-7, 105°W). (b) Offset of the 30 most populous

(continued)

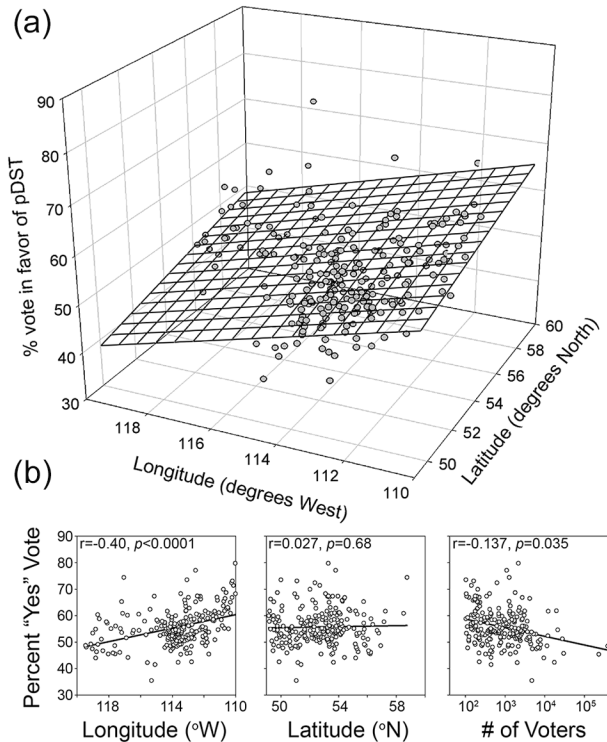


Figure 2. (a) Graph presenting the Multiple Linear Regression analysis showing the relationship between latitudinal and longitudinal position and the % vote in favor of pDST. The mesh plane represented the output of the best-fit multiple linear regression analysis. (b) Simple Pearson's correlations depicting how % vote in favor of pDST correlates with Longitudinal Position, Latitudinal Position, and Number of Votes Cast (as a metric for the population of district). Abbreviation: pDST=permanent Daylight Saving Time.

$p < 0.001$, $r^2 = 0.232$, Figure 2a), revealing that both longitude and latitude contributed significantly to the outcome of the vote when considered together ($p < 0.001$). Percentage of votes in favor of pDST was described by the regression model:

$$\% = 200.680 + (1.021 * \text{Latitude}) - (1.749 * \text{Longitude}). \quad (1)$$

Every longitudinal degree more to the west removed 1.749% of the votes in favor of pDST ($t = 8.371$, $p < 0.001$), while every degree more to the north added 1.021% to votes in favor of pDST ($t = 4.552$, $p < 0.001$). When the analysis was run including all 289 districts, the overall result was similar ($F_{2,288} = 29.703$, $p < 0.001$). In addition to the multiple linear regression analysis, which considers the combined effect of the various factors, we also explored how longitude, latitude, and community size correlated individually with the percentage of votes in favor of pDST (Figure 2b). There was a significant negative correlation between % of votes in favor of pDST and longitude location ($r = -0.40$,

$p < 0.0001$), such that communities to the east had a higher percentage of votes in favor of pDST, while those to the west had lower percentage of votes in favor of pDST. There was also a small but significant correlation with the number of votes ($r = -0.137$, $p = 0.035$) such that communities with many voters tended to have lower % votes in favor of pDST. There was no significant correlation between the percentage of votes in favor of pDST and latitude location ($r = 0.027$, $p = 0.68$). The fact that latitude was not significant on its own, but was a significant factor in the Multiple Linear Regression analysis, indicates that it is only a significant predictor when considered with Longitude.

Overall, these findings demonstrate a clear East-West gradient in preference for pDST. There was also a minor contribution of latitude to the preference for pDST. These findings mirror those from Norway (Bjorvatn et al., 2021) where communities to the north and east favored ending the biannual clock change tradition. However, due to the nature of the vote in Alberta, preference to end the time change tradition and adopt year-round StdTime was not an option, so the results are not entirely comparable. In addition, the geographic location relative to the neighboring jurisdictions of SK and BC likely contributes. In the case of Norway, while it does border on countries following an earlier time zone (Russia and Finland), this northeast region of Norway is not heavily populated. The border with Sweden and economic integration with the rest of Western Europe likely would influence decisions to coordinate time with these partners. In the case of Alberta, the province of SK to the east follows UTC-6 year-round, while the province of BC to the west mostly follows a later time zone than Alberta (i.e. UTC-8 in the winter, UTC-7 in the summer), although it has passed legislation to eventually adopt UTC-7 permanently. Eastern communities in Alberta heavily favored pDST, likely to coordinate social and economic activities with neighboring communities in SK. In particular, the community of Lloydminster straddles the border between AB and SK, and 79.8% of voters preferred pDST. Larger communities near the SK border also heavily favored pDST (Cold Lake: 66%, Medicine Hat: 61%). Conversely, communities to the west had a strong preference to avoid pDST. Communities close to the border with BC, such as Canmore and Banff, strongly opposed pDST (34% yes and 41% yes, respectively). Communities in the northwest of the province, such as Grande Prairie (42% yes), also showed a preference to avoid pDST. At 118.8°W, Grande Prairie lies longitudinally west of Los Angeles, CA (118.23°W) and is geographically quite close to the meridian that would define the ideal center of UTC-8 (120°W).

While an early online poll showed strong preference for pDST in Alberta (91%), the referendum led to the slim rejection of pDST (49.8% in favor of pDST). The referendum vote, but not the online poll, was preceded by a strong public engagement effort by our group to educate the population about the consequences of the two options on the ballot. This included engagement with television, radio, print media, and efforts through social media such as Facebook, Twitter, YouTube, and TikTok. The change in preference from the online poll to the referendum was dramatic (~40% change) and may have been due to a variety of factors, including the public education efforts. Advocacy highlighted not only professional arguments for StdTime in general (Roenneberg et al., 2019a, 2019b; Rishi et al., 2020) but also arguments based on the unique geographic considerations for Alberta.

The chronobiology community has made excellent efforts over the past 25 years to educate the public about the harms of the twice-yearly clock changes (e.g., Coren, 1996; Janszky and Ljung, 2008; Barnes and Wagner, 2009; Sipilä et al., 2016). As governments consider abandoning the clock change tradition, the efforts of the chronobiology community need to shift to advocate for which permanent time to follow. In cases where this decision is relegated to the voters of a region, it is useful to understand the baseline preference of the population to target educational efforts for maximal effectiveness.


ACKNOWLEDGMENTS

MCA is supported by a Discovery Grant from the Natural Sciences and Engineering Research Council (NSERC) of Canada.

CONFLICT OF INTEREST STATEMENT

The author(s) have no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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NOTE

Data used for analysis and advocacy materials used by our group to educate the public in advance of the 2021

referendum are available at: <https://dataverse.scholarsportal.info/dataset.xhtml?persistentId=doi:10.5683/SP3/ARQOHP>.

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