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Patterns in Aggregated Human Conflict Behaviour: Spectral analyses reveal 7- and 29-day periodicities reflecting weekly and monthly lunar cycles

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ABSTRACT
Previous works demonstrated that human creative output fluctuates in periods of 500-years, and more importantly that these periods of creative output maxima occurred simultaneous with increased solar activity. Indeed, early works by Chizhevskiy pointed to the correlation between solar-and-lunar geophysical variables and human behaviour. Interestingly, Persinger, and St. Pierre demonstrated increased aggression in rats during increased geophysical activity. Using these studies as a foundation, we explored the CDB90 Battle Dataset to find a pattern or potential periodicity in large scale human aggressive behaviour – war – specifically within the duration of battles. Using the mean duration of battles for various wars from 1600 to 1950 revealed a 7-day periodicity in military conflicts during the 20th Century, with subharmonics at 14, 22, and 29-days. The existence of the 7-day period in large-scale aggregate behaviour may suggest the reflection of biological cycles also of 7-days, whose original entrainment is likely due to solar and lunar influences. Such entrainment may be why attempts to organize human societies with cycles other than 7-days become superseded by circaseptan systems as they reflect a natural, biological pattern.

Keywords: Chizhevskiy; biorhythms; Conflict and War; circaseptan cycle; human aggregate behaviour

INTRODUCTION

Complex and dynamic terrestrial systems have all developed under constant environmental pressures. Among these pressures, those originating extra-planetarily are more consistently recognized as potentially significant sources of variance in a growing body of literature. Pioneering work in the field began with Alexander Chizhevskiy, who investigated the historical cycling of sunspots which led to the discovery of its 11-year periodicity. Soon after noticing the correlation between large sunspots and powerful aurorae and magnetic storms, it began to impress upon Chizhevskiy that cosmic pressures may influence biological behaviors [1, 2]. Heliobiology itself was not a novel concept, as ancient sources such as Hippocrates and Aristotle suspected that there was indeed a correlation between the human organism and the fluctuations of the physical and natural world, fluctuations which were in some way resultant from the Sun [2]. Indeed, within his work Chizhevskiy noted that gross measures of violent human activity (*e.g.* revolutions) occurred during sunspot maxima, while peaceful periods of human progress occurred during sunspot minima [1].

Following from his initial work, further studies have only since added evidence that large-scale human behaviour patterns are governed in some way by the Sun and other space weather variables [3-5]. Using data comprising 97 Arabian & Persian, 78 Chinese, and 54 Japanese poets living during the period of 600 to 1900 CE, it was found that the emergence of “Great Poets” within these regions followed a ~500-year periodicity [6]. Although the data did not incorporate Western contributions, they indicated that the periods of creative maxima were synchronous with well-known Golden Ages of Western Literature – the Greeks of Homer (800's BCE) and of Plato and Aristotle (300's BCE), for example. In contrast to Golden Ages, a similar 500-year periodicity was found when investigating the mean ruling duration of Egyptian Dynasties corresponding roughly to the waxing and waning of political power [7]. The authors note again that the periods of peace and strife also roughly correlate to synchronous cycles of political unrest in China. Within both papers, the authors point to a possible neuroendocrine source driving the cycles. Using updated methods and data, it is known that revolutions occur simultaneously with solar maxima and periods of peace occur within solar minima, confirming Chizhevskiy's original observations [2]. Periodicities in the emergence of gifted persons were also noted by Kaulins, hypothesized to be due to biological patterns [8, 9].

Indeed, as humans are but one of many biological organisms (*i.e.* complex systems) that have evolved under environmental and space weather variables, it should not come as a surprise that cycles emerge within large-scale human behavior in relation to these pressures; mention is also made of the individual-level observations, most prominently in changes of heart rate variability [10-12]. While conflicting arguments have been reported, the evidence does suggest a ~55-year periodicity within cultures that seems to reflect human hemispheric dominance [13]. Cultures which develop under alternating domination in social awareness of pragmatism, futurism, optimism, and subordination of the world to laws of reason; contrasted with periods of domination by interest in the past, romanticism, self-will, self-determination, and pessimism. These shifting hemispheric personalities are observed through a culture's expression of artistic style and architecture, music, letters and literature, and in some cases evidenced through economic reform and policy [13, 14]. There is objective and reliable evidence of historical and social rhythms in the patterns of human behaviour. Most concretely, and corresponding most appropriately with Chizhevskiy's original 11-year cycle, are studies indicating 12 to 60-year periods in European history by Sasse, and more recently a confirmation of the 11-year cycle in history by Putilov [9, 15]. History, it would seem, does indeed repeat itself.

When taken together and considered as reflective of human group behaviour, these studies all demonstrate fully the theories of Parish and Edelstein-Keshet. Their work indicates that aggregations of individual species function as an integrated whole, with emergent properties often unpredictable from the respective individual components [16]. When observed from a purely operational standpoint, conflicts and wars are large-scale aggregations of human aggressive behavior, and in line with Parish and Edelstein-Keshet, aggregates of humans do engage in such upscale forms of individualized aggression. Furthermore, humans have evolved immersed in the cosmological factors governing our planet, in particular geomagnetic and solar influences [17]. Such basic heliobiology is most poignant in light of St. Pierre & Persinger's work demonstrating consistent correlations in animal aggression with increases in global geomagnetic activity, a phenomenon that is enhanced if the perturbations of the geomagnetic field involved the highly labile temporal lobes of the brain [18-20].

In a similar vein, the present study sought to explore whether patterns of human aggressive behaviour, as observed through conflict and war, had functional periodicities that might reflect gross cosmological influences. Persinger demonstrated previously that up to 50 per cent of the variance regarding the number of annual wars for the-years 1904 to 1950 [17]. His work corroborates earlier Russian studies demonstrating cycles and periodicities in human culture and conflict, though it does not suggest a specific periodicity aside from the influence of the 11-year sunspot cycle. However, it does cement the observation that large-scale human behaviour responds to cosmic influence, namely perturbations in geomagnetic activity. Using data for the-years 1600 to 1975, the present study sought to expand on this body of research that evidences periodicity in human behaviour, a periodicity directed and influenced by cosmological variables. The present manuscript attempts to model human conflict and war behaviours along that of a first order approximation of satiation; that is, if one observes behaviour, the essential operation of "habituation" or "extinction" occurs. The time required to reach extinction can be modelled with $T_e = {IRT^2}/{R_t}$, where T_e is the extinction period, *IRT* is the "inter-response time" or time between responses, and R_t is the duration of the response [21]. If this model can fit with conflict and war data, then it might be further evidence of geophysical and cosmological influences on large-scale human aggregate behaviour.

MATERIALS AND METHODS

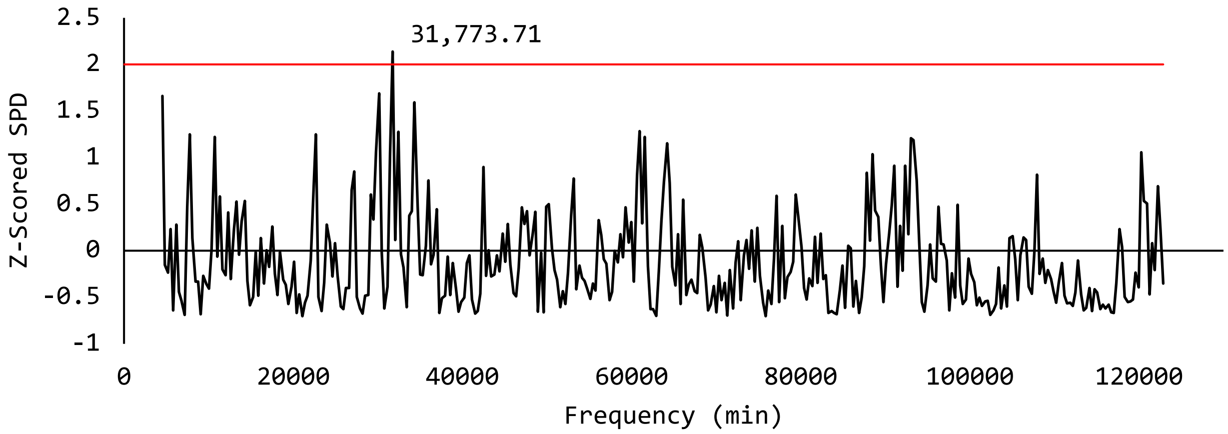
Database

The CDB90 Battle Dataset is an open-source version of the CAA Database of Battles, Version 1990. The database comprises information on military engagements over the last 400-years, a period of roughly 1600 to 1975 CE. The military engagements are exclusively land battles, and variables in the original dataset include battle names, dates, locations; the strengths of the forces before and casualties sustained during the confrontation; victor; temporal duration of the battle; as well as some environmental data such as the tactical battlefield, fortification descriptions, tactical plans, weather, *etc.* For the purposes of the present analyses, the *Start* and *End Dates*, down to the minute, for each of the N=874 battles were utilized, as well as the *Temporal Battle Duration*.

Statistical Analyses

Data were imported into SPSS v.23 for detailed statistical analyses. New variables were computed from the individual components of the *Start* and *End Dates* (day, month-year, hour, and minute all coded as separate variables), and a new *Battle Duration* variable was computed. The variable *Battle Duration* was computed to ensure the accuracy of the entries for the original dataset. Upon reviewing the two *Battle Duration* variables, the original and the newly computed, it was revealed that several entries were incorrect. In cases where a time component was missing in the original dataset a flat 1440 minutes was entered as the battle duration, leading to a total of n=48 cases which ultimately were removed from the analysis. In addition to the computed *Battle Duration* variable, an *Inter-Battle Time* variable was also computed, where IBT = ($StartDate_Y$ – $EndDate_X$). Stated alternatively, the *Inter-Battle Time* is the duration from the end of one conflict in the database to the start of the next conflict. Data were then subjected to spectral analysis within SPSS, which employs the Fast-Fourier Transform algorithm, and in all instances, no smoothing windows were applied.

RESULTS



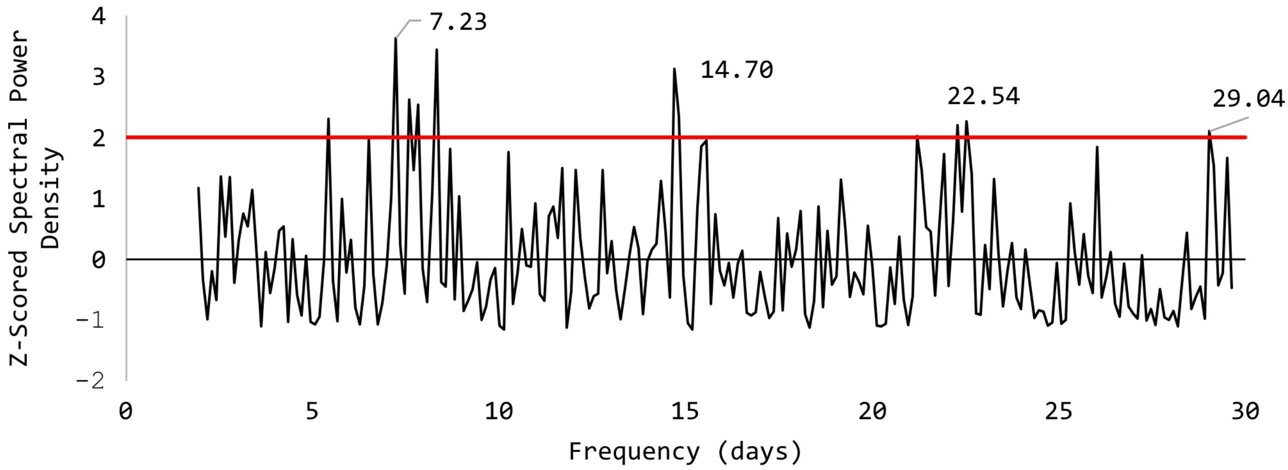
Pre-1900

Figure 1 - Standardized spectral power density output for the entire battle duration database. Significance is indicated with the red line (+2 SD).

Using the entire database, a single significant peak in the spectral analysis was revealed at 31,773 min, or roughly 22.06-days (Figure 1). Comparison of this peak to the estimated T_i and other descriptive data in Table 1 does not immediately call one's attention. However, it was assumed that the significant changes in military technologies over the four centuries of warfare demanded smaller periods of investigation. Four major conflicts of relatively equal sample sizes in the context of battles within wars (~n=20) were selected at random for subsequent spectral analysis: The Thirty-years' War (1618 to 1648); the Seven-years' War (1754 to 1763); the Napoleonic Wars (1803 to 1815); and the American Civil War (1861 to 1865). No significant spectral peaks were found for these first four large-scale conflicts.

Table 1 - Summary of relevant descriptive statistics, calculated T_i values, and significant spectral peaks (if any).

Conflict (years)	Mean B_t	Mean IBT	Calculated $T_i = {IBT^2}/{B_t}$	Significant Spectral Peaks
Whole Database (N=826)	3870.23 min 2.69 d	1520265.60 min 1055.74 d	597175747.8 min 413763.9 d	22.06 d
Thirty-years' War (1618-1648 n=17)	326 min 0.22 d	858887 min 596 d	2,262,843 min 1,571,418 d	
Seven-years' War (1754-1763 n=16)	302 min 0.21 d	615604 min 427 d	1,254,861 min 871,431 d	
Napoleonic Wars (1803-1815 n=42)	425 min 0.29 d	128113 min 88 d	38,618,684 min 26,818,530 d	
American Civil War (1861-1865 n=80)	634 min 0.44 d	33663 min 23 d	1,787,377 min 1,241 d	



20th Century

Figure 2 - Standardized spectral power density output for the period of 1900-1973. Significance is indicated with the red line (+2 SD).

Using identical methodology but isolating for the period of 1900 to 1973, spectral analysis revealed a peak periodicity of 7.23-days, with subharmonics at 1.08, 14.7, 22.5, and 29.03-days, together approximating a weekly/monthly cycle. As before with the entire database, the period of 1900 to 1973 was separated into three major conflicts of suitable sample size for finer investigation – World War I (1914 to 1918), World War II (1939 to 1945), and the Arab-Israeli War (1948). Descriptive statistics, including the calculated T_i are listed in Table 2. Strangely absent from the database is the Vietnam Conflict (1955 to 1975). Of these three conflicts, only two showed significant spectral peaks – World War II and the Arab-Israeli Conflict, listed in Table 2 and on Figures 2 and 3.

Table 2 - Summary of relevant descriptive statistics, calculated T_i values, and significant spectral peaks (if any).

Conflict (years)	Mean B_t	Mean *IBT*	Calculated $T_i = {IBT^2}/{B_t}$	Significant Spectral Peaks
The World Wars (1900-1950 n=492)	5295 min 3.67 d	85554 min 59.41 d	1,382,339 min 959.95 d	7.23, 14.7, 22.5, 29.4 d
World War I (1914-1918 n=136)	9618 min 6.67 d	54,093 min 37.5 d	304,226 min 211 d	
World War II (1939-1945 n=227	3962 min 2.75 d	37,706 min 26.18 d	358,884 min 249 d	1.26, 3.22, 4.49 d
Arab-Israeli War (1948 n=48)	741 min 12.35 h	1937 min 32.38 h	5063 min 84.3 h	7.71 h

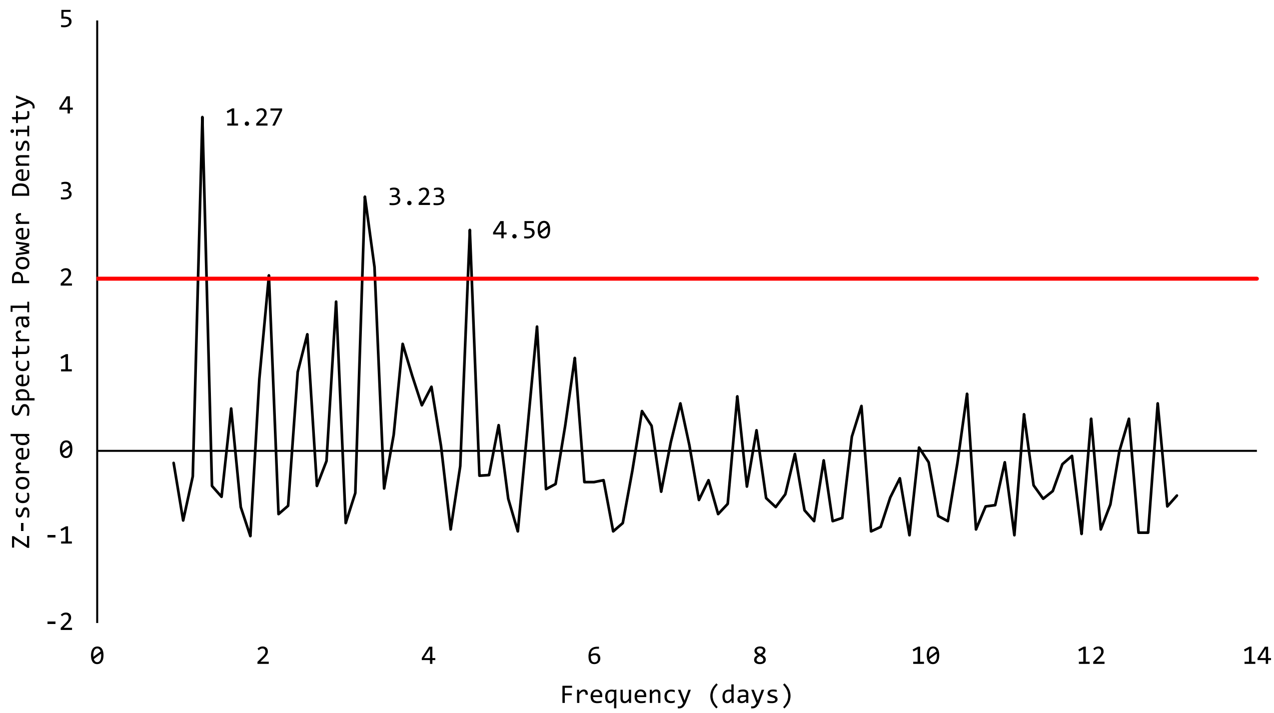


Figure 3 - Standardized spectral power density output for World War II (1939 to 1945). Significance is indicated with the red line (+2 SD).

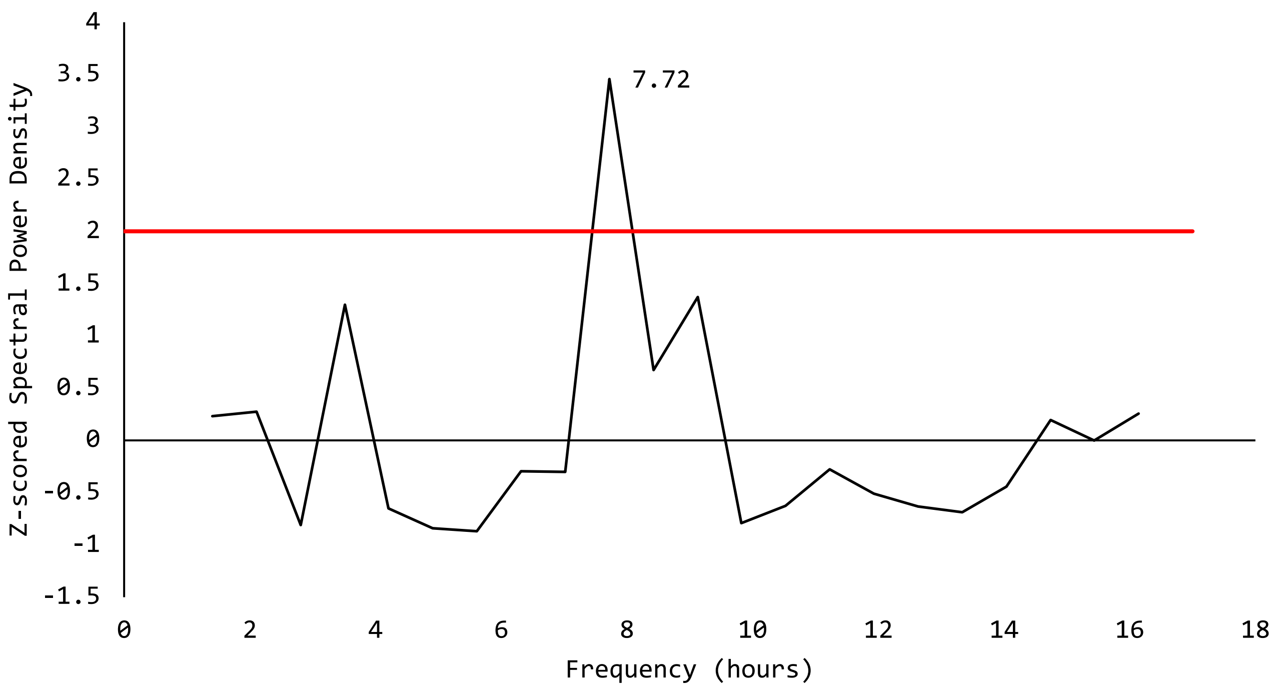


Figure 4 - Standardized spectral power density output for the Arab-Israeli War. Significance is indicated with the red line (+2 SD).

DISCUSSION

The original intent and purpose of these analyses was an attempt at demonstrating an IRT^2/R_T-type relationship, the first order approximation of satiation time, specifically within the context of large scale human conflict [21]. In the original work, Persinger hypothesized that large-scale conflict may also follow the basic operational parameters that govern all organismal behavior, for example estimating that if there was a 5-day battle every three months the war should be expected to end within 4.5-years. However, with the data available from the CDB90 database and through selecting for individual wars, this exact relationship could not be demonstrated. Predicted (R_T) satiation periods for wars were either much longer (thousands of years) or much shorter (> one year, Table 1). Failure to match the predictive model is likely due to small sample sizes in pre-1900 conflicts. For conflicts in the 1900's, all three selected wars are qualitatively different from one another in regards to military tactics utilized during their respective campaigns, with ostensibly long periods of inactivity between periods of extremely high activity. Methods employing more scrutiny, or perhaps investigations at the level of individual battles, may be more revealing in future analyses. Despite this, the data available for the American Civil War comes close to matching the predictive methodology, where the R_T-calculated was ~3.4-years compared to the actual war lasting just over 4-years.

The employment of spectral analyses on the CBD90 Database revealed several interesting and unexpected results. The most striking comes from the period 1900 to 1975, where spectral analyses revealed a significant periodicity of 7.23-days, and harmonics at 14.7, 22.54, and 29.04-days. An incredible number of human biological and behavioural rhythms operate within a 7-day periodicity – level of physical activity [22]; cellular mitosis rates [23]; physical work capacity during physical training [24] – to name a few. Reinberg and colleagues have summarized decades of human chronobiology research which point to and indicate the presence of a circaseptan (around seven-day) cycle across myriad human biological functions and behavioral patterns [25]. Considering this strong evidence suggestive of 7-day cycles, it is perhaps not surprising that a 7-day periodicity was revealed for 20th Century Warfare; the exact reasoning or mechanism for how this came to be is beyond the scope of this paper, however. Suffice it to say the enormous scale of 20th Century Conflicts and the larger sample sizes may have enabled the underlying 7-day periodicity within humans involved in the conflicts to colour various aspects of military strategy and tactics. It could all very well be due to the standardization of time which occurred over the 19th Century [26]. Although the weaker of the two effects, the presence of a 22-day periodicity in both the 1900 to 1975 subset of data and the entire database is also worthy of note.

The origin of the 7-day cycle within humans and other organisms is still a hotly debated topic. One of the most prominent examples is that the 7-day periodicity results from entrainment with the rotation of the moon, specifically the occurrence of Full Moons, whose myriad lunar effects are well known interdisciplinarily [27]. It is likely not a spurious coincidence that the fourth and final significant periodicity for the 1900's is 29.05-days, within a half-day of the rotational period of the Moon (29.53-days). The 22-day periodicity can also be related to ¾ of a Moon rotation, in line with previous research demonstrating the entrainment of various behaviours with the activity of the Moon [27, 28]. Moreover, it was also determined that a number of 7-day periodicities across organisms are the direct result of being part of the Moon-phase; that is, the 7-day periods were directly attributable to the rotation of the Moon [25, 27, 29]. Thus, the presence of the 22-day cycle may be of more relevance than might first appear, and its potential presence within chrono- and heliobiological patterns should be investigated further.

The presence of 7-day cycles within various aspects of human culture, namely religion, also cannot be overstated. The number 7 itself has also been held in high mystical regard across various cultures, beginning with Greek philosophers such as Pythagoras of Samos, where imbuing otherwise mundane phenomena with number qualities granted otherworldly energy [25]. Copious stories, traditions, sayings, and other phenomena are associated with the number

7[1]; it would be a massive oversight not to mention the Bible and the proscribed 7-day week given in Genesis (1:5), for instance. It is commonly agreed that this was a strong factor in the synchronization to a 24 hour, 7-day week amongst first the Hebrews, then the Christians, and eventually most of Western Civilization as Christianity was adopted by the Romans [25, 30]. Before this occurrence, however, several different options were selected for and given trial runs for the length of a week; the Babylonians utilized a 5-day cycle, the Romans invariably went from 8 to 10-day periods, depending on the month. Despite these alternative durations for the length of a week, the largest determiner of time for early civilizations was still primarily the passing of the Lunar phases, and calendars derived by almost all cultures reflect this prominence [25, 31]. Perhaps the most interesting historical observation is that Babylonian astronomers accurately recorded the 7-day lunar phase cycle; why it was not utilized for the period of a week is unknown.

CONCLUSION

With the Christianization of the Roman Empire under Emperor Constantine and the standardization of the Hebraic 7-day week, there was strong sociocultural reinforcement of any endogenously formed 7-day periods, whatever their ultimate origin [25]. It is perhaps salient to note that attempts to redefine the 7-day week by both Revolutionary France (10-day week) and Stalinist Russia (6-day week) were both met with failure; the former led to discontent and unrest, while the latter saw a dramatic decrease in economic and industrial output [25, 32]. Despite some evidence that the 7-day periodicity may be in part due to the effects of cosmic or geomagnetic influences, contradictory results have been published in studies that sought to isolate subjects from these particular sources of entrainment [25, 33, 34]. However, the prominence of the 7-day cycle and its intimate relation to the lunar cycle is strong enough that the notion of our 7-day week being a coincidence is highly unlikely [35]. For further reading regarding 7-day periodicities, the review by Reinberg and colleagues is a most useful resource [25]. In line with their conclusions, it is agreed that any entrainment stimuli are likely enhanced endogenously occurring 7-day cycles, rather than being triggered by ambient signals, sociocultural factors, or other ecological features. The massive scale of the conflicts in the 20th Century is one such factor that enabled the observation of this endogenous entrainment.

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