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Impact of sunspots on the incidence of autism in the human population

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Abstract

Autism spectrum disorder (ASD) is a neurodevelopmental impairment with unclear etiology in which genetic and environmental factors are involved. The purpose of the current study is to investigate the relationship between solar activity and the incidence of autism. The Sun periodically increases its irradiance, following eleven-year cycles, during which significant shifts in solar activity result in magnetic storms on its surface known as sunspots. Changes in solar activity may affect people, causing physiological disturbances. For the study, individuals with neurodevelopmental disorders registered in centers for the assistance of persons with disabilities in Bulgaria were studied over a twenty-year period, from 2003 to 2024. The statistical analyses showed a correlation between the births of children with disabilities and solar activity, where the increase in the incidence of autism immediately follows periods of a high number of sunspots. We suggest further investigation of the impact of solar radiation on the predisposition to ASD development and its specific behaviors. Our findings provide predictability of the deterioration of autistic manifestations depending on solar activity.

Keywords: Autism, Behavior, Geomagnetic storm, Solar activity, Solar cycle, Sunspots.

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1. Introduction

Autism spectrum disorder (ASD) is a neurodevelopmental impairment that starts in early childhood and is characterized by communication deficits, abnormal social interaction, restricted interests, and repetitive behavioral patterns [1]. The mechanisms underlying ASD have been the subject of intense study and debate for decades. Common atypical behaviors and

symptoms appear in all individuals with autism, but it has not been resolved how its pathogenesis is related to the formation of structural and metabolic abnormalities in the brain. Although its comprehensive etiopathogenesis is unresolved, ASD is considered to be a multifactorial disorder caused by combinations of genetic, epigenetic, and environmental factors [2]. Brain developmental processes, such as cell proliferation, migration, differentiation, synaptogenesis, and myelination, are sensitive to damage caused by various environmental factors [3].

The influence of the Sun affects the dynamics of biological systems, including humans [4]. The distance between the Earth and the Sun is 107 solar diameters, which is a prerequisite for the integrated Sun-Earth physical system, where the Earth is continuously influenced by the mass, magnetic field, and radiation energy output of the Sun [5]. The Sun periodically increases its irradiance, following eleven-year cycles in which there are significant shifts in its activity, resulting in magnetic storms on its surface known as sunspots [6]. The solar cycles are considered to be magnetic in nature and are produced by processes within the Sun acting as a dynamo [7]. The maximum of the solar cycle is characterized by many spots of intense radiation on the Sun, frequent and powerful coronal mass eruptions, and solar radio bursts, which result in strong geomagnetic storms on Earth [8]. Sunspots affect the electrical and magnetic phenomena, both in the atmosphere and in the Earth's crust. Solar radiation is a predominant and life-critical source of energy on Earth, containing a significant amount of ultraviolet (UV) rays, infrared rays, and visible light. UV radiation consists of electromagnetic energy having both bad and good effects on human health and consists of the following wavelength categories: UVA1 (340–400 nm), UVA2 (320–340 nm), UVB (311–313 nm), and UVC (100–280 nm) [3, 4].

The impact of solar activity on human health is a current subject of research in heliobiology. There have been studies on the relationship between the solar cycle and pandemics of influenza [9]. The possible effects of sunspot numbers on the appearance of world viruses, including COVID-19, have been suggested to be used for forecasting the geographical appearance of future pandemics [10]. Investigations on the potential impact of the geomagnetic field on blood pressure have been discussed in a recent review [11]. Solar activity affects the condition of healthy individuals subjected to nervous and emotional stress and ill people suffering from mental diseases and physical traumas, as the effect is most marked during the recovery phase of geomagnetic storms and is accompanied by inhibition in the central nervous system [12]. Ambient electromagnetic fields impact human mood, behavior, and mental health and increase the risk of suicide [13]. Electroencephalogram tests reveal that geomagnetic variations and solar activity have disturbing and modulating effects on the structural function of healthy brain parameters and its power spectrum [14]. According to a study involving 237,000 patients, the radiation peaks in the 11-year solar cycles, particularly the chaotic solar cycles, are associated with a higher incidence of mental disorders, including ASD [3]. Although increasing data supports the hypothesis for the correlation of solar cycles and the frequency of incidence of various categories of disease, the influence of solar activity on human health has not yet been studied enough to enable appropriate actions to be taken for effective prevention and therapy.

The purpose of the present study is to investigate and substantiate a relation between the solar cycles, sunspot formation, and the manifestation of various developmental disorders in the autism spectrum, including intention deficits, hyperactivity, and speech and communication deteriorations. We suggest that solar activity-associated physical processes, such as UV radiation, temperature, humidity, and changes in atmospheric pressure during the solar cycle periods, affect the child and its sensorial activity, cognitive processes, and behavior.

2. Materials and Methods

2.1. Research Model

A juxtaposition of the solar activity and the variety of disabilities of 1986 children and pupils in Bulgaria was performed over a period comprising the time from May 2003 to April 2021.

The heliobiological research "epoch-imposition method" was applied. This method reduces the influence of random causes on the overall result and makes it possible to analyze mass phenomena over time in relation to solar activity.

Data were analyzed with the IBM SPSS Statistics® version 25.

2.2. Participants

Altogether, 1,986 children with disabilities, of which 502 had autism spectrum disorder, were selected from the Regional Center for Inclusive Education – Sofia City. The baseline information about the participants was collected between May 2003 and April 2021. A written informed consent statement was obtained from the guardians of the children.

The study was conducted according to the guidelines of the Declaration of Helsinki and was approved by the Ethics Committee of Sofia University "St. Kliment Ohridski," Protocol No. 93-M-412/1.10.2024.

3. Results

The cohort of the 1986 children with disabilities comprised 502 people with autism, 264 with attention deficit hyperactivity disorder, 428 with intellectual disabilities, 526 with learning difficulties, 154 with speech difficulties, 35 with physical disabilities, 40 with hearing disorders, 24 with visual impairment, and 13 with multiple disabilities. The characteristics of the analyzed children are described in Table 1.

Table 1.
Distribution of disabilities in the cohort of 1986 children born in the period from May 2003 to April 2021.

Disorder	Number
Autism	502
Attention deficit hyperactivity disorder	264
Intellectual disabilities	428
Learning difficulties	526
Speech difficulties	154
Physical disabilities	35
Hearing disorders	40
Visual impairments	24
Multiple disabilities	13

An analysis was made of all the groups of disorders compared to the solar activity, in order to distinguish an interconnection.

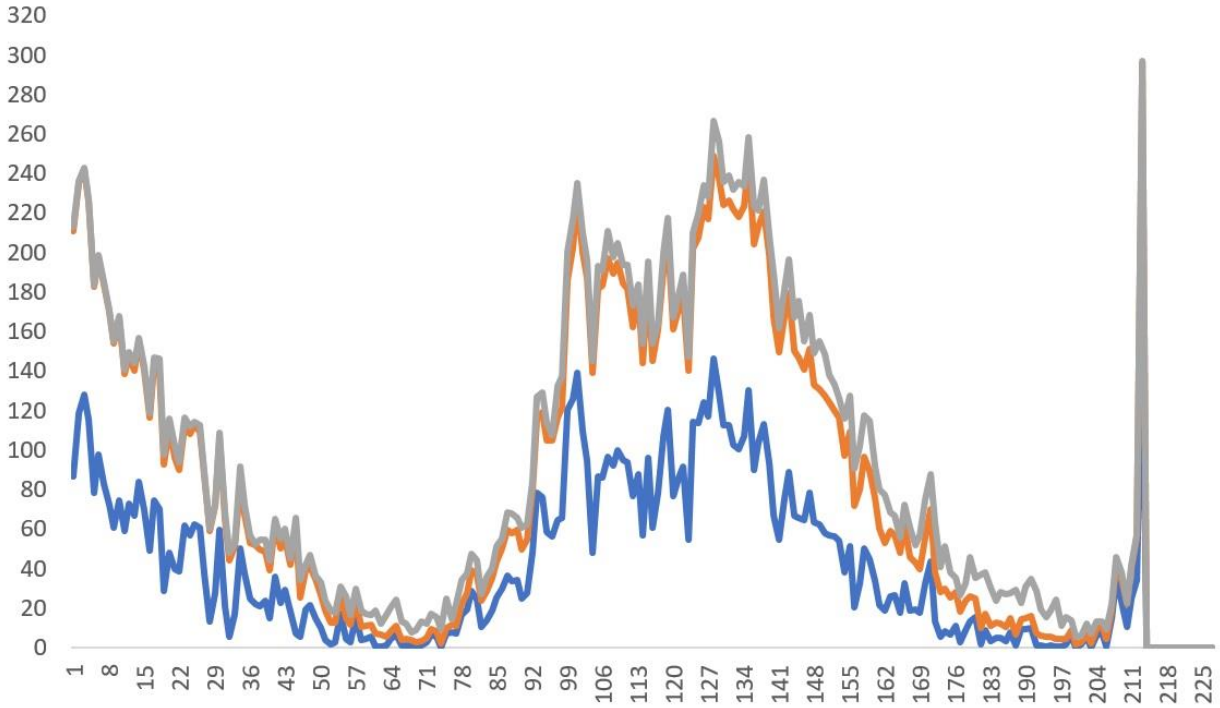

Figure 1.
Comparison between children born with disorders in Bulgaria, the number of sunspots for each month and the aggregated number of sunspots for the 9 months of the mother's pregnancy.

The number of sunspots in each month in which the child with the disorder was born is marked in blue; the number of sunspots for 9 months is aggregated, representing the period during which the mother's pregnancy took place, marked in orange; the number of children born with disabilities in Bulgaria is marked in gray.

There is a positive correlation between the studied quantities. Over the years, the number of births of children with disabilities increases and declines, closely following the line of the solar cycle with sunspot formation. The line that is combined for the nine months of pregnancy shows a closer follow-up. This may mean that the influence of solar activity is constant and of a higher value precisely during the period of embryogenesis, and not in the month of the child's birth.

After establishing a positive correlation between the number of sunspots and the number of children born with disabilities in Bulgaria, we analyzed the group of those with autism, shown in Figure 2. This group represents 502 children and is the second largest in the general group, following that of learning difficulties, which has 526 children.

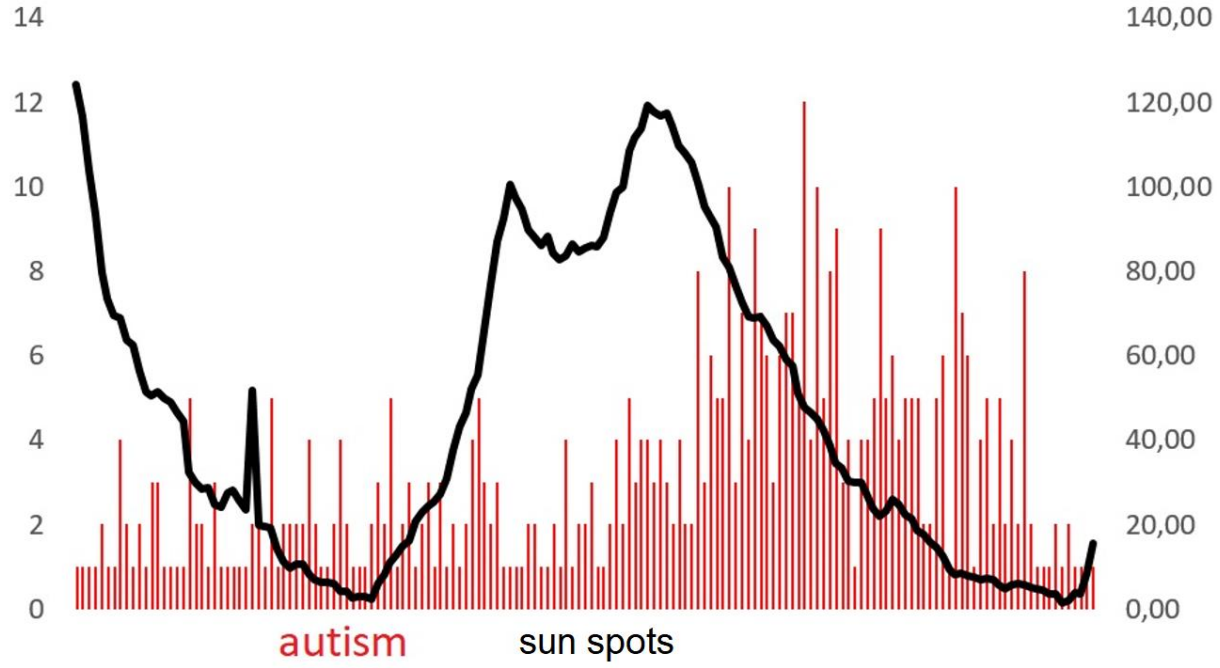

Figure 2.
Births of children with autism correlated to the number of sunspots.

Number of births of children with autism, shown on the left Y-axes, and the number of sunspots for each month over the years, shown on the right Y-axes.

It can be seen that those born with autism form a peak that does not coincide with but follows the solar peak. There is a correlation, but with a delayed effect, since the curves follow the same profile, but with a delay.

We performed an analysis of the children with autism, the number of sunspots combined by the 9-month period of pregnancy, and the months in which they were born. We compared the number of sunspots by the months in which children with autism were born in the period between May 2003 and April 2021, shown in Figure 3, and the arithmetic average by 9 months back for each child with autism (averaged over 9 months of pregnancy) is shown on figure 4. In both graphics the numbers in which there are no births of artists have been subtracted.

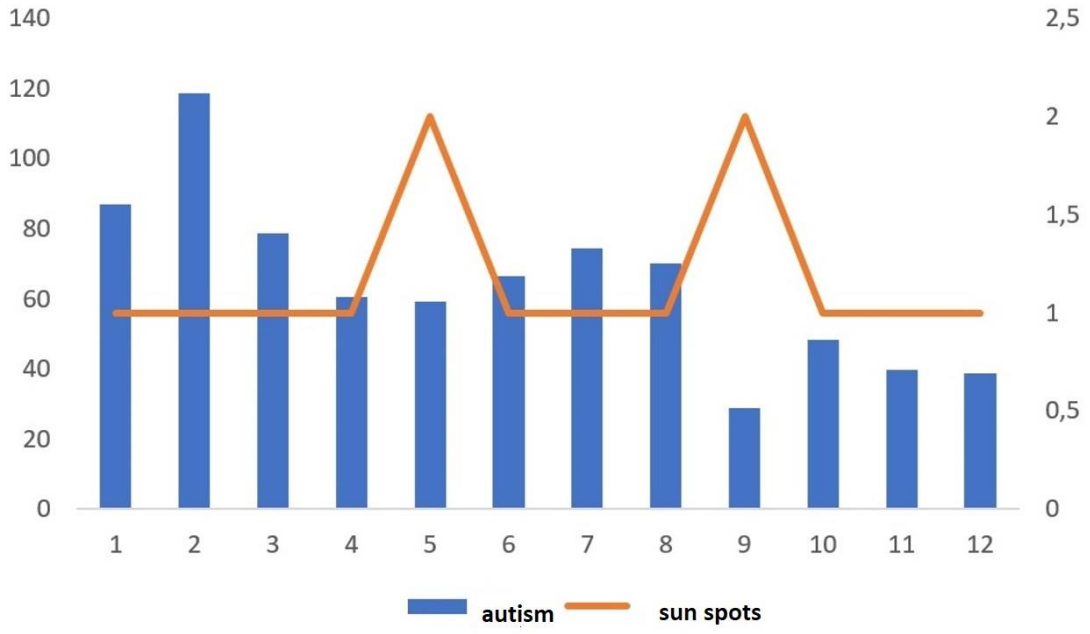

Figure 3.
Comparison of the number of sunspots by the months in which children with autism were born in the period between May 2003 and April 2021.

The axes show the number of children with autism born in a year. The ordinate shows the average count of sunspots during the year, and the values of the number of sunspots for the years in which there are no births of autistic children have been subtracted.

According to the graph, there is an inversely proportional relationship. When there is a minimum in sun spots, a maximum is observed in the number of children born with autism.

Since from Figure 1 it can be concluded that a closer follow-up of children with disabilities is generally reported for the line that is combined for the 9 months of pregnancy, then we performed an analysis only for those born with autism during this period, following the aggregation model for the numbers in the nine months, shown on Figure 4.

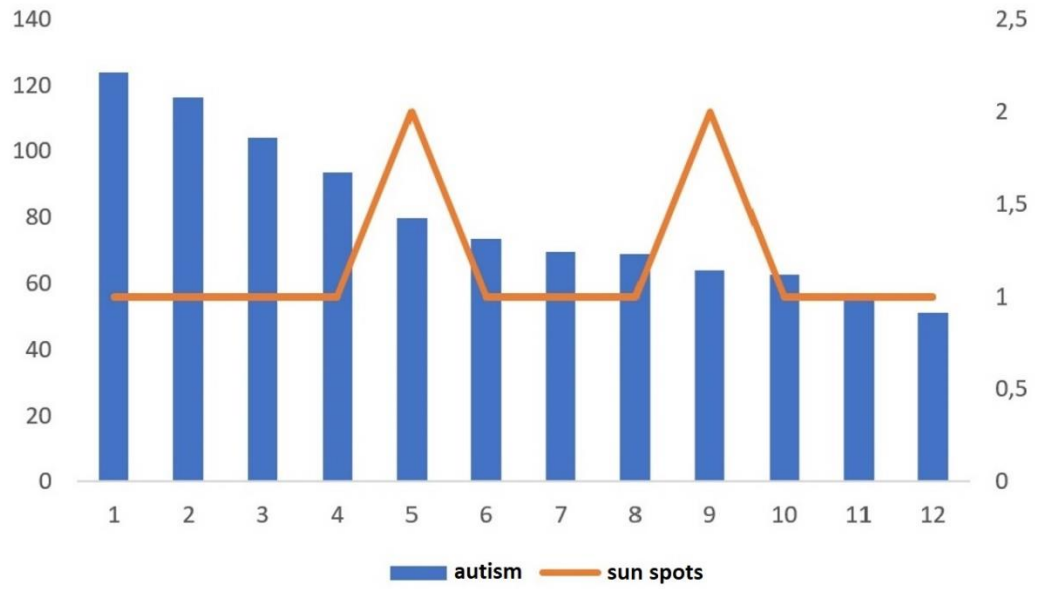

Figure 4.
Arithmetic average by 9 months back for each child with autism (Averaged over 9 months of pregnancy).

The axes show the number of children with autism born in a 9-month interval. The ordinate shows the average count of sunspots during the 9-month period. The values of the number of sunspots regarding the years in which there are no births of autistic children have been subtracted.

In Figure 4, it can be seen that the pattern repeats itself quite well. We have a peak in births with autism approaching the solar minimum. This could mean that a lag period is possible that follows the solar maximum several months earlier.

Regardless of the characteristic patterns, it can be reasonably concluded that there is a correlation between sunspots, children born with disorders, and children with autism in particular.

4. Discussion

In the cohort of 1986 children born in the period from May 2003 to April 2021, we found that the number of births of children with disabilities correlates with the data about sunspot formation. The data aggregated over the 9 months of pregnancy showed closer follow-up, which is due to the constant influence of solar activity, not restricted to the month of the child's birth. It can be assumed that there is a significant impact on the growing individual during the entire pregnancy period, especially during the period of embryogenesis, where neurogenesis and most of the neurodevelopmental events take place. Brain developmental processes are extremely vulnerable, and cell proliferation, migration, differentiation, synaptogenesis, and myelination are sensitive to damage caused by various environmental factors [3]. It must be noted that the birth of an individual with a particular disability is the end result of the effects of increased solar activity, but it is not possible to specify by what mechanism these changes occurred in the growing organism.

According to a study involving 237,000 patients, the radiation peaks in the 11-year solar cycles, especially chaotic solar cycles, are associated with a higher incidence of mental disorders, including ASD [15]. In our experiment, the incidence of ASD increased sharply when the intensity of solar radiation was drastically reduced after the peak of solar radiation had passed. It could be speculated that the high incidence of autism following a peak of solar activity is due to mutations induced by electromagnetic solar radiation. Many susceptibility genes implicated in autism have been identified by genetic analysis [16]. Three major categories of genetic risk are implicated in autism spectrum disorder: common polygenic variations, rare inherited mutations, and *de novo* mutations [17]. Single nucleotide polymorphisms are considered to account for 40-50% of autism cases [18]. However, it should be taken into account that UVA radiation can penetrate the skin, reaching the dermis, whereas UVB radiation penetrates the skin's surface layer to reach the basal layer of the epidermis [4]. In fact, any light of a wavelength shorter than 290 nm, including the short UVB spectrum and UVC, is absorbed by the ozone layer. Therefore, we suggest that UVA, UVB, and UVC radiation are not able to induce de novo mutations in the DNA of the cells inside the gonads of the parents of children with ASD, nor in the growing embryo. This is in disagreement with the statement of G. E. Davis and W. E. Lowell, 2006, that increased solar radiation during the peaks of the solar cycles induces mutations that result

in a high frequency of diseases in the population on Earth [15]. Increasing evidence shows that infrared radiation is implicated in neuromodulation and neuron activity in both peripheral and central nervous systems, but the detailed cellular and biological processes and the underlying biophysical mechanisms are still subjects of investigation [5]. Therefore, we suggest that the impact of infrared radiation on the appearance of any changes affecting neuron function should be studied further.

We propose that more complicated biochemical and physiological events, having impact on the organisms of the parents and the growing embryo are intricated in the trigger of ASD development and manifestation during the periods of deceased sun radiation. Extensive research on the positive effects of ultraviolet radiation on the body metabolism, cardiovascular system, and behavioral functions have been performed [19, 20]. Moderate UV-light exposure affects behaviors related to the CNS, such as emotion, learning, and memory [21]. UV-activated intracellular glutamate biosynthetic metabolic pathway in neurons is intricated in neurological conditions including brain development, mood improvement, addiction, cognition, learning and memory [22]. It could be proposed that sun exposure during pregnancy results in neurotransmitters production in the growing fetus, and further investigations would contribute to the better understanding of the importance of sunlight for prevention of inherited and of not genetically based neurodevelopmental disorders. Such findings explain the mild, moderate and abrupt changes in the behavior and mood of children with developmental disorders, especially ASD, when the weather or climate changes. This could be used to predict their condition and performance, including in the classroom activities. A recent review article collects the experimental and observational evidence that solar radiation, especially its ultraviolet spectrum, has significant effects on human body homeostasis, which are defined by their wavelength and energy, nature of chromophores and of molecules produced in the skin being a barrier organ [19]. These authors conclude that local physicochemical changes induced by solar radiation can lead to activation of local neuro-immuno-endocrine sensing and regulatory mechanisms with their projection to the central or systemic levels [19]. These data support our findings that neurodevelopmental disorders frequency in human populations, especially of autism spectrum disorder, depend on the intensity of sun radiation during the phases of the solar cycles and the amount of sun spots.

The line that is combined for the 9 months of pregnancy shows closer follow-up. This may mean that the influence of solar activity is constant and of a higher value precisely in the period of embryogenesis, and not restricted to the month of the child's birth. We suggest that the delay of ASD children's births compared to the peaks of sunspots could be a result of events in the mother's organism that accumulate during periods of increased solar activity and reveal during neurogenesis and neurodevelopment in the embryos and fetuses. These events most probably affect metabolic and endocrine pathways that depend on sun radiation exposure. On the other hand, it could be assumed that decreased exposure to sun radiation during pregnancy could result in an abnormal metabolic and hormonal balance. The precise mechanisms of sun radiation interactions with the development and function of the nervous system remain to be explored.

5. Conclusion

In summary, there is a distinct correlation between solar cycles, the amount of sunspots, the quantity of solar radiation, and the birth of children with neurodevelopmental disorders such as autism. It can be assumed that there is a clearly defined trend which, when taken into account in research, can lead to a number of positive predictions, including the period of conception and opportunities to improve lifestyle and regimen for the prevention of developmental deficiencies. We suggest further investigation into the mechanisms by which solar radiation impacts specific behaviors in autism. Solar activity, which is chronologically always accurate, can also be used to explain certain seemingly illogical behaviors of children with autism. Knowledge of these processes would allow for more effective and adequate conduct of classes in the classroom with students with autism.

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