

F. Ivanovic-Zivic¹
R. de la Vega²
N. Ivanovic-Zivic²
P. Rentería¹

Affective disorders and solar activity

¹ Clínica Psiquiátrica Universitaria
Facultad de Medicina Norte
Universidad de Chile
² Círculo de Santiago
Centro de Estudios Científicos

Introduction. The present work discusses the link between solar activity and appearance of affective disorders. Solar activity is reflected by the Wolf number, which is given by the formula $R = K(10g + f)$, where g corresponds to the groups of sunspots and f is the total number of sunspots.

Methods. We examined 1212 clinical files at the Clínica Psiquiátrica Universitaria, Santiago de Chile. Patients with major depressions and manic disorders, who were admitted to the clinic for the first time and had no previous treatment were considered. We examined the correlation between annual incidence of hospitalization and average Wolf numbers for those years, included in the period 1990-2000, which corresponds to a complete solar cycle of 11 years.

Results. An important number of hospitalizations of depressive patients occurred during years of low solar activity, and there was a slight increase in the number of manic patients during years of high solar activity. Depressive disorders showed a negative correlation with solar activity, the Pearson coefficient being equal to -0.72 . Manic disorders showed a positive correlation, with coefficient equal to $+0.334$.

Conclusions. Depressive disorders have an inverse correlation with solar activity, while manic disorders have a positive correlation.

Key words:

Sun. Affective disorders. Mayor depression. Manic disorders.

Actas Esp Psiquiatr 2005;33(1):7-12

Enfermedades afectivas y actividad solar

Introducción. Este trabajo presenta las relaciones entre la actividad solar y la incidencia de desórdenes afectivos. La actividad solar está representada por el número de Wolf mediante la fórmula $R = K(10g + f)$, donde g corresponde al grupo de manchas solares y f es el número total de manchas solares.

Correspondence:

F. Ivanovic-Zivic
Callao 2979 of. 604
Las Condes. Santiago (Chile)
E-mail: ferlore@netline.cl

Métodos. Se revisaron 1.212 historias clínicas de la Clínica Psiquiátrica Universitaria de Santiago de Chile. Se consideraron sólo pacientes con depresiones mayores y manías que fueron hospitalizados en el primer episodio y sin tratamientos previos. Se examinó la correlación entre la incidencia anual de hospitalizaciones y el número de Wolf promedio para ese determinado año durante el período comprendido entre los años 1990 a 2000, ambos inclusive, lo que corresponde a un ciclo solar completo de 11 años.

Resultados. Un número importante de hospitalizaciones de depresiones mayores ocurrieron en años de baja actividad solar, mientras que las manías mostraron un aumento en años con mayor actividad solar. Los cuadros depresivos mostraron una correlación inversa con la actividad solar, con un coeficiente de rango de correlación de Pearson de $-0,72$. Las manías mostraron una correlación positiva, con un índice de $+0,334$.

Conclusiones. Los desórdenes depresivos poseen una correlación inversa con la actividad solar, mientras las manías poseen una correlación positiva.

Palabras clave:

Sol. Enfermedades afectivas. Depresión mayor. Manía.

INTRODUCTION

From ancient times, the sun has symbolized the divine and has been the object of worship in primitive tribes and civilizations such as the Egyptian, Greek, etc. ones. An attempt has also been made to relate the cosmos with the psychic life and the individual with the universe, by astrological and cosmological studies. Since centuries before, the moon has been attributed as having an influence on human beings, it regulating some biological parameters and human behaviors¹. Prior to the appearance of electric light, the impression existed that nights when there was a full moon facilitated the alterations in the sleep-awakeness rhythms, causing sleep deprivation, giving rise to the appearance of bipolar affective pictures and to epileptic episodes in subjects susceptible to these variations².

Different mental disorders have been linked with the influence of the stars on the human being. That affective disorder has been studied most. A group of these pictures, seasonal affective disorders, has been correlated with variables such as geographic latitude, acclimatizing time in migratory journeys or trips, ethnic and genetic characteristics and seasons of the year. Most of these investigations show that a percentage of the subjects with both monopolar and bipolar affective disorder are linked to seasonal rhythms³.

The estimated prevalence of seasonal affective disorders varies from 0% to 9.7%. Most of the studies state that depressions are more common in winter, that the affective disorders linked to seasonality are more frequent in northern latitude zones and that their prevalence varies according to ethnic groups³. Bipolar depressions that occur with greater amount of light record shorter hospital stays⁴.

Seasonal variations have also been attributed to other psychiatric disorders such as eating disorders, anxious disorders, premenstrual syndrome, alcoholism, obsessive-compulsive disorder and other pictures^{3,5}. It has been stated that bulimia is more frequent during winter⁶. However, these subjects frequently have comorbidity with affective disorders. In the studies performed, the affective disorders are those that are most frequently related with seasonal rhythms.

One of the hypotheses used most states that depressions are more frequent in winter due to the lower amount of light in this season of the year. This has been correlated with the scarce light that sites located in latitudes closest to the north receive, where a greater amount of depressions would be found⁷. However, in Japan, it is observed that the amount of daily sun light hours during winter is a factor of greater prediction in the appearance of seasonal affective disorder than latitude⁸. Other authors have not found links between latitude and the prevalence of seasons affective pictures, these being attributed to factors such as genetic vulnerability and sociocultural context⁹. Greater genetic vulnerability to seasonal affective disorders in twins and close relatives has been suggested¹⁰.

In this way, there is still a controversy on the role played by seasonality or the amount of sunlight received in the affective disorders called seasonal. It is mentioned that depressive subjects with a greater incidence of their symptoms in winter do not correlate with cloudiness, rain or atmospheric pressure, but do so with the amount of sunlight and duration of the day, which would support the influence of light on these depressions¹¹.

On the other hand, phototherapy is an effective treatment for seasonal affective pictures. Subjects with depression treated with phototherapy undergo a decrease in their symptoms, both in seasonal depressions and in those that do not follow this pattern¹². The response to phototherapy is superior the greater the amount of light applied¹³.

It has been mentioned that melatonin, hormone secreted by the pineal gland especially during the day, would be a concurrent factor. However, the affective disorders are not necessarily accompanied by variations in melatonin levels, although phototherapy and also other therapies that reduce melatonin levels have therapeutic effect in affective disorders¹⁴.

Another variable that may correlate with the appearance of affective diseases is the energetic activity of the sun. In 1610, Galilei observed sunspots in a telescope for the first time. The Chinese observers recognized them with naked eye observation and recorded them at least 1000 years before.

One characteristic of the sunspots is their permanent variation over time, in days, months and years. Their periodicity was verified by Heinrich Schabe in 1843. Since 1849, measurements of these spots have been made and were systematized by Wolf, who detected an increase and decrease in them in regular periods of 11 years. This was called solar cycle, which repeats constantly. The spots are closely associated to the sun energetic activity, this being greater when a greater amount of spots is observed on the sun surface.

The energy released by the sun has been linked with earth variations, although a strict relationship has not been established between solar activity with earth climate. However, during the years 1645 to 1715, it corresponded to a period of low terrestrial temperatures, which occurred parallelly to a lower number of sunspots followed by an increase in the amount of snow fallen.

The sun has numerous actions on the earth such as temperature, seasons, presence of life, etc. Other facts have been observed related with the periodicity of the solar activity represented by sunspots, such as variations in precipitations, quality of wines in certain zones, abundance of crops, electrocolloidal changes in blood, growth of bacteriological cultures. An interesting finding is the observations in the growth rings of trees that indicate their age. This is seen when a transversal cut of the trunk is made. Its rings show a greater extension of years of maximum solar activity. In these meristems, clear and dark zones alternate and reveal more or less favorable conditions in the different years. It has been observed that these rings present variations in 11 year periods. This has been attributed to the frequency of sunspots and solar activity¹⁵. These examples indicate some relationship between the solar cycles and different biological parameters whose natural rhythms have a link with the solar activity¹⁶.

Up to date, only the influence of sunlight and climate conditions on some psychopathological pictures has been considered, but the influence of the solar activity itself on the human being has not been studied. Solar activity is not only manifested by the light emitted, but also by sources of greater energetic activity such as X-rays, ultraviolet rays and other energy sources. The present study attempts to relate solar activity with the appearance of affective disorders during a complete sun cycle.

MATERIAL AND METHODS

A total of 1,212 clinical records of subjects having a diagnosis of affective picture and who were hospitalized in the Clínica Psiquiátrica Universitaria of the University of Santiago de Chile during the years 1990 and 2000 were reviewed. Diagnoses of both major depressive pictures and bipolarity were adapted to the DSM IV proposed criteria, a

procedure that is common in patients hospitalized in the Clínica Psiquiátrica Universitaria. To evaluate the relationship with the solar activity, only the incidence of first hospitalization of major depressions and manic disorders that complied with the requirements of not having previous hospitalizations and treatments were considered.

The clinical records that fulfilled these inclusion requirements corresponded to 312 subjects. Of these, 210, 67%, experienced depressive pictures (136 women, 74 men) and 102 manic disorders, 33%, (52 women, 50 men) as a diagnosis of their first hospitalization. Appearance age of the depression occurred between 17 and 72 years, with an average of 42 years. For the manias, it was between 17 and 62 years, with an average of 29 years.

The incidence of subjects with major depression and manic disorders was correlated with the solar activity measured by the Wolf number during the same year period included between the years 1990 and 2000, fulfilling a complete sun cycle for these 11 years. The Pearson correlation coefficient was calculated and a regression line drawn for those variables that were significantly associated.

The Wolf number varies daily and is given by the formula $R = K (10 g + f)$, where K is a constant that depends on the observer, g represents the number of sunspot groups and f the total spot number. For effects of the study, the average number of Wolf for the years mentioned was considered.

RESULTS

Figure 1 shows the solar activity indexes measured by Wolf number. Figure 2 shows the incidence of hospitalizations for major depressions and manias for the period ranging from the years 1990 to 2000 in the Clínica Psiquiátrica Universitaria, University of Chile.

It is observed that depressions increase their hospitalization incidence during the years in which solar activity meas-

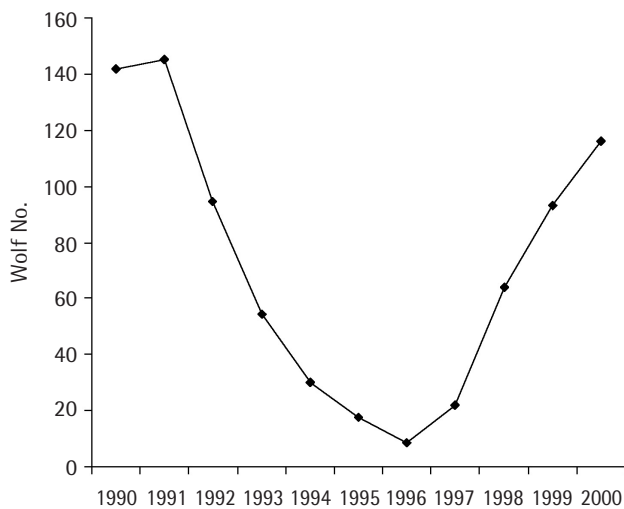


Figure 1 | Average number of Wolf for the years 1990-2000.

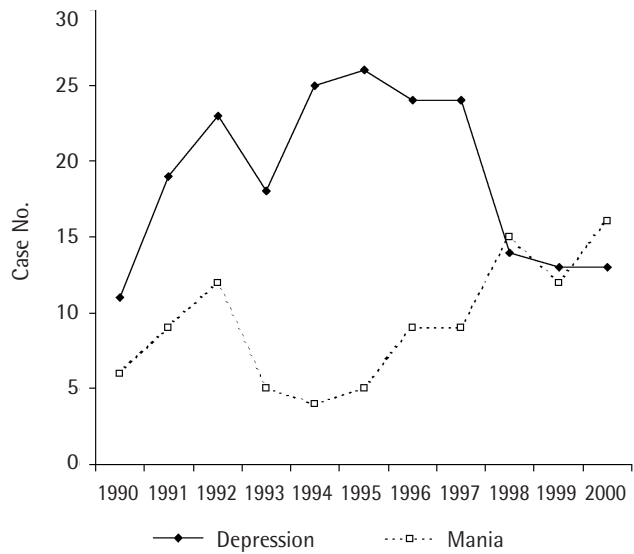


Figure 2 | Incidence of hospitalizations of major depression and mania between the years 1990-2000.

ured by Wolf number decreases, which corresponds to decreased periods of energy released by the sun. On the contrary, there is a tendency in the manias to decrease their hospitalization incidence during the years in which the solar activity decreases and to increase their frequency in the years of greater solar activity.

From the comparison between the figure 1 data (solar activity) and those of figure 2 (mania and depression incidence), the depressive pictures show a statistically significant correlation with solar activity, this being negative, with a Pearson rank correlation coefficient of -0.72 ($p = 0.012$). Figure 3 shows that the depressions decrease their frequency as solar activity measured by Wolf number increases. The manias showed a positive, but not statistically significant, correlation with solar activity, with a Pearson rank correlation coefficient of 0.334 ($p = 0.316$).

The association was calculated between the Wolf number and depressions, those which adjust to a linear model represented by the equation: $\text{No. of Depressions} = 24.89 - 0.08 \times \text{No. of Wolf}$, in which the constant is 24.89 and the slope 0.08 to explain the dependent variable (No. of depressions) by the independent variable (solar activity expressed by Wolf number).

DISCUSSION

The major depressive pictures show a different behavior from the manias. In the former, there is a clear statistically significant inverse relationship with solar activity, while the manias show a weak positive correspondence, according to the correlation indexes, which is not statistically significant with solar activity. A greater incidence of depression hospitalizations was observed in the years with less solar activity.

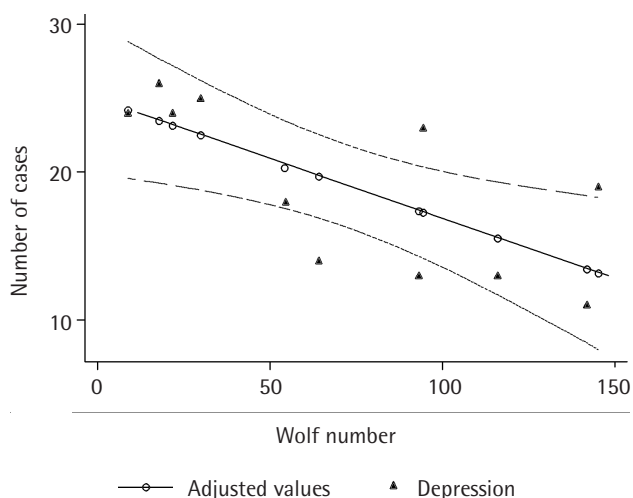


Figure 3 | Regression line: number of cases of depression according to Wolf number (discontinuous lines represent the 95% confidence interval).

The manics showed a mild tendency to be hospitalized in the years with greater solar activity.

Some considerations can be made on solar activity. The Wolf number represents an index of energy released by the sun towards the earth. Solar activity not only includes the amount of visible light that reaches the earth in a given moment but also the energy contained in the gamma rays, X rays, ultraviolet light, these latter being the main responsible aspects of solar energy, which, in the last analysis, is that which indicates the Wolf number. The visible light is a tiny fraction of the electromagnetic solar radiations field. These are transversal vibrations of sinusoidal appearance of a double electric and magnetic field. The visible spectrum of the light is limited, on the one side, by an infrared zone that has a greater wave length and by ultraviolet light, followed by the X rays and gamma rays of even smaller wave length¹⁷.

The behavior of the sunspots is not uniform, but, on the contrary, their presence and activity varies daily, by months and years, acquiring different dimensions and they can sometimes be observed with the naked sight in the solar disk.

The sunspot corresponds to a sun depression of hundreds of kilometers under the general visible surface of the sun. Its center has a temperature of 3,900 degrees Kelvin compared with 5,600 degrees Kelvin of the remaining solar surface¹⁸. The surface of the spots reaches diameters of up to 50,000 kms to 90,000 kms (seven times the earth's diameter)¹⁵. In this way, the investigations show that the temperature related to the inside of the spots represents colder areas and therefore that they irradiate less amount of light¹⁶. As the sunspots increase, a lower amount of light is observed in the form of photons from this zone, however, an increase in magnetic solar activity and energy, strictly speaking, is observed.

The sunspots, in turn, are surrounded by bright zones called faculae and separated by a region of penumbra. The faculae are branched reliefs that extend from the solar surface and are brighter than the photosphere, being made up by enormous luminous clouds that give rise to chromospheric eruptions or glows.

The total luminosity of the sun is a consequence of irradiation that arises from both the photosphere and the faculae. The shifting of the earth axis around the sun determines the luminosity received by this planet, which, in turn, is related with the temperature and early climatic changes, so that the luminosity on the earth varies according to the atmospheric conditions.

The periodic increase and decrease of the sunspots are accompanied by a consequent variation of the faculae since as the spots increase, bright zones appear in their borders, so that the decrease of the amount of light from the spots is linked with a greater amount of light from the faculae.

The faculae have a hot central zone and release energy in form of light, which can be observed at naked sight, especially in the sun borders, since the luminosity of the photosphere decreases in these zones. After an intense activity, they become smaller until disappearing, so that in an 11 year range, variations of the total area of the spots as well as of the faculae are found¹⁵.

On the other hand, there is a clear relationship between the spots measured by the Wolf number and the sun's magnetic activity. The solar magnetism is seen in relationship to the peak and decrease of the sunspots¹⁵⁻¹⁷. The intensity of the magnetic field in a sunspot increases to values between 2,000 to 4,000 oersted, that of the earth field being 0.5 oersted. In this way, variations in the number of spots also involve changes of importance in the solar magnetic activity, which is seen in the earth by means of magnetic storms and phenomena such as northern lights observed close to the poles. The maximum intensity of the magnetic field corresponds to the center of the spot, progressively decreasing towards the periphery until disappearing in the area of the shadows. A darker and cooler spot than normal and thus which emits less light presents a superior magnetic intensity. Recent investigations state that the sun nucleus varies in its activity also in 11 year period, releasing plasma to the surface, a phenomenon parallel to the magnetic activity of the sun that reaches its maximum as new spots arise on the solar surface^{18,19}.

In other words, when the number of spots increases, there is a lower proportion of visible light from these less bright zones of the solar surface, due to their lower temperature. However, both the magnetism and solar energy increase, represented by ultraviolet rays, x rays and gamma rays that have a greater energy in the measure that they represent solar emissions of smaller wave length, while the infrared rays are components of lower energy in relationship to the visible light spectrum emitted by the sun. The gamma rays, X rays and ultraviolet rays are highly energetic invisible photons of the solar spectrum. The ultraviolet light may play an important role, since this zone of the solar spectrum

contains greater invisible energy, but one increased in its intensity in the measure that there is a greater frequency of sunspots.

These assertions make it possible to establish some hypotheses regarding these results. Part of the solar energy reaches the earth in form of light, but there is also an important amount of energy from other sources, in which the light only represents a small proportion of the solar spectrum. Both phenomena arise concomitantly, also suggesting that it would be the total energy released by the sun that may be related with the lower frequency of depressions in years of less solar activity.

The present paper studied the solar activity by means of the Wolf number, that indicates the amount of spots. This also includes, but indirectly, the presence of faculae that emit luminous energy, whose appearance follows a pattern similar to the sunspots. On the other hand, phototherapy has a recognized effect on some depressions, since it increases the photoperiod, obtaining greater amount of daily light hours by this procedure²⁰⁻²². The clinical response to phototherapy includes both the subjects who experience a seasonal pattern of the symptoms as well as those who do not, verifying that its therapeutic action would be linked to the intensity of photons that impact on the retina since the human eye is capable of perceiving only a range of the solar spectrum, in this case photons emitted by a luminous source. These facts could be similar to the greater activity of the faculae that accompany the appearance of the sunspots.

However, other mechanisms could be responsible for the possible molecular changes from the energy released by the sun under the form of ultraviolet rays, gamma rays and X rays. According to the findings of the present study, in addition to the participation of the visible spectrum photons, the solar energy variable is added. Both are concomitant phenomena, which would play a role in the greater or lesser yearly incidence of depressions and manias.

CONCLUSIONS

The depressive pictures showed a different behavior from the manias. In the former, there is an inverse, statistically significant, relationship with solar activity while manias show a weak positive correspondence that is not statistically significant with solar activity. A greater incidence of hospitalizations for depressions was observed in the years with less solar activity, with a mild tendency of the maniacs to be hospitalized in the years with greater solar activity.

The studies on the solar activity indicate that the total energy irradiated by the sun, including all the electromagnetic spectrum, varying between several hundreds and thousands percent, showing a periodicity related with the number of sunspots, energy that may modify some biological parameters such as those explained in the present study.

The presence and activity of sunspots are presently subjected to constant review, especially in that regarding the

inside of this star, so that these and other hypotheses should be clarified in later studies to understand the findings found herein. These findings indicate a greater incidence of depressions in years of less solar activity, together with a greater incidence of manias in years of greater solar activity.

ACKNOWLEDGEMENTS

We thank Dr. Rosemarie Fritsch, who provided the statistical advice for the present study, for her collaboration.

REFERENCES

1. Liebre A. El influjo de la luna. Madrid: Artes Gráficas EMA, 1978; p. 39-73.
2. Raison C, Klein H, Steckler M. The moon and madness reconsidered. *J Affect Dis* 1999;53:99-106.
3. Magnusson A. An overview of epidemiological studies on seasonal affective disorder. *Acta Psychiatr Scand* 2000;101:176-84.
4. Benedetti F, Colombo C, Barbini B, Campori E, Smeraldi E. Morning sunlight reduces length of hospitalization in bipolar depression. *J Affect Dis* 2001;62:221-3.
5. Kochman f, Ducrocq F, Parquet J. Cyclic eating disorders. *Rev Pratic* 1997;47:1913-6.
6. Gruber NP, Dilsauer SC. Bulimia and anorexia nervosa in winter depression: lifetime rates in a clinical sample. *J Psychiatr Neurosci* 1996;21:9-12.
7. Potkin SG, Zetin M, Stamenkovic V, Kripke D, Bunney WJ. Seasonal affective disorder: prevalence varies with latitude and climate. *Clin Neuropharmacol* 1986;4:181-3.
8. Sakamoto K, Kamo T, Nakadaira S, Tamura A, Takahashi KA. Nationwide survey of seasonal affective disorder at 53 outpatient university clinics in Japan. *Acta Psychiatr Scand* 1993;87:258-65.
9. Mersch P, Middendorp H, Bouhuys A, Beersma D, Van den Hoofdakker R. Seasonal affective disorder and latitude: a review of the literature. *J Affect Dis* 1999;53:35-48.
10. Sher L. Genetic studies of seasonal affective disorder and seasonality. *Comprehen Psychiat* 2001;42:105-10.
11. Molin J, Mellerup E, Bolwig T, Scheike T, Dam H. The influence of climate on development of winter depression. *J Affect Dis* 1996; 37:151-5.
12. Metzger J, Berthou V, Perrin P, Sichel J. Phototherapy: clinical and therapeutic results of two years experience. *Encephale* 1998; 24:480-5.
13. Lee T, Blashko C, Janzen H, Paterson J, Chan C. Pathophysiological mechanism of seasonal affective disorder. *J Affect Dis* 1997; 46:25-38.
14. Beullens J. Melatonin and affective disorders. *Acta Neuropsychiat* 1995;7:75-9.
15. Abetti G. El sol. Buenos Aires: Eudeba, 1962; p. 67-170.
16. Rudaux L, Vaucouleurs G. *Astronomía*. Barcelona: Labor, 1962; p. 330-70.
17. Rousseau P. *La luz*. Buenos Aires: El Ateneo, 1978; p. 17-34.
18. Parker EM. *El sol*. Selecciones de Scientific American. Madrid: H. Blume Ediciones, 1977; p. 35-43.

19. Mesme-Rides E, Baliunas S, Sokoloff D. The stellar dinamo. *Scient Am* 1996;8:45-52.
20. Lewy A, Bauer V, Cutler N, Sack R, Ahmed S, Thomas K, et al. Morning vs evening light treatment of patients with winter depression. *Archiv Gen Psychiat* 1998;55: 890-6.
21. Wirz-Justice A, Graw P, Krauchi K, Sarrafzadeh A, English J, Arendt J, et al. «Natural» light treatment of seasonal affective disorder. *J Affect Dis* 1996;37:109-20.
22. Risco L, Arancibia P. Otras terapias biológicas. En: Heerlein A, editor. *Psiquiatría clínica*. Santiago: Ediciones de la Sociedad de Neurología, Psiquiatría y Neurocirugía, 2000; p. 615-24.