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CHARACTERISTICS OF CHANGES IN DURATION OF SUBJECTIVE MINUTE AT DIFFERENT SPACE-AND-TIME CONDITIONS

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Duration of subjective minute (*DSM*) is a psychophysical index and an important component of the general process of space and time perception in humans. To estimate *DSM* we used the well-known test, which was performed in the following way: test person turned on the stopwatch, evenly, calmly, without pauses counted to 121-180 and then documented the completion time.

The study of *DSM* registered in one individual during February 2001 – January 2002 (7-8 times a day, at average) at the polar station Vostok (Antarctica) demonstrated that the values vary in a wide range between 36 and 88 sec (daily average values - between 45 and 62 sec, See Fig.1). The distribution of values is normal. The variations of *DSM* during a day correspond to the day-night alternation: the highest values were registered from 3 to 7 a.m. (56-63 sec), while during the day they did not exceed 54-55 sec. Three local minimums (50-52 sec) were found - at 9 a.m., 1-3 p.m. and 7-9 p.m. Matching the daily average values of heart rate (*HR*, beat/min), respiratory rate (*RR*, respiratory cycle/min) and *DSM* showed inverted correlations between them (r = -0.43 and r = -0.52), which became more distinct after averaging *HR, RR* and *DSM* over 5 spots (Fig.2, curves 1, 2 and 3, r = -0.79 and r = -0.68, respectively). The changes in daily average *DSM* values (Fig.2, curve 3) well agree with such a seasonal factor as alternation of polar day and night. Within the period including the polar night divide, *DSM* first grows from 47 to 55 sec and then decreases to 52-53 sec. As the Sun rises over the horizon and the polar day begins, *DSM* reaches its highest point of 59 sec.

With the data being available on *HR, RR* and *DSM* registered before the individual's staying in Antarctics (Sep 1st, 2000-Jan 28th, 2001) and after it (Jan 27th-Jul 6th, 2002), it was possible to do the similar analysis for these two periods. Matching the levels of *HR, RR* and *DSM* values, at which biological rhythms of *HR* and *DSM* become synchronized in the periods preceding, during and following the wintering, showed that rearranging *HR* and *DSM* levels during the intervals is largely caused by changes in cardiovascular activity defining cardiac rhythm and in psychophysical activity defining perception of time.

In the period of wintering (compared to the preceding and following periods), cardiovascular system worked with more intensity, while psychophysical activity noticeably decreased. It is confirmed with average *HR* and *RR* values, which, during the wintering, grew up to 63.9 beat/min (compared to 55.6 and 59.2 beat/min) and 9.3 resp.cycle/min (compared to 8.2 and 8.4 resp.cycle/min), respectively, while *DSM* dropped to 53.3 sec (compared to 61 and 71.1 sec). Moreover, the parameters have similar values when the two rhythms are synchronized (Fig. 4).

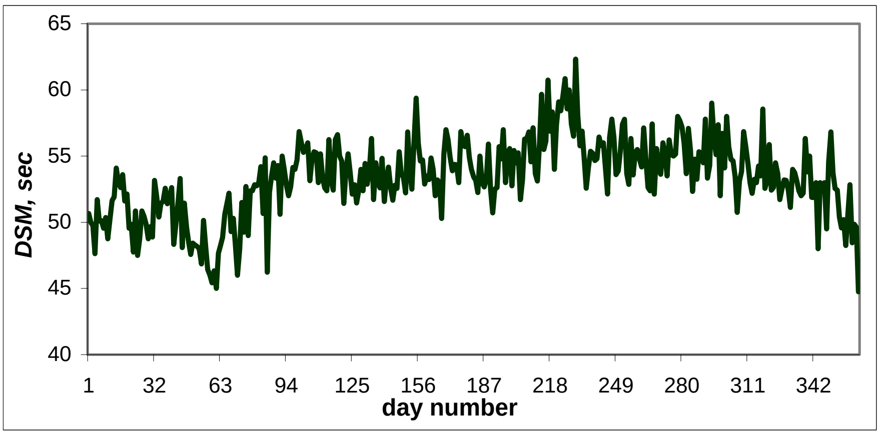

Fig. 1. Daily average fluctuations in duration of subjective minute (*DSM*) in the period of Jan 29, 2001-Jan 26, 2002 in the extreme conditions of Antarctica.

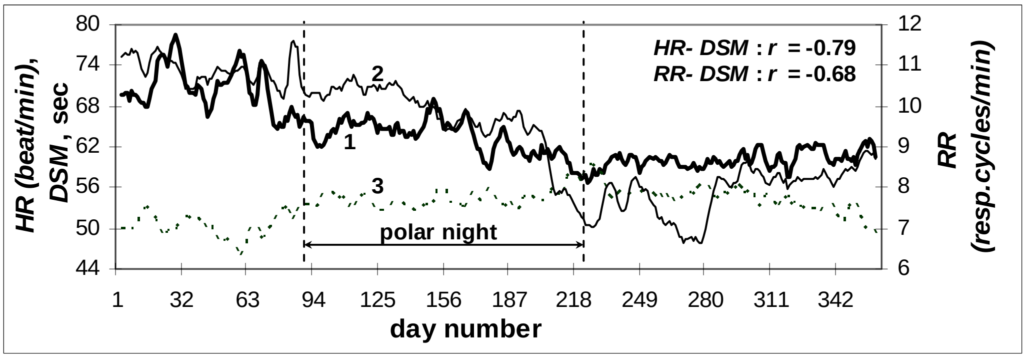

Fig. 2. Matching fluctuations in heart rate (*HR*, curve 1), respiratory rate (*RR*, curve 2) and duration of subjective minute (*DSM*, curve 3) in the period of Jan 29, 2001-Jan 26, 2002 averaged over 5 spots.

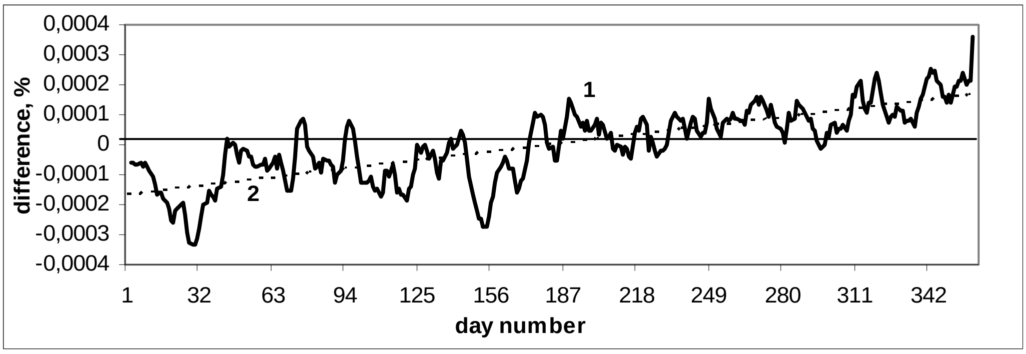

Fig. 3. Daily average difference between normalized *RR* and *DSM* values (curve 1) in the period of Jan 29, 2001-Jan 26, 2002. Illustration of lag-lead of one rhythm (physiological) over the other (psychophysical). Curve 2 is a linear trend of curve 1.

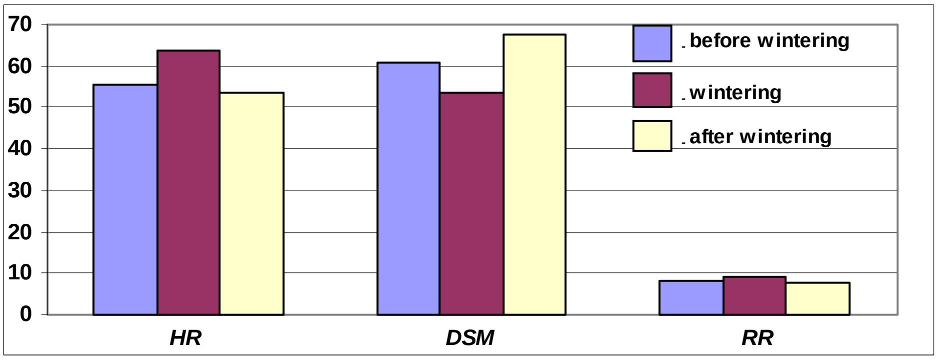

Fig. 4. Changes of *HR* (beat/min), *RR* (resp.cycles/min) and *DSM* (sec) at synchronization of two rhythms – physiological (*RR*) and psychophysical (*DSM*) before, during and after stay in Antarctica.

The further study of *DSM* was performed in 2002-2008 to estimate the influence of such astronomic phenomena as new moon (*NM*), full moon (*FM*), solar and lunar eclipses (*SE, LE*) onto *DSM* variations. Over 20 sets of registering *DSM* during 6 to 12 hours were done, covering the astronomic phenomena named above and intervening intervals.

In each case (except intervening intervals) the variations of *DSM* were similar: within 2-2.5 hours it increased to the maximum, exceeding 1.5-1.8 times the level at intervening intervals (at the moment of the Sun, the Earth and the Moon’s collinear positioning), and then decreased within appr. 2-2,5 hours. Fig. 5 illustrates the averaged density of distribution of *DSM* fluctuations (19 sets), describing *NM, FM, SE* and *LE*, with the peak values co-located in one point. Fig. 6 describes it for nadirs of the Sun (12 sets), with the values registered at 1 a.m. co-located in one point. The average values of *DSM* peaks are: 86,3 sec at *FM*, 99,5 sec at *LE*, 85 sec for *NM*, 90,3 sec for *SE* and 65 sec for intervening intervals.

The distribution pattern for *DSM* peaks describing *NM, FM, SE* and *LE* during the day was defined. According to it, *DSM* extreme values are located within the interval of 4-6 hours, which clearly agrees with its daily distribution.

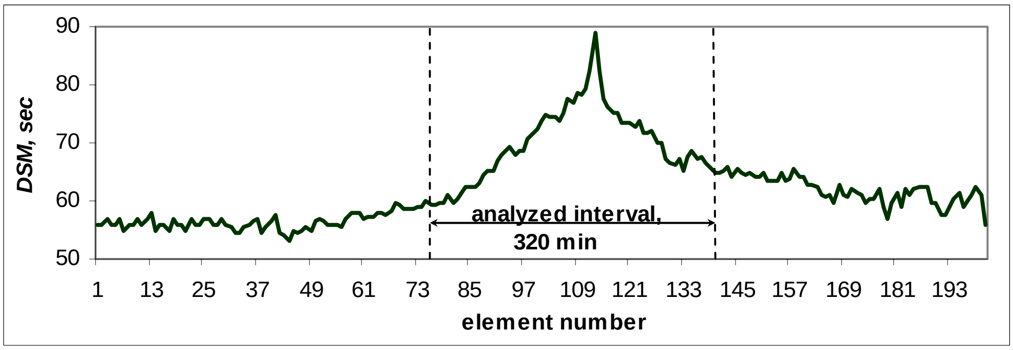

Fig. 5. Average density of distribution of *DSM* fluctuations, describing solar and lunar eclipses, new moon and full moon (19 sets), with the peak values co-located in one point.

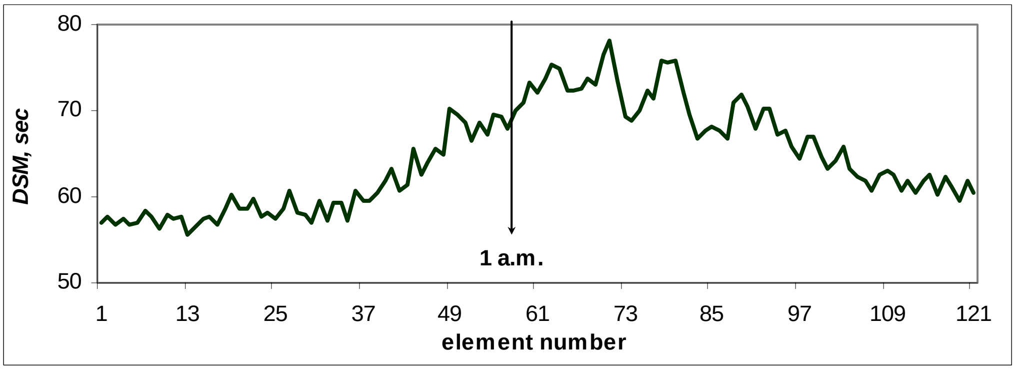

Fig. 6. Average density of distribution of *DSM* fluctuations, describing nadir of the Sun (12 sets), with the values registered at 1 a.m. co-located in one point.

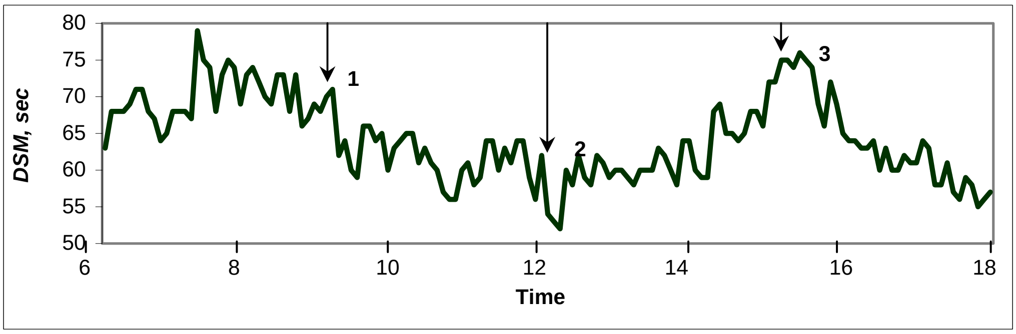

Fig. 7. Fluctuations of duration of subjective minute (*DSM*) at the Venus transiting across the disk of the Sun on June 8, 2004 from 9.13a.m. to 3.16p.m. Spot 2 – the moment of minimal angular distance between the centers of the Sun and the planet. Spots 1 and 3 – moments of touching the disk.

We also estimated the possible influence on *DSM* from a rare planetary phenomenon (previously observed in 1882), connected with the Venus transiting across the disk of the Sun on June 6, 2004 (from 9.13 a.m. till 3.16 p.m.), by analyzing the registered *DSM* variations from 6 a.m. till 6 p.m. (See Fig. 7). We found that the *DSM* variations during the outer intervals (approaching the solar disk and moving away from it) and during *NM* (*FM*, *SE, LE*, nadir of the Sun) are similar. *DSM* rises dramatically (from 67 to 79 sec) about 2 hours prior to the planet starting moving across the disk. After that it drops down to the level of intervening intervals, noticeably dips with the beginning of the eclipse and keeps decreasing more intensely down to the minimum (52 sec) as the planet reaches the point equidistant to the limb of the Sun. Then *DSM* increases to 74-76 sec (during the time interval of the eclipse ending), which is followed with a sharp decline to 55-57 sec in the next 3 hours. Similar changes of *DSM* were registered during the Mercury transiting across the disk of the Sun on November 8-9, 2006 (the phenomenon previously observed in 1886).

We studied the dynamics of *DSM* for each case: in Antarctica, at *NM* (*FM, SE, LE*), at nadirs of the Sun, at the Mercury and Venus transiting across the disk of the Sun (See Fig.8). *DSM* varies in the evidently similar manner: each cycle of the parameter fluctuations includes upward and downward trends to the left and to the right from the studied phenomenon, describing the "eclipse" phase.

The only difference is duration of the eclipse phase: from several minutes for *NM* (*FM, SE, LE*) to about 6 hours for the Mercury and Venus transiting across the solar disk and over 4 months for the polar night. Such a pattern of *DSM* changes in various situations reflects the similarity of the processes, related either to the fact of three celestial bodies conjunction: Sun-Earth-Moon (Mercury, Venus) or to the solar "eclipse" akin to the polar night.

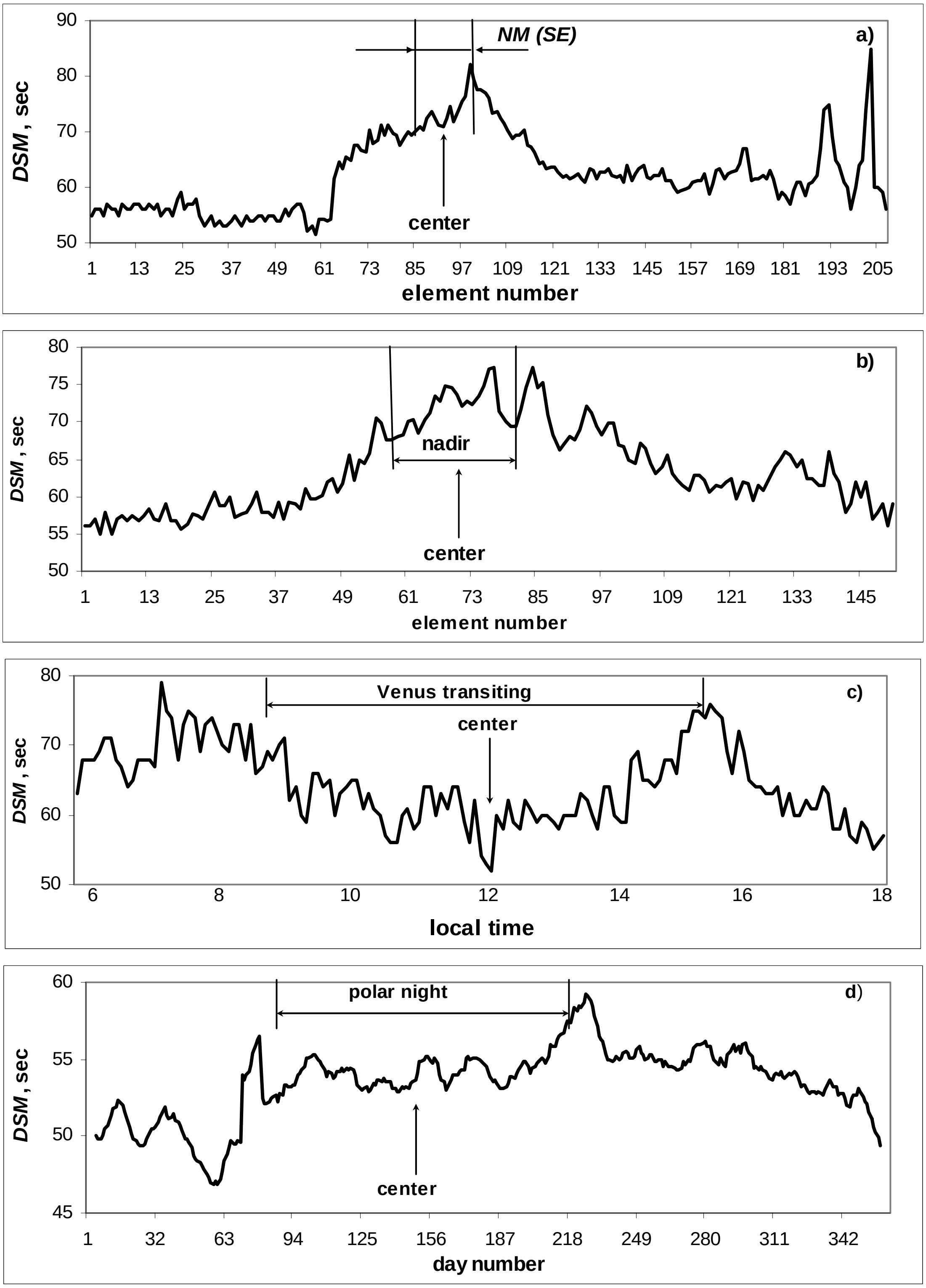

Fig. 8. *DSM* fluctuations during various analyzed intervals, including: a) *NM* (*SE*); b) nadir of the Sun; c) the Venus transiting across the solar disk; d) the polar night. Illustration of similar character of the processes.

The findings confirm the direct relation of the phenomena in question to the dynamics of biospheric processes.