EXPERIMENTAL BIOLOGY

Measurements of Time and Space as Manifestation of Spatiotemporal Organization of Reflection

Yu. A. Romanov and O. A. Irikov

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We studied measurements of the individual minute and individual decimeter. Individual time and length measures were reproduced separately or in combination (drawing 1 dm over 1 min). The measurements of time and space as coordinates of a vector for the space-and-time image are a single system of spatiotemporal organization of reflection. We revealed individual differences in the measurement of time and space. The individual minute was more variable than the individual decimeter.

Key Words: *time measurement; space measurement; spatiotemporal organization; individual minute; individual decimeter; reflection*

The relationship between mental activity in humans and objective time and space is an urgent problem of physiology and psychology. Studies of this problem include evaluation of assessment, reproduction, and measurements of time and space [3,5,6]. Assessment suggests perception of represented segments and their verbal description in units of time and length. Reproduction is the performance of a memorized or presented action over the time that does not differ from the duration of this action. In other wards, this is reproduction of the segment of length or time similar to the presented one. Measurements are reproduction of time or space segments in the corresponding units. Published data show that assessment, reproduction, and measurements of time and space are individual interrelated parameters [3-7]. Many attempts were made to reveal the relationship between these characteristics and physiological parameters of the organism [5]. Here we studied the individual characteristics of measurements of time and space as a spatiotemporal continuum.

Russian State Medical University, Moscow

MATERIALS AND METHODS

We examined 10 men (16-18 years). The measurements were performed in two or more repetitions.

The examinee should identify the period of time equal to 1 min by delivering the sound signal at the beginning and by the end of measurements. The actual period of time (individual minute, IM) was recorded using a stopwatch. Rhythmic movements and «internal counting» were forbidden.

In our observations, 1 dm served as the measured segment of length. As differentiated from 1 cm, this value is sufficiently high to reveal individual differences and technically simplifies drawing. The examinee drew a 10-cm line on paper over an arbitrary period of time. The actual length of this line was measured with a rule (individual decimeter, ID).

It was interesting to study the space-and-time measurements. The examinee should draw a 10-cm smooth line on paper over 1 min. The start and end of time-and-drawing measurements were accompanied by delivering the sound signal. The actual duration of time was recorded using a stopwatch. The actual length of a drawn line was measured with a rule. These parameters were named the individual minute of chronotop

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(IMC) and individual decimeter of chronotop (IDC), respectively. IMC and IDC were taken as coordinates of a vector for the space-and-time image, since perception and storage of spatiotemporal objects are considered as a single system.

We attempted to reveal the relationship between individual space-and-time recording and physiological characteristics of the organism. Heart rate (HR) was estimated under resting conditions and after physical exercise (10 crouching movements). HR is an important physiological parameter characterized by rhythmicity. The regulation of heart rhythm is realized via a multiloop system with various levels of control [1]. Heart rhythm serves as the integral parameter of organism's activity, which is of considerable interest with respect to the biological mechanisms of "internal time consciousness".

RESULTS

Depending on IM, the examinees were divided into 3 groups (Table 1): IM<1 min (examinees 1, 3, 4, 5, 7, and 9; IM=50±2 sec), IM≈1 min (examinees 2, 6, and 8; IM=59±1 sec), and IM>1 min (examinee 10; IM=81 sec). This classification of examinees is consistent with published data [5]. Most examinees belonged to the 1st group. Average HR in examinees of these groups were 100, 104, and 112 bpm, respectively. Therefore, lengthening of IM was accompanied by the increase in HR.

The examinees were characterized by considerable individual differences in IM (30-100 sec, 117% of 1 min). Repeated measurements showed that the IM variability was different in various examinees. IM were quite regular in examinees 1, 4, 6, and 7 (variability 8-17% of the average value), but least stable in examinees 2, 3, 5, and 8-10 (variability 27-62%).

It should be emphasized that the IM variability did not necessarily correlate with the HR variability. For example, examinee 1 was characterized by regular IM and considerable variations in HR. In examinees 2 and 10, HR was regular, while IM underwent marked variations. The average variability of HR in examinees of these groups was 22%.

The measurements of ID allowed us to divide the examinees into 3 groups (Table 1): ID<10 cm (examinees 1-5, 8, and 9; ID=8.0±0.5 cm), ID≈10 cm (examinees 6 and 7; ID=10.1±0.5 cm), and ID>10 cm (examinee 10; ID=11.3 cm). These data show that most examinees measured the segment, whose length was less than 1 dm.

In examinees 2 and 6, ID remained unchanged during repeated measurements (variability 3-4%). ID was characterized by an insignificant variability in examinees 1, 3-5, 8, and 9 (10-17%). The ID variability was most pronounced in examinees 7 and 10 (20-33%).

Therefore, IM is a less regular value than ID (variability 30 and 14%, respectively).

The duration of IM during drawing of a 1-dm line over 1 min was different. Depending on this parameter, the testes were divided into 3 groups: IMC<1 min (examinee 6; IMC=48 sec), IMC≈1 min (examinees 1, 7, and 8; IMC 58±1 sec), and IMC>1 min (examinees 2-5, 9, and 10; IMC=76±5 sec). As differentiated from separate measurements of IM, in this task most examinees belonged to the 3rd group. These results indicate that the individual period of time underwent lengthening.

IMC were characterized by individual variations. This parameter was most stable in examinees 5, 6, and 10 (variability 10-15%), but variable in examinees 1-4 and 7-9 (variability 23-49%). Thus, the composition of groups that included examinees with various regularities of IMC and IM was different. The differences were least significant in groups with most pronounced variability of these parameters.

Depending on IDC, the examinees were divided into 3 groups: IDC<1 dm (examinees 1-5, 8, and 9; IDC=7.8±0.5 cm); IDC»1 dm (examinee 6; IDC=9.6 cm), and IDC>1 dm (examinees 7 and 10; IDC=10.7±0.2 cm). By the composition, these groups practically did not differ from those composed after separate measurements of 1 dm.

IDC measurements in the same individual differed in repeated tests. The maximum stability was found in examinees 3, 5, and 6 (variability 6-8%), intermediate in examinees 1, 2, 4, 7, and 8 (variability 12-17%), and lowest in examinees 9 and 10 (variability 19-33%).

Similarly to separate measurements, IMC were characterized by a lower regularity than IDC (variability 27 and 14%, respectively).

IMC and IDC differed from IM and ID during separate measurements. However, the ID variability was insignificant. These variations were much lower than 1 cm (less than 10% of the ideal value, Table 1). Taking into account a similar composition of groups formed after the measurements of ID and IDC, our results indicate that reproduction of the spatial parameter is relatively regularity.

We observed other variations in IM during drawing of ID over 1 min (1-40 sec, 3-67% of the ideal value). In most examinees IM increased during measurements of a vector for the space-and-time image.

Under resting conditions HR underwent considerable variations. During repeated tests the regularity of this parameter differed between examinees. It was high in examinees 2, 3, 6, 7, and 10 (variability 0-18%), but low in examinees 1, 4, 5, 8, and 9 (variability 30-38%).

TABLE 1. Individual Parameters of Time and Space Measurements in Examinees

Examinee	IM, sec	ID, cm	IMC, sec	IDC, cm	HR, bpm	
					under resting conditions	after physical exercise
1	48	7 .1	58 (10)	7.3 (0.2)	132	150
	51	8.4	70 (19)	8.0 (-0.4)	114	138
	46	7.2	51 (5)	7.2 (0)	90	126
	49	7.8	55 (6)	8.1 (0.3)	120	132
Average	49	7.6	59 (10)	7.7 (0.1)	114	137
2	73	6.8	83 (10)	7.3 (0.5)	114	126
	47	7.0	66 (19)	6.5 (-0.5)	108	126
Average	60	6.9	75 (15)	6.9 (0.0)	111	126
3	30	7.3	62 (32)	7.9 (0.6)	84	102
	58	8.6	98 (40)	8.0 (-0.6)	96	132
	48	7.8	62 (14)	7.5 (-0.3)	102	126
Average	45	7.9	74 (29)	7.8 (-0.1)	94	120
4	47	5 .9	71 (24)	5.6 (-0.3)	66	90
	51	6.6	76 (25)	6.4 (-0.2)	66	84
	51	5.6	56 (5)	6.1 (0.5)	90	114
Average	50	6.0	68 (18)	6.0 (0.0)	74	96
5	44	9.6	67 (23)	8.5 (-1.1)	162	168
	63	8.6	74 (11)	8.0 (-0 .6)	120	144
Average	54	9.1	71 (17)	8.3 (-0.8)	141	156
6	53	9.9	44 (-9)	10.0 (0.1)	90	126
	63	9.5	51 (-12)	9.2 (-0.3)	90	120
Average	58	9.7	48 (-10)	9.6 (-0.1)	90	123
7	43	12.5	65 (22)	11.9 (-0.6)	96	126
	47	9.5	50 (3)	10.4 (0.9)	108	144
	48	9.1	60 (12)	10.1 (1.0)	90	120
Average	46	10.4	58 (12)	10.8 (0.4)	98	130
8	43	8.9	47 (4)	8.4 (-0.5)	90	126
	67	9.5	70 (3)	8.5 (-1.0)	132	168
	69	9.8	3 (-16)	9.8 (0)	114	162
	61	9.5	58 (-3)	9.5 (0)	108	156
Average	60	9.4	57 (-3)	9.1 (-0.3)	111	153
9	44	9.1	59 (15)	8.2 (-0.9)	72	108
	53	8.6	78 (25)	9.1 (0.5)	66	102
	48	9.4	72 (24)	9.9 (0.5)	90	120
	65	9.0	66 (1)	9.2 (0.2)	90	132
	59	9.9	77 (18)	9.0 (-0.9)	72	102
Average	54	9.2	70 (16)	9.1 (-0.1)	78	113
10	68	10.2	105 (37)	8.7 (-1.5)	102	126
	91	11.3	98 (7)	10.5 (-0.8)	114	138
	100	12.4	90 (-10)	12.2 (-0.2)	114	138
Average	86	11.3	98 (12)	10.5 (-0.8)	110	134

Note. Absolute differences between IMC and IM and between IDC and ID are shown in brackets.

Changes in HR in response to physical exercise were insignificant in examinees 1, 2, 5, and 10 (increase by 11-22%), but more pronounced in examinees 3, 4, 6, and 9 (increase by 28-45%).

We compared changes in HR after physical exercise (reactivity of the cardiovascular system) with variations in IM (individual reflection of the time unit) and IMC (characteristic of reflection during complex measurements of the length unit). A shift of IMC in relation to IM was sometimes opposite to changes in HR after physical exercise. For example, in examinee 8 differences between IMC and IM were insignificant; IMC was even shorter than IM. However, this examinee displayed a strong reaction of HR (shift by 38%). In examinee 6 a considerable reaction of HR (shift by 37%) was accompanied by the decrease in IMC (compared to IM). However, examinees 1, 2, 5, and 10 demonstrated a moderate increase in HR after physical exercise (11-22%) and considerable lengthening of IMC (compared to IM). These data suggest that during spatiotemporal measurements the individual unit of time is associated with reactivity of the cardiovascular system. This problem requires further investigations.

A. A. Ukhtomskii reported that the chronotop (complex of spatiotemporal relationships between environmental objects and events) is characterized by unity of time and space. He hypothesized that the chronotop can be perceived by humans and animals, if the reflecting mechanisms are based on single spatiotemporal relationships. Our results indicate that the measurements of time and space as coordinates of a vector for the space-and-time image are a single system of spatiotemporal organization of reflection. The measurements of time and space are characterized by individual differences. The individual unit of time is more variable than the individual unit of space.

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