Hunger and Satiation in the Structure of Temporal Organization of Impulse Activity of Masticatory Muscles in Rabbits

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Impulse activity of masticatory muscles, jaw elevators and depressors, during hunger, eating, and satiation was studied in chronic experiments on rabbits. The state of hunger is specifically reflected in the structure of temporal organization of impulse activity of proper masticatory muscles as a monomodal distribution of interpulse intervals and in activity of the mylohyoid muscle as bimodal distributions. Food intake induces reorganization of the temporal structure of impulse activity in both muscles manifesting in the form of similar bimodal patterns of distributions of interpulse intervals.

Key Words: *masticatory muscles; impulse activity; hunger; eating; satiation*

According to P. K. Anokhin's theory of functional systems, the integral information properties of nutrition functional systems related to the formation of food motivation and its satisfaction should be holographically reflected in activity of the central and peripheral elements included in this system [11]. It is now established that the states of hunger and satiation are specifically reflected in interval characteristics of impulse activity of individual neurons in various brain structures [4,5]. The reflection of food motivation and its changes under the effects of food reinforcement in the temporal structure of impulse activity of the proper masticatory muscle (PMM) was studied in only few papers [6]. We found no published data describing reflections of hunger and satiation in the structure of temporal organization of impulse activity of the mylohyoid muscle (MM) playing the trigger role in chewing and swallowing acts.

Here we studied reflection of the state of hunger and its alteration under the effect of food reward in the temporal structure of impulse activity of PMM and MM in rabbits.

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MATERIALS AND METHODS

Impulse activity of PMM and MM was continuously recorded in 5 Chinchilla rabbits (body weight 2.5-3.0 kg) subjected to 24-h food deprivation for 3 h before and after feeding. Impulse activity of masticatory muscles was studied under conditions of free behavior. In parallel, behavioral activity of animals was recorded with a video camera. Impulse activity of PMM and MM was recorded via a chronically implanted original bipolar silver electrodes [3,8,10], the wires were soldered to a radiotechnical connector positioned on the animal [7]. During the experiment, the connector counterpart with a special commutation device [9] was connected to input contacts of EMG-100C alternating current module amplifiers with transmission band of 1-1000 Hz. The subsequent automatic analysis of temporal parameters of pulse activity was performed using MP-100 microprocessor and AcqKnowledge softawe.

The following temporal parameters of impulse activity of motor units of PMM and MM under conditions of hunger, eating, and satiation were processed: consecutive interpulse intervals, duration of spike bursts, interburst intervals, periods of burst-like spike rhythms, interpulse intervals with the bursts.

Statistical processing of the results was performed using Shapiro—Wilk *W* test; autocorrelation function was calculated [1,2]. Intergroup differences were analyzed using Mann—Whitney *U* test.

RESULTS

Electrical activity of PMM under conditions of 24-h food deprivation was characterized by aperiodically appearing bursts of regular low-amplitude firing of individual motor units (Fig. 1). The state of hunger was reflected in the structure of temporal organization of impulse activity of PMM in the form of monomodal distributions of interpulse intervals with a maximum ~15-40 msec (Fig. 2), which did not correspond to normal distribution (W=0.98529). This was also seen from other parameters of interpulse intervals (Table 1). The mean duration of interpulse intervals was 28.04±0.05 msec, which corresponded to a frequency of 38.99±0.075 Hz. Similar results were obtained by other investigators [12].

Under conditions of food deprivation, electrical activity of PMM was characterized by aperiodic

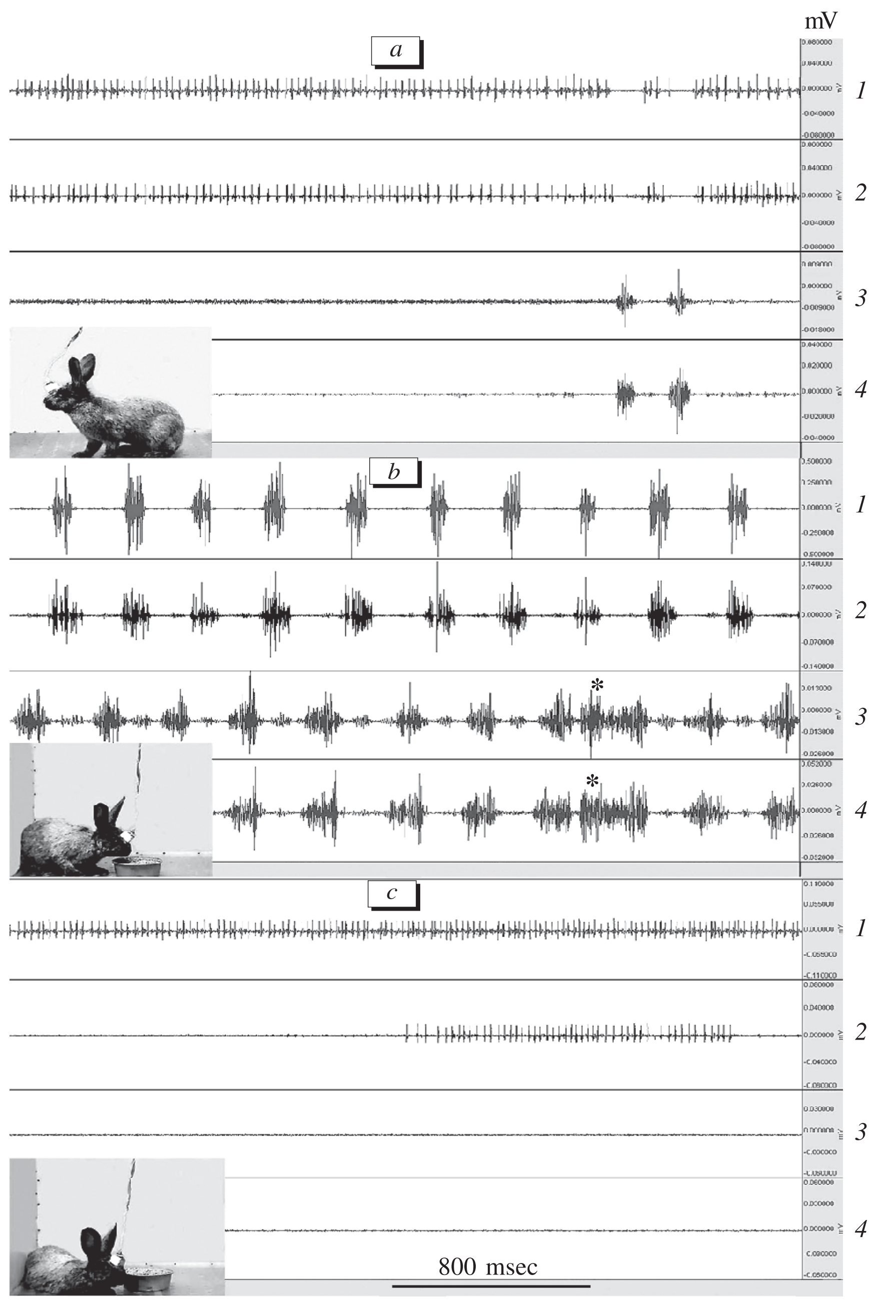

Fig. 1. Pulse activity of right (*1*) and left (*2*) PMM and right (*3*) and left (*4*) MM in rabbits under conditions of hunger (*a*), eating (*b*), and satiation (*c*). Spike burst triggering the swallowing act is shown by an asterisk.

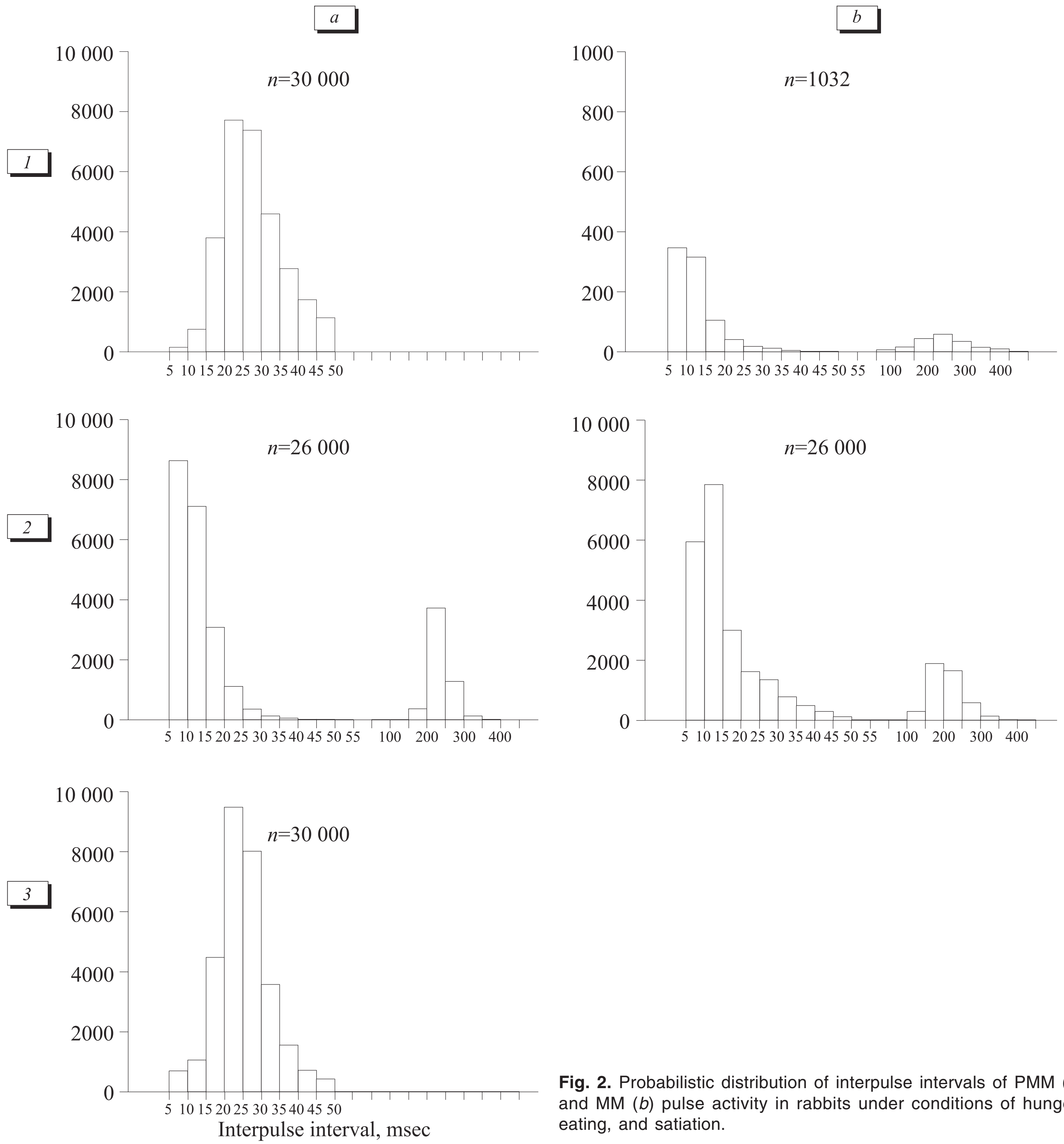

Fig. 2. Probabilistic distribution of interpulse intervals of PMM (*a*) and MM (*b*) pulse activity in rabbits under conditions of hunger, eating, and satiation.

burst-like pulse activity (Fig. 1). The state of hunger was reflected in the structure of temporal organization of impulse activity of MM as bimodal distributions of interpulse intervals with predominant durations of 5-20 and 150-300 msec (Fig. 2), which did not correspond to normal distribution (W= 0.545906). The mean duration of periods of burst-like activity was 282.55±5.54 msec (Table 2), which corresponded to a frequency of 3.83±0.087 Hz. Differences in the temporal parameters of pulse activity of PMM and MM under conditions of food deprivation were significant (U=23184, p<0.001). Generation of spike bursts in MM suppresses tonic pulse activity of PMM (Fig. 1), which attests to possible reciprocal interrelations between motoneurons in jaw elevator and depressor muscles in hungry animals.

Eating induced reorganization of impulse activity in both muscles, which manifested in regular generation of spike bursts (Fig. 1). Generation of a

TABLE 1. Temporal Parameters (msec) of Pulse Activity of PMM in Rabbits under Conditions of Hunger and during Eating

Parameter	Hunger	Eating				
	interpulse interval	interpulse interval	interpulse interval in the burst	burst duration	interburst interval	period of burst-like rhythmic activity
n	30,000	26,000	20,497	5503	5503	5503
M±*n*	28.04±0.05	59.79±0.57	12.38±0.04	46.12±0.20	236.38±0.37	282.51±0.38
Median	27.00	13.00	11.00	45.50	234.00	280.00
Square deviation (δ)	8.12	98.48	5.29	15.01	27.37	28.29
Asymmetry coefficient (As)	0.51	1.47	1.59	0.49	0.80	0.82
δ_{As}	0.01	0.02	0.02	0.03	0.03	0.03
Excess coefficient (Ex)	-0.09	0.32	4.03	0.65	2.00	2.19
δ_{Ex}	0.03	0.03	0.03	0.07	0.07	0.07
Quartile 25%	22.50	9.00	8.50	35.50	218.50	264.00
Quartile 75%	33.00	22.50	15.00	55.50	251.00	297.50

spike burst in MM anticipated the appearance of spile burst in PMM, which attested to reciprocal relations between motoneurons of the masticatory center innervating PMM and MM during eating. Changes induced by food reward were reflected in the temporal structure of impulse activity of PMM

TABLE 2. Temporal Parameters (msec) of Pulse Activity of MM in Rabbits under Conditions of Hunger (Numerator) and during Eating (Denominator)

Parameter	Interpulse interval	Interpulse interval in the burst	Burst duration	Interburst interval	Period of burst-like rhythmic activity
n	1032 / 26,000	847 / 21,435	185 / 4565	185 / 4565	185 / 4565
M±*m*	50.65±2.70 / 49.46±0.47	12.48±0.20 / 15.68±0.06	57.14±1.76 / 73.60±0.38	225.41±5.04 / 208.08±0.65	282.55±5.54 / 281.68±0.68
Median	12.00 / 14.50	11.00 / 13.00	54.67 / 74.00	226.00 / 202.50	281.66 / 276.00
Square deviation (δ)	86.87 / 75.89	5.96 / 8.37	23.91 / 25.95	68.60 / 44.17	75.34 / 45.93
Asymmetry coefficient (As)	2.08 / 1.92	2.06 / 1.51	0.83 / 0.10	0.20 / 0.69	0.27 / 0.59
δ_{As}	0.08 / 0.02	0.08 / 0.02	0.18 / 0.04	0.18 / 0.04	0.18 / 0.04
Excess coefficient (Ex)	3.03 / 2.23	5.80 / 1.91	1.19 / -0.26	-0.17 / 0.72	0.03 / 0.86
δ_{Ex}	0.15 / 0.03	0.17 / 0.03	0.36 / 0.07	0.36 / 0.07	0.36 / 0.07
Quartile 25%	9.00 / 10.50	8.50 / 10.00	38.34 / 55.50	177.00 / 177.00	231.66 / 251.50
Quartile 75%	21.00 / 29.00	14.33 / 18.50	70.67 / 91.00	267.50 / 234.50	320.33 / 309.00

and MM in the form of similar interpulse intervals with maxima corresponding to 5-25 and 150-300 msec and to 5-30 and 150-300 msec, respectively (Fig. 2), which did not correspond to normal distribution (*W*=0.53245 and *W*=0.585412). The duration of periods of burst-like spike rhythms generated in PMM and MM (Table 2) corresponded to frequencies of 3.57±0.0047 and 3.64±0.0087 Hz, respectively. The differences in temporal parameters of pulse activity of PMM and MM during food behavior and impulse activity of MM in hungry animals were insignificant (*U*=487,987, *p*=0.3522; *U*=15,575, *p*=0.114). In parallel with spike generation in MM corresponding to the rhythm of chewing, burst-like impulse activity corresponding to the rhythm of swallowing was noted (Fig. 1) with period and frequency of 10,128.75±226.549 msec and 0.101±0.002 Hz, respectively. These findings confirm the trigger role of MM in the realization of chewing and swallowing acts. The state of satiation was reflected in the structure of PMM pulse activity in the form of regular low-amplitude firing activity of motor units (Fig. 1), which was seen as monomodal distributions of maxima in the range of 10-35 msec on histograms of interpulse intervals (Fig. 2), which did not correspond to normal distribution (*W*= 0.964394). The duration of interpulse intervals was 25.44±0.42 msec, which corresponded to a frequency of 43.48±0.10 Hz. Under conditions of satiation, the frequency of pulse activity of PMM is significantly higher than in hungry animals (*U*= 453,459, *p*=0.00312). No pulse activity of MM during satiation was observed.

Thus, the state of hunger is reflected in temporal structure of pulse activity of PMM in the form of monomodal distributions of interpulse intervals and in MM activity in the form of bimodal distributions, which according to anticipation principle of reality reflection [11] carry information on the properties of the forthcoming food reward. This location of maxima on histograms of interpulse intervals determines temporal parameters of impulse activity of PMM and MM during future effective food-procuring behavior.

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