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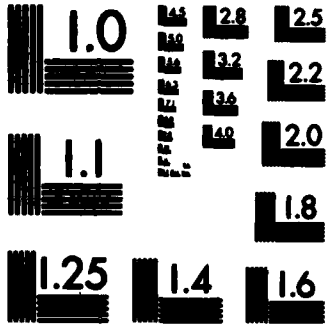

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FOREIGN TECHNOLOGY DIVISION

THE EFFECT OF PROLONGED RESTRAINT OF MOTOR ACTIVITY ON THE VITAL ACTIVITY OF MONKEYS

by

N.A. Rokotova, P.D. Bogina, et al

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EDITED TRANSLATION

FTD-ID(RS)T-1128-82 26 August 1982

MICROFICHE NR: FTD-82-C-001141

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English pages: 12

Source: Problemy Kosmicheskoy Biologii, Nr. 2, 1962, pp. 417-427

Country of origin: USSR
Translated by: Robert D. Hill
Requester: AFAMRL/STINFO

PREPARED BY:

TRANSLATION DIVISION
FOREIGN TECHNOLOGY DIVISION
WP-AFB, OHIO.

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Block	Italic	Transliteration	Block	Italic	Transliteration
А а	*А а*	A, a	Р р	*Р р*	R, r
Б б	*Б б*	B, b	С с	*С с*	S, s
В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

*ye initially, after vowels, and after ъ, ь; e elsewhere.
When written as ё in Russian, transliterate as yё or ё.

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English	Russian	English	Russian	English
sin	sin	sh	sinh	s h	$\sinh^{-1}$
cos	cos	ch	cosh	c	$\cosh^{-1}$
tg	tan	th	tanh	a	$\tanh^{-1}$
ctg	cot	cth	coth	arc cth	$\coth^{-1}$
sec	sec	sch	sech	arc sch	sech^{-1}
cosec	csc	csch	csch	arc csch	csch

Russian	English
rot	curl
lg	log

GRAPHICS DISCLAIMER

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THE EFFECT OF PROLONGED RESTRAINT OF MOTOR ACTIVITY ON THE VITAL ACTIVITY OF MONKEYS

N.A. Rokotova, P.D. Bogina, O.P. Bolotina, T.M. Kucherenko, Ye.S. Rogovenko, R.L. Sheykin

If we keep in mind that the subsequent space flights will last for an extent of many months and even years, then to the factors which affect the organism of the cosmonaut we can add also the prolonged effect of the unusual conditions of the existence with restraint of motor activity. It is well-known that a short-term restraint of monkeys changes the habitual situation and disrupts the vital stereotype, which causes deviations from the normal behavior, development of a neurotic state and distortion of a number of physiological functions (Utkin, 1960; Utkin and Avdzhian, 1960; Startsev, 1961). Mason (1958) and Lilly (1958) developed a special apparatus for the prolonged fixation [restraint] of monkeys (from 4-6 weeks to 14-15 months). The authors point to a number of complications observed in monkeys who are found under conditions of prolonged fixation, namely: a certain loss of tone of muscles of the abdominal wall, edema of the rear limbs and disturbances of the integrity of the skin integuments. Mason and Lilly noted that the monkeys placed into the fixator adapted in 1-5 days to the new conditions of existence, and they develop contact with people very rapidly.

The task of our investigation was to find out to what degree prolonged restraint affects the physiological function and behavior of monkeys, and also whether or not an animal found in conditions of restraint of the motor activity can serve as a valuable object

for studying other factors affecting the organism in space.

Method

For this purpose we conducted an investigation in which we used both the modified restraining apparatus of Mason and Lilly and the fixator designed in our laboratory by R.L. Sheykin. The apparatus of R.L. Sheykin is a metal structure consisting of a base and longitudinal planks, to which four leg braces were attached. Restraint of the animal is accomplished by a belt, collar and seat, and for the Capuchins, pedestals (Fig. 1). The distance between the seat, belt and collar is established depending on the size of the monkey. The belt and collar are connected with the legs through sectional rods with variable adjustable rigidity. The fixator has detachable side walls of plexiglass for limiting the aggressive movements of the animal. In front of the monkey is a container-like table for eating, and located under the fixator is a container for wastes. The design of the fixator makes it possible to install different sensors and instruments for investigating the physiological functions of the animal.

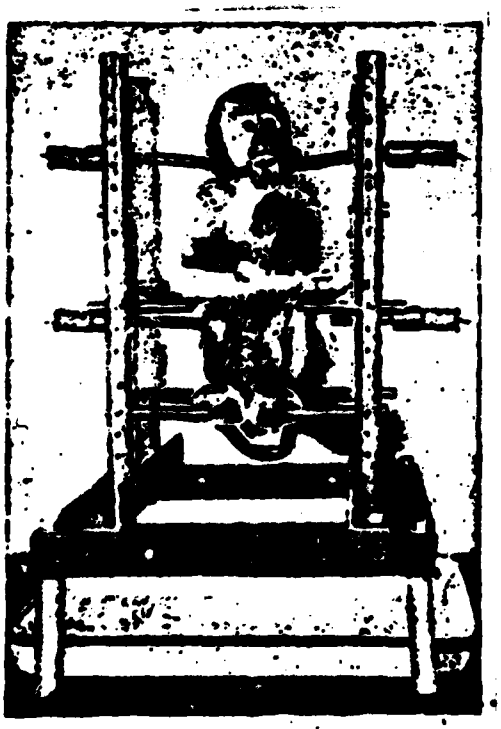

Fig. 1. Photograph of a monkey (Capuchin named Yurkiy) in the fixator of the design of R.L. Sheykin.

The experiments were conducted on four monkeys: two macaques, one hamadryed baboon and one Capuchin. Two series of experiments were set up.

In the first series three monkeys (macaque named Mal'chik, hamadryed baboon Katod, and Capuchin named Yurkiy) were subjected to a 10-day fixation in the Mason and Lilly apparatus. The behavior of the monkeys was observed around-the-clock, and the results were compared with the behavior of monkeys during such a period but with unrestrained movements. Considered here were the awake and sleep time, motor activity and food reaction, which were evaluated visually according to a developed scale. Taken for the state of the awake period was such a form of behavior in which the monkey sat quietly with eyes opened, did not show aggressive or playful reactions, but reacted normally to his name. If the monkey sat in a quiet pose with his eyes opened, having relaxed the muscles of his body and neck, not responding to a quiet call, then such a state was evaluated as sleep. Taken for motor activity was such behavior of the animal when the monkey jumped about the cage and crawled along its walls (under conditions of free behavior) or actively moved its limbs and head, trying to change the position of its body (under conditions of restraint). The food reaction was evaluated by the time of the eating of the food and the quantity of food eaten. The monkeys were given food weighed according to standards established in the monkey nursery in Sukhumi and were allowed to eat until full. Then the remains were weighed, and the quantity of food actually eaten in a twenty-four hour period was considered. The monkeys ate twice a day: at 0900-1000 and during 1500-1600 hours.

In the second series of experiments two monkeys were subjected to prolonged fixation for an extent of 3.5 months. One monkey (macaque by the name of Seryy) was place into the restraining apparatus twice for periods of 1.5 and 3.5 months. Another monkey (a Capuchin Yurkiy) rested for a long time after the first series of experiments and then was restrained in the apparatus of R.L. Sheykin for 3.5 months. Conducted in this series of experiments were the quantitative calculation of the food eaten and the general observation of the state of health of the animals.

The respiration and pulse rates were taken in both monkeys, and the weight of the animals before and after fixation was considered.

For the characteristic of the higher nervous activity of the monkeys, oberservations were made on the manifestation of the reference-investigatory [orienting-investigatory] reflex according to the method of L.G. Voronin (Voronin and Shirkova, 1949). The state of the orienting reflex is judged by the rate of the fading away and the number of reactions observed in the first five seconds of presentation of the subject.

As a result of the studies, it has been established that the 10-day fixation did not cause any substantial disruptions in the physiological functions and changes in the vital activity of the monkeys. Observed in all the animals was a similar nature of the occurrence of those or other reactions; therefore, as an example, we cite data obtained on the hamadryed baboon by the name of Katod (Fig. 2). The figure gives changes in the daily rhythm of behavior which characterizes this monkey both in conditions of the usual inhabited cage and with limitation of movements. The duration of sleep during a day [twenty-four hours] under conditions of the usual content is represented on the diagram in the form of the average magnitude with the average error of deviation for 10 days - background. Periods of motor activity with the usual content are also represented in the form of an average with a deviation error during 10 days - background. The corresponding values which characterize sleep and motor activity of Katod during his stay in the fixator are not averaged but are sums of values for each of the days. Given at the end of each diagram are averaged values with the average deviation error for 10 days. An analysis of the diagrams showed that on the first and second days of fixation, the time of sleep (Fig. 2A) was decreased, and then on the subsequent days the sleep lasted longer than that under conditions of free behavior. The motor activity (Fig. 2B) only on the first day was noticeably increased and further was not considerably changed. The staying awake of Katod was more lasting on the first two days of fixation and from the third day did not exceed the initial background values. Observed in other monkeys were such shifts in the daily rhythm which sometimes continued for

not two but three to four days. In the Capuchin, Yurkiy, the motor activity was considerably lowered from the first day of restraint of movments. It must be noted that the Capuchin, under conditions of free behavior, crawled all the time about the cellular walls of the cage and was rarely kept in one place. In the fixator he could not show the motor reactions inherent to him. Other monkeys were not distinguished by such specificity of movements.

The duration of the feeding reactions were unchanged, but the amount of food eaten by the animals during one day was decreased. Data of these studies are given in Table 1.

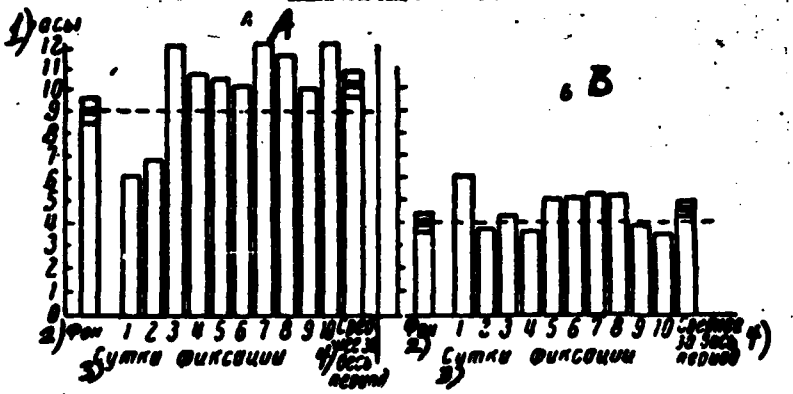

Fig. 2. Change in the diurnal rhythm of behavior in the monkey Katod during a 10-day fixation. A - total daily duration of sleep; B - total daily motor activity; dashed line - average duration of given reaction under conditions of free behavior. Key: 1) Hours; 2) Background; 3) Days of fixation; 4) Average for whole period.

Table 1 Quantity of food eaten by the monkeys under usual life conditions and during a 10-day fixation

1) Клички	2) Среднее количество пищи, съедаемое за сутки, г		3) Разница	
	4) свободное поведение	5) фиксация	г	%
6) Катод	1137	838	299	26
7) Мальчик . . .	652	460	192	30
8) Юркий	370	185	185	50

Key: 1) Name; 2) Average amount of food eaten in a day in grams; 3) Difference; 4) free behavior; 5) fixation; 6) Katod; 7) Mal'chik; 8) Yurkiy.

As is shown in Table 1, for Katod and Mal'chik the amount of food eaten in a day was decreased by only 26-30% and for Yurkiy, 50%. Probably, such a lowering of the food excitability in Yurkiy

can be attributed to the sharp decrease in motor activity.

In connection with the fact that the percentage makeup of the edible daily ration in all the monkeys proved to be extremely similar, let us given the total data obtained on three animals of the mean diurnal percentage makeup of food for monkeys under conditions of free behavior and during fixation (Table 2).

Table 2 Percentage makeup of the daily ration of monkeys in conditions of free behavior and during a 10-day fixation

1) Компонент рациона	Свободное поведение 2)	Фиксация 3)
4) Орехи	6	5
5) Фрукты	18	30
6) Овощи	15	14
7) Мучные продукты	11	11
8) Яйца	3	3
9) Жидкость (вода и молоко)	47	37
10) Всего	100%	100%

Key: 1) Component of ration; 2) Free behavior; 3) Fixation; 4) Nuts; 5) Fruit; 6) Vegetables; 7) Flour products; 8) Eggs; 9) Fluids (milk and water); 10) Total.

The large amount of fruit eaten during the fixation is explained by the fact that for the monkeys found in conditions of limitation of the motor activity, fruit was additionally added to the ration. Probably, for this reason the amount of fluid consumed in this period was somewhat decreased. The remaining products were eaten by the monkeys in identical quantities both in the usual conditions and during fixation.

Shifts in the behavior of the monkeys observed by us were short-term and insignificant. Results of the first series of experiments made it possible to extend the period of fixation of the animals and permitted in the second series of experiments to be limited to the general observation on the state of the monkeys and an account of the food eaten.

In the whole period of the prolonged fixation, the monkeys ate a sufficient amount of food, were distinguished by a quiet behavior and actively played with the different objects given to them. During the tidying up of the fixator, they showed normal aggression and

reacted with a natural orienting reaction to any changes in the surrounding situation. The state of the skin and hair coverings was good, which is also indicative of the health of the animals.

The amount of food eaten varied depending on the period of fixation. The animals ate the greatest amount of food during 10-20 days in that period when they had already completely adapted to conditions of restraint of the movements, but the feeding excitability had still not decreased. In later periods of fixation the amount of food eaten in a day was reduced. This is especially clearly marked in the monkey by the name of Seryy (Table 3).

Table 3 Amount of food eaten by the monkeys at different periods of prolonged fixation

1) Имена	2) Среднее количество пищи (в г), поедаемой за период			
	1—10-е сутки 3)	11—20-е сутки 3)	51—60-е сутки 3)	91—100-е сутки 3)
4) Серый	740	1048	978	778
5) Юркий	185	287	242	272

Key: 1) Name; 2) Average amount of food (in grams) eaten during the period; 3) days; 4) Seryy; 5) Yurkiy.

The percentage makeup of the diurnal ration in this series did not fundamentally differ from the ration of the monkeys in the first series.

As was already stated, the weight of the animals before being put into the fixator and after being released was considered.

In the 10-day fixation the weight of the monkeys was essentially unchanged (approximately ±4-8% of the initial value) as compared with those changes which were observed with the prolonged keeping of the monkeys in the fixator. As is shown in Table 4, during the period of the first fixation (41 days) Seryy gained 1.050 kg in weight, which is 19% of his weight. With repeated fixation during 106 days, his weight was increased from 6.545 kg to 9.250 kg, i.e., 2.705 kg, which is 41% of the initial weight. The sharp increase in weight in Seryy indicates that the ration of the restrained monkeys was excessive, and that the feeding of them in this case should be done with an account of the usual conditions of the existence in which motor activity is excluded.

Table 4 Weight of the monkeys in conditions of free behavior and during fixation

1) Кличка	2) Срок фиксации, сутки	3) Вес до фиксации, кг	4) Вес после фиксации, кг	5) Разница	
				6) кг	%
7) Катод	10	8,850	8,150	−0,700	8
8) Мальчик . . .	10	3,300	3,550	+0,250	7
9) Юркий	10	1,350	1,400	+0,050	8
10) Серый	41	5,500	6,550	+1,050	19
11) Серый	108	6,545	9,250	+2,705	41

Key: 1) Name; 2) Period of fixation, days; 3) Weight before fixation, kg; 4) Weight after fixation, kg; 5) Difference; 6) kg; 7) Katod; 8) Mal'chik; 9) Yurkiy; 10) Seryy; 11) Seryy.

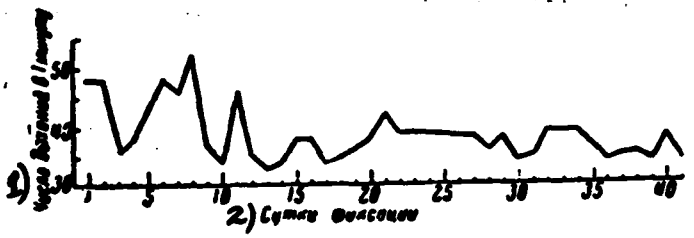

Fig. 3. Respiration rate in the monkey Seryy with prolonged fixation. Key: 1) Number of breathings per minute; 2) Days of fixation.

The results obtained in both series of experiments of the daily observations on the pulse and respiration rate did not indicate any substantial changes in the respiratory and heart activity. Figure 3 gives data obtained on the macaque Seryy for the period of the first seating into the fixator. During the first 11 days the rate of respiratory movements varied from 39 to 54 per minute. From the 12th day the oscillations were decreased (38-42), and respiration was maintained at a more stable level. The pulse rate was found to be less constant. We are inclined to attibute the observed sharp oscillations to the incorrect method. The pulse was determined by palpation, and the monkeys, as a rule, arrived agitated and even showed resistance.

When the monkeys are freed after a 10-day fixation, a certain paralysis was noted in the animals in the movements of the rear limbs, which lasted for 2-3 hours. In Seryy, after a one and a half month's restraint of the movements, observed was a weakening of the tone of the muscles of the abdominal wall, and upon freeing the monkey a weakness of the rear limbs was revealed. The monkey could not jump

onto the shelf located 1.5 m from the floor. But these phenomena soon passed, and on the next day Seryy moved about the cage normally. After fixation which lasted for 3.5 months, difficulties in walking were observed. For 2-3 days the monkey moved very slowly and carefully with its legs and in several days preferred to be in a sitting position, simulating a pose of that usually for fixation. However, it appears to us that the difficulties in walking can be considered not only to be the consequence of a prolonged stay in the sitting position, but also the result of the great addition in weight of the body of the animal, because all the remaining reactions of behavior, for example, aggression, were completely normal.

Experiments with prolonged fixation revealed a certain advantage of the fixator with variable rigidity of securing developed in our laboratory as compared with the fixator of Mason and Lilly, in which for the extent of the first days of fixation it was necessary to adjust repeatedly the parts of the fixator. The stay of the monkey in our fixator completely eliminates the possibility of chafing and bedsores, which cannot be said of the apparatus of the American authors.

In all the monkeys the orienting-investigatory reflex was studied in conditions of free behavior and with restraint of the motor activity. In the first series of experiments, the state of the orienting reaction was checked on the 2nd and 8th day of fixation. In the second series experiments were conducted on the 2nd and 8th days, and further every 10 days: on the 20th, 30th, 40th... and 100th day of fixation. In some experiments the animals, with an interval of one minute, were offered pieces of rubber tubes and in others, rocks (sea pebbles) wrapped in white paper. The orienting reflex was considered quenched if the monkey did not take the object five times in a row.

Completely regular changes in the showing of the orienting--investigatory reflex were observed in the majority of the monkeys. Figure 4 A shows the average rate of quenching and limits of variations of the orienting reaction under conditions of free behavior (I), on the 2nd day (II) and on the 8th day (III) of fixation. The total data obtained on four monkeys are given.

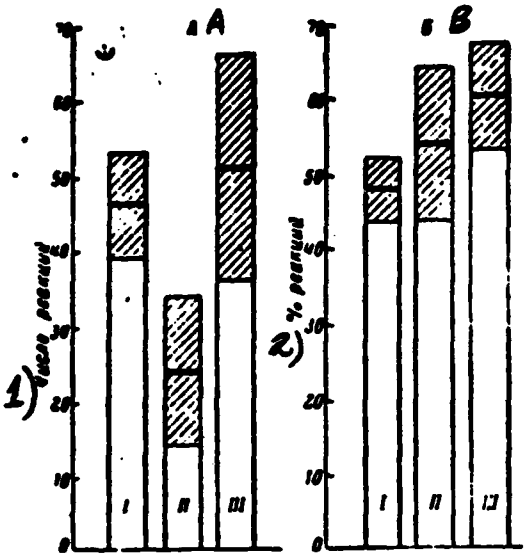

Fig. 4. Change in the orienting-investigatory reflex in monkeys during a 10-day fixation. A - rate of quenching of reflex; B - Number of rapid reactions; I - in conditions of free behavior; II - on 2nd day of fixation; III - on 8th day of fixation. Key: 1) Number of reactions; 2) % of reactions.

On the 2nd day of fixation, noted in all the animals was a more rapid quenching of the orienting reflex, and the monkeys began to doze toward the end of the experiment. On the 8th day of fixation, indicators of the oppression of the orienting-investigatory reflex were not observed. In certain cases even, on the contrary, an intensification of the reaction was noted, and this was expressed in its slower quenching. In subsequent periods of fixation, we practically did not obtain a quenching of the orienting reflex, since the experiments were ceased after the animals continued to take the offered objects for more than 150-200 times.

Besides the rate of the quenching of the orienting-investigatory reflex, we considered the percent of reactions observed in the first five seconds of display of the object (Fig. 4 B). The figure gives the quantity (in %) and limits of variations in the rapid reactions under conditions of free behavior (I), on the 2nd (II) day and on the 8th day (III) of fixation. The number of reactions during the first five seconds increased as the animals stayed in conditions of restraint of motor activity.

For the monkey Seryy found in the fixator for 3.5 months (Fig. 5), by the end of this period the number of rapid reactions grew

to 89-96% compared with 48% in conditions of free behavior.

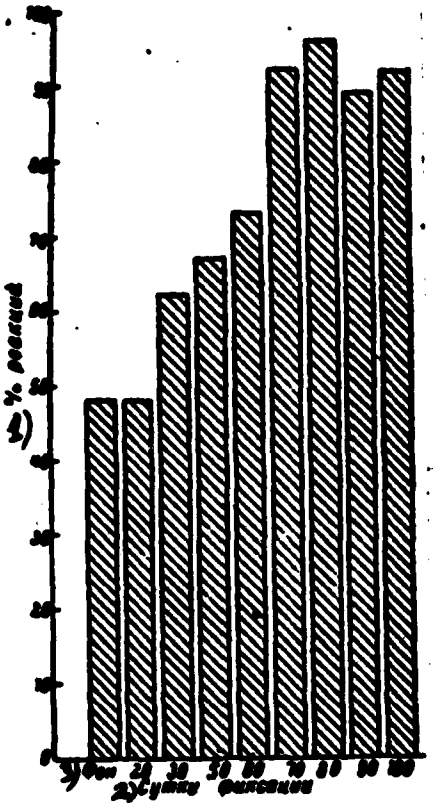

Fig. 5. Change in the number of rapid reactions with fixation during 3.5 months. Key: 1) % of reaction; 2) Days of fixation; 3) Background.

Thus only on the 2nd day of fixation was there noted a certain oppression of the orienting-investigatory reflex. Further, the orienting reaction proved to be more marked than that in conditions of free behavior. Considering the high degree of development of the orienting reflex in the monkeys and comparing the data obtained with the general behavior and state of the animals in the period of fixation, we assume that it is more correct to consider the intensification of the orienting-investigatory reflex to be the result of equal conditions of the existence in which the monkeys are found and not the manifestation of increased excitability of the nervous system. Results of this part of the investigation indicate that the restraint of the motor activity does not have an oppressive effect on the higher nervous activity of the monkeys.

In summing up what has been said, we can conclude that the prolonged stay of the monkeys in conditions of restraint of the motor activity did not unfavorably reflect on the manifestation of the

physiological functions, the behavior of the animals and the functional state of their nervous system. Insignificant shifts in the activity of being asleep and awake, which were observed in the first 2-4 days of fixation, or the oppression of the orienting reflex during this period were short-term, and from the 3rd to 5th day no deviations from the state of the animals in conditions of the free behavior were observed.

Based on the obtained data, we can make the following conclusions.

1. Prolonged restraint of the motor activity does not affect the vital activity of the monkeys very considerably.

2. The monkeys found in conditions of fixation can serve as valuable objects for further studies.

3. The design of the fixator developed by R.L. Sheykin for the chronic restraint of the mobility of the monkeys ensures the prolonged sustaining of the normal physiological state of the animals and is more economical and portable as compared with the fixator of Lilly and Mason.

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