Azerbaijan Journal of Physiology, Vol. 37, No 1, pp. 45-50 (2022)

https://doi.org/10.59883/ajp.14 UDC 796.01:612

CHANGES OF THE DRINKING SKILLS UNDER THE INFLUENCE OF CHEMICAL STIMULATION OF DIFFERENT NUCLEI OF THE AMYGDALA

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The purpose was to study the role of various nuclei of the amygdala in the implementation of the acquired drinking behavior, chemical stimulation (carbocholine, serotonin, noradrenaline), and temporary shutdown of its basolateral and central nuclei. The results of the studies testify to the modulating role of the basolateral and central nuclei of the amygdala in the formation of complex forms of behavior. The results obtained using the methods of chemical stimulation and a temporary shutdown of the AB and AC nuclei of the amygdala indicated their modulating role in the formation of complex forms of behavior. Since memory and learning are realized through the emotional status with the involvement of serotonergic and noradrenergic fibers, in these cases, the involvement of the amygdala in these nervous processes will be determined by the formation of emotionally positive behavior by the serotonergic system and emotionally negative behavior by the noradrenergic one.

Key words: carbocholine, serotonin, noradrenalin, novocaine, conditioned drinking reflex

INTRODUCTION

The amygdala complex is one of the components of the limbic system and has a modulating effect on the activity of the main brain stem formations, through which the formation of emotional and motivational states is carried out. The amygdala has numerous connections with various brain structures. So, it receives information from all senses. This is possible due to its connections with the thalamus [15]. A direct connection with the amygdala is necessary for a quick response to external stimuli [11, 12]. The amygdala complex has connections with associative zones – areas of the cortex and the hippocampus. In addition, the amygdala has numerous bilateral connections to subcortical structures such as the basal ganglia and accessory nuclei, as well as to the prefrontal cortex. The amygdala has an effect on the prefrontal cortex in risk/reward assessment in animals [9], and stimulation of projection pathways from certain areas of the prefrontal cortex into the amygdala can enhance or decrease prosocial behavior [3]. Damage to the connections between the amygdala and the prefrontal cortex can lead to post-traumatic stress disorders, depression, etc. [13]. Of particular importance are the connections of the amygdala with the hypothalamus, which play an important role in the regulation of stress responses, sexual behavior, and aggression [5].

Different nuclei of the amygdala complex are involved in a variety of behavioral responses. Thus, the lateral nucleus plays a role in reactions associated with fear [4]; the basolateral nucleus responds to both negative stimuli (fear, anxiety) and positive ones (reward) [10]; the central nucleus of the amygdala is responsible for reactions to emotional stimuli, the medial nucleus in animals is especially important in sexual behavior. In humans, MeA mainly reacts to pungent odors [1] and takes part in their memorization [2].

Based on the foregoing data, the main goal of this study was to study the effect of chemostimulation (carbocholine, serotonin, noradrenaline) and temporary shutdown (novocaine) of the basolateral and central nuclei of the amygdala on the realization of the developed drinking conditioned skill.

METHODS

The studies were carried out on 25 Chinchilla rabbits weighing 2-3 kg, trained in the drinking conditioned reflex. Animals were subjected to water deprivation for 24 and 48 h, after which they were taught instrumental drinking habits. In response to a sound signal, the rabbit pressed the pedal, which opened the door, jumped over the barrier from the starting compartment of the box to its target compartment to receive water in a strictly defined dose (5-10 mL), and then returned to the starting point of the box. The conditioned stimulus was applied at regular intervals (every 45 sec) 10 to 15 times during the experiment. During the experimental day, the animals received an average of 100-120 mL of water. The experiments were carried out till reaching the 100% training criterion. In the study of behavioral reactions, the time from the moment the signal was given to the beginning of the jump (latent period), the time of the jump and run, as well as the time spent on returning to the starting point of the box, were recorded.

Micro-application of neurochemical preparations was carried out in a volume of 5 µL of saline using a special device consisting of a micromanipulator and a syringe connected to an injection needle with a polyethylene tube, which makes it possible to inject chemical solutions into various brain structures under conditions of free behavior of the animal. The micro-application was made in doses: carbocholine (CH) from 0.5 to 3 µg; serotonin (5-OT) from 10 to 100 µg, noradrenaline (NA) from 10 to 50 µg. Temporary shutdown of the studied areas of the CNS was carried out with the application of a 10% novocaine solution. In controls, saline was injected into the studied area in a volume equal to the injected solutions.

RESULTS AND DISCUSSION

The results of the conducted studies showed that the administration of carbocholine into the basolateral nucleus of the amygdala at a dose of 0.5 µg did not lead to impairment of the skill. The animals responded in a timely manner to the sanctioned signal. Time spent running, licking, and coming back remained at baseline levels. An increase of the dose of the administered drug to 2–3 µg led to an aggressive reaction: the animal became shy, shuddered at the sound signal, and could hardly be picked up. At the same time, the realization of the skill was not violated. An intense emotional reaction developed constant hissing, grumbling, continuous walking around the room, moving away from the experimenter, and piloerection. There was an increase in the latent period of the reaction to the conditioned stimulus (from 1.23±0.07 to 3.57±0.08 sec) and returning (from 4.2±0.07 to 8.5±0.07 sec). The remaining components remained at the level of background indicators. Registration of the amount of water consumed showed that it did not differ from the intact animals (Fig.1 - 4). Similar changes in the behavior of animals were also noted after introducing the indicated doses of CH into the AC nucleus of the amygdala (Fig.2 - 4).

The micro-application of 5-OT to the amygdala core AB in doses of 10–20 µg did not lead to a violation of the conditioned drinking task. The rabbits placed in the starting point of the experimental box showed signs of emotional disturbance in anticipation of a sanctioned stimulus.

When a conditioned stimulus was presented, the rabbit reacted to it in a timely manner. The time spent on the jump-run, and lapping led to the formation of an alert reaction, pronounced salivation, and return did not change either. Under increased dose to 30-40 µg the animals did not show signs of emotional anxiety, which was reflected in an increase in the time of the latent period of reaction to the conditioned stimulus (from 1.27±0.07 to

3.37±0.09 sec). The administration of serotonin did not affect the overall motor activity. The animal made a run-jump, lapping and returning. The time indices of these components of the conditioned task remained at the level of the background indicators and were respectively: 3.37±0.1 sec; 20.23±0.15 sec and 4.23±0.07 sec. Increasing the dose to 50-100 µg led to complete inhibition of the conditioned task (Fig.1 - 5).

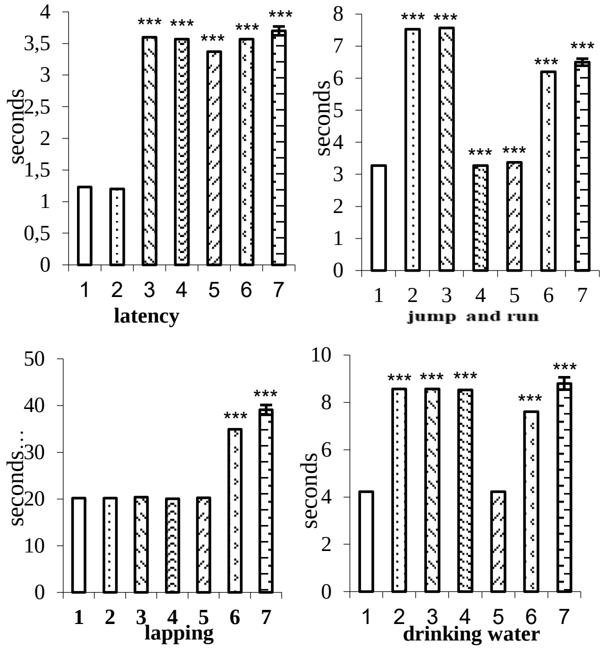

Figure 1. Influence of electrical and chemical stimulation of the AB of the amygdala nucleus on the time indices of the execution of the conditioned drinking task.

Note: 1 – background; 2, 3 – low- and high-frequency stimulation; 4 – CH micro-application; 5 – micro-application of 5-OT; 6 – HA micro-application; 7 – the application of novocaine.

The amount of water consumed did not change either. Similar changes in the behavior of animals were noted after the administration of 5-OT into AC (Fig.2 - 5).

The micro-application of NA (20 µg) into the amygdala nucleus AB led to the formation of a state of lethargy, and stupor in animals, which resulted in an increase in the time of the latent conclusions period of the reaction to the conditioned stimulus (from 1.23±0.07 to 3.57±0.08 sec). There was also an increase in the time spent on a jogging jump (from 3.27±0.07 to 6.2 ± 0.07 sec), lapping (from 20.27±0.12 to 34.93±0.15 sec), and vice versa. return (from 4.17±0.09 to 7.6±0.09 sec) (Fig.1 - 6). The micro-application of NA did not affect the amount of water consumed, which remained at the level of background indices. Similar changes in the behavior of animals were also noted after the micro-application of NA (20 µg) into the AC nucleus of the amygdala. There was an increase in the time of the latent period of the reaction - from 1.2±0.07 to 3.6±0.08 sec; jogging jump - from 3.3±0.07 sec to 6.2±0.07 sec; lapping - from 20.3±0.12 sec to 34.93±0.15 sec and return – from 4.2±0.09 sec to 7.6±0.09 sec (Fig.2 - 6).

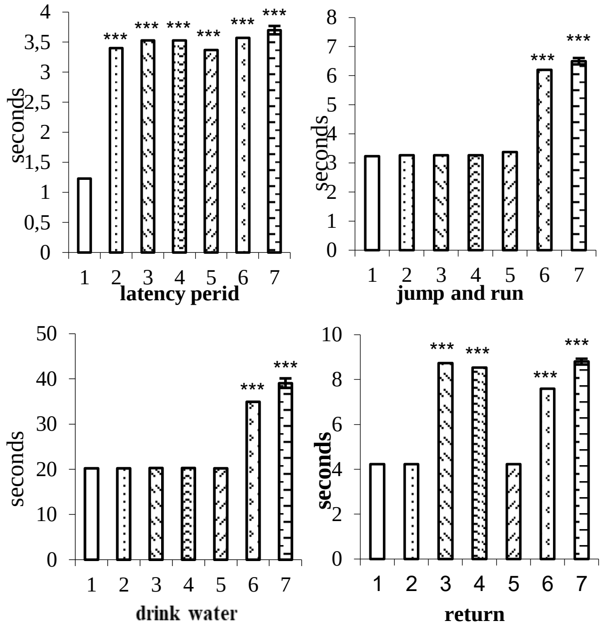

Figure 2. Influence of electrical and chemical stimulation of the AC nucleus of the amygdala on the time indices of the execution of the conditioned drinking task.

Note: All abbreviations as in Fig.1.

The introduction of a 10% solution of novocaine in AB led to some changes in the behavior of the animals. Animals placed in the experimental chamber did not show, as usual, signs of emotional arousal. The animal did not show any aggressive or defensive reactions and became tame. On the whole, such an inhibited state did not disturb the performance of the developed drinking habit. The animal reacted to the applied sound signal with a long latent period of 3.7±0.07 sec instead of 1.27±0.07 sec. The time spent on a jogging jump also increased - from 3.23±0.07 sec to 6.5±0.11 sec, lapping - from 20.07±0.1 sec to 39.07±0.21 sec, reverse return – from 4.27±0.07 sec to 8.8±0.13 sec. Registration of the amount of water consumed under conditions of novocaine blockade of AB in the amygdala nucleus did not reveal its change compared to the background index (Fig.1 - 7). Similar changes in the behavior of animals were also noted after the administration of novocaine into the central nucleus of the amygdala (Fig.2 - 7).

Our studies have shown that the micro-application of 2 μg of CH in both AB and AC amygdala nuclei of animals induced aggressive reactions: the animal became shy and shuddered at the sound signal, and it was difficult to pick it up. At the same time, the performance of the skill as a whole did not change. there was an increase in the time of the latent period of the reaction to the conditioned stimulus and the reverse return (2 times). The advent of searching motor reaction, a response of alertness, pronounced salivation, accompanied by an increase of the time of the latent period of the response to the conditioned stimulus, was also noted when 30 μg of serotonin was applied to the AB and AC of the amygdala nucleus. A similar behavioral response was observed by some scientists when 5-OT was administered to the AB nucleus of the amygdala complex in cats. An increase in the time of the latent period of the alimentary conditioned reflex was also noted in experiments on rabbits when the precursor of serotonin, 5-hydroxytryptophan, was administered intravenously [14]. At the same time, other scientists noted that, when serotonin was administered, in animals a violation of the coordination of movements, the development of a stupor state, and the phenomena of catalepsy were observed [8]. The degree of inhibition and the duration of the effect depended on the dose of the substance. Increasing the dose to 50-100 μg in our studies led to complete inhibition of the conditioned behavior. The emergence of a state of inhibition was noted by us through the micro-application of NA (20 μg), which was accompanied by an increase in all temporal parameters of the conditioned task. A similar behavioral response was obtained by some scientists when NA was micro-applied into the amygdala [6] - in rabbits, inhibition of food-conditioned behavior is observed, in dogs it partially inhibits motor food behavior.

We noted a more pronounced inhibition of the conditioned drinking task during novocaine blockade of the studied nuclei of the amygdala, while the animals became tame. In this case, there was an increase in all-time indices of the execution of the conditioned drinking reaction, but more pronounced than with the application of NA. The disappearance of the fear reaction without any special disturbances and motor reactions was obtained after the damage of the amygdala. The disappearance of aggressive reactions after the destruction of the amygdala and the fact that the animal becomes tame after such an operation suggests that the amygdala has a facilitated effect on the mechanisms of aggressive behavior. The most pronounced aggressive reaction was observed when the tonsils were irritated. Moreover, the lowest threshold for the alertness reaction and the orienting-exploratory reaction was evoked in our studies with nucleus AB, while the aggressive-defensive response was observed only with AC stimulation [7]. Thus, our data on the participation of the amygdala in conditioned reflex drinking behavior, obtained by the methods of electrical, chemical stimulation, and temporary switching off of the AB and AC of its nuclei, indicate its modulating role in the formation of complex forms of behavior. Since memory and learning are realized through the engagement of the emotional sphere including serotonergic and noradrenergic fibers [14], in these cases, the involvement of the amygdala in these nervous processes will be determined during the formation of emotionally positive behavior by the serotonergic system, and emotionally negative – by the noradrenergic system.

CONCLUSIONS

The effects of chemostimulation of the AB and AC nuclei of the amygdala showed that its different nuclei are associated with manifestations of opposite emotional states, which can be divided into three groups: search behavior of an emotionally positive type (licking, sniffing, salivation), the reaction of alertness and aggression. The data obtained indicate the modulating role of the amygdala in the formation of complex forms of behavior [14]. Since memory and learning processes are realized through the emotional status with the involvement of serotonergic and noradrenergic fibers, in these cases the involvement of the amygdala in these nervous processes is determined by the formation of emotionally positive behavior by serotonergic systems, and emotionally negative behavior – by the noradrenergic system.

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ИЗМЕНЕНИЕ ПИТЕВОГО НАВЫКА ПОД ВЛИЯНИЕМ ХИМИЧЕСКОЙ СТИМУЛЯЦИИ РАЗЛИЧНЫХ ЯДЕР АМИГДАЛЫ

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Целью исследования было изучение роли различных ядер амигдалы в реализации условного питьевого рефлекса, химической стимуляции (карбохолином, серотонином, норадреналином) и временном отключении ее базолатерального и центрального ядер. Результаты исследований свидетельствуют о модулирующей роли базолатерального и центрального ядер амигдалы в формировании сложных форм поведения. Результаты, полученные методами химической стимуляции и временного выключения ядер АВ и АС амигдалы, свидетельствуют о ее модулирующей роли в формировании сложных форм поведения. Поскольку память и обучение реализуются через эмоциональный статус с вовлечением серотонинергических и норадренергических волокон, то в этих случаях вовлечение миндалевидного тела в эти нервные процессы будет определяться формированием эмоционально положительного поведения серотонинергической системой, а эмоционально отрицательного - норадренергической.

Ключевые слова: карбохолин, серотонин, норадреналин, новокаин, условный питьевой рефлекс.

AMİQDALANIN MÜXTƏLİF NÜVƏLƏRİNİN KİMYƏVİ STİMULYASİYASI TƏSİRİNDƏN SONRA İÇMƏ BACARIĞININ DƏYİŞİLMƏSİ

Rəfiqə Məzahir qızı Bağırova

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Tədqiqatın məqsədi amiqdalanın müxtəlif nüvələrinin şərti içmə refleksinin həyata keçirilməsində, kimyəvi stimulyasiyasında (karbokolin, serotonin, norepinefrin ilə) və onun bazolateral və mərkəzi nüvələrinin müvəqqəti söndürülməsində rolunun öyrənilməsindən ibarət idi. Tədqiqatın nəticələri amiqdalanın bazolateral və mərkəzi nüvələrinin mürəkkəb davranış formalarının formalaşmasında modullaşdırıcı rolunu göstərir. Onun mürəkkəb davranış formalarının formalaşmasında amigdalanın AB və AC nüvələrinin kimyəvi stimulyasiya və müvəqqəti söndürülməsi üsulları ilə əldə edilən nəticələr modulyasiyaedici rolunu dələlət edir. Yaddaş və təlim serotoninergik və noradrenergik lifləri əhatə edən emosional status vasitəsilə həyata keçirildiyindən, bu hallarda amiqdalanın bu sinir proseslərində iştirakı serotoninergik sistemin emosional müsbət davranışının, noradrenergik sistemin emosional mənfi davranışının formalaşması ilə müəyyən edilir.

Açar sözlər: karboxolin, serotonin, norepinefrin, novokain, şərti içmə refleksi

Çapa təqdim etmişdir: Arif Əli-Övsəd oğlu Mehdiyev (redaktor), b.e.d., dosent.
Redaksiyaya daxil olma tarixi: 11.01.2022.
Təkrar işlənməyə göndərilmə tarixi: 21.01.2022.
Çapa qəbul edilmə tarixi: 18.04.2022.