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Participation of Various Nuclei of the Amygdala in the Implementation of the Drinking Conditioned Reflex

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ABSTRACT

The main goal of this study was to study the effect of electrical stimulation and temporary switching off of the basolateral and central nuclei of the amygdala on the performance of the developed drinking conditioned reflex skill. From the first minutes after stimulation of the basolateral nucleus of the amygdala, an increase in behavior of an emotionally positive type was noted - the rabbit was animated, sniffing the starting compartment of the experimental chamber, licking, washing, sometimes chewing movements appeared. An increase in stimulation parameters led to the occurrence of the reactions described above directly during stimulation and continued after the cessation of the stimulus. The subsequent increase in the strength of the current led to rage. Electrical stimulation of the AC at low parameters of the stimulating current led to the emergence of an aggressive-defensive state. An increase in the parameters of the stimulating current led to the emergence of an aggressive-defensive state. When the basolateral nucleus of the amygdala was temporarily switched off, 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 execution of the skill was not violated in both cases. The effects of electrical stimulation of AB and AC nuclei of the amygdala showed that its different nuclei are related to opposite manifestations of emotional states, which can be divided into three groups: search behavior of an emotionally positive type (licking, sniffing, salivation), reaction of alertness and aggression.

Introduction

The amygdaloid region (almond-shaped complex, amygdala) is a complex formation of the brain that is part of the limbic system. Being its integral part, it has a modulating and corrective effect on the activity of the main brain stem formations, through which the formation of a motivational-emotional state is carried out. The amygdala receives information from all the senses [1]. This is possible due to its communication with a structure called the entry gate in the brain - the thalamus. Direct communication with the amygdala is necessary for a quick response to external stimuli [2]. In addition, emotional responses include the occurrence of precipitating factors simply by thinking or imagining [3]. To do this, the amygdala has a connection with associative zones - areas of the cortex, covering the assembly of incoming information into whole images, as well as with the hippocampus. In addition, the tonsils are found with subcortical structures such as the basal ganglia and the accessory nuclei. With most structures, the amygdala is connected by bilateral connections, and above all, with the prefrontal cortex. For example, the amygdala influences the prefrontal cortex (PFC) in risk/reward risk assessment in animals [4], and stimulation of the projection pathways of certain regions of the PFC to the amygdala can increase or decrease prosocial behavior [5].

Violation of the connections between the amygdala and PFC can be detected in a number of pathological conditions-post-traumatic stress disorder (PTSD), depression, etc. [6]. The amygdala is also associated with the hypothalamus, which plays an important role in the regulation of stress reactions, sexual behavior, and aggression [7]. Different nuclei of the amygdala are involved in different behaviors. So, the lateral nucleus plays a role in reactions that are associated with fear [8]; the basolateral nucleus contains groups of neurons that respond to both negative stimuli (fear, anxiety) and positive ones (reward) [9]. CEA is the main exit gate of the amygdala. This part is responsible for reactions to emotional stimuli. The medial nucleus of the amygdala in animals is especially important in sexual behavior. In humans, MeA mainly reacts to pungent odors [10] and takes part in their memorization [11]. Considering all of the above, the main goal of this study was to study the effect of electrical stimulation and temporary switching off of the basolateral and central nuclei of the amygdala on the performance of the developed drinking conditioned reflex skill.

Methods

Experiments were performed using 20 rabbits breeds of "Chinchilla" in weight 2-3kg trained to perform a conditioned operant drinking behavior reflex. The animals were subjected to water deprivation for 24 and 48 hours, after which they were trained in the instrumental drinking skill. In response to the sound signal, the rabbit pressed the pedal, as a result of which the door opened, jumped over the barrier from the starting compartment of the chamber to its target section to receive water in a strictly defined dose (5-10 ml) and then returned back to the starting section cameras. The conditioned stimulus was applied at regular intervals (every 45 s) from 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 under conditions of 100% reinforcement. In the study of behavioral reactions, the time from the moment the signal was given to the start of the jump (latency period), the time of running, lapping, and also the time spent on returning to the starting box of the camera were recorded. Electrical stimulation of the basolateral nucleus of the amygdala - AB (A-1; L5; H18) and central nucleus of the amygdala - AC (A-1; L5; H16) of the brain was carried out using a universal electro stimulator ESU-1. Temporary shutdown of the studied areas of the CNS was carried out with a 10% novocaine solution. To control the rabbits in the study area was injected with saline in a volume equal to the injected solutions.

Results and Discussion

Our research revealed the functional differentiation of the amygdala complex in relation to the execution of the developed conditioned reflex skill. So, electrical stimulation AB nucleus of the amygdala at low stimulation parameters of 10-50 μA; 5 Hz, 0.5 ms) did not lead to a violation of the drinking habit. The rabbits responded in a timely manner to the sound signal, making a running jump from the starting section of the chamber to the target section to receive reinforcements (water 5–10 ml) and then returning back to the starting section of the experimental chamber. The time parameters of the conditioned reflex skill remained at the level of background indicators: latent period - 1.23±0.07 sec, jogging - 3.27±0.07 sec, lapping - 20.23±0.12 sec, reverse return 4.23±0.07 sec. An increase in stimulation parameters (50–100 μA; 5–10 Hz msec) also did not lead to a violation of the drinking habit. In comparison with intact rabbits, from the first minutes after stimulation, there was an increase in behavior of an emotionally positive type - the rabbit is animated, sniffing the starting compartment of the experimental chamber, licking, washing, sometimes chewing movements appear. At the same time, despite this increase motor activity, when a sound signal was given, the animal promptly responded to the given sound signal by jumping and running from the starting compartment of the chamber to its target box, followed by lapping.

The latent period of the reaction remained at the level of background indicators (1.2±0.07 sec), while the time spent on jumping and running due to the occurrence of a search reaction increased from 3.27±0.07 sec to 7, 5±0.1 sec. The time spent on the consumption of 5 ml of water did not change and amounted to 20.17±0.11 sec. In connection with the occurrence of the reaction of licking, washing, sniffing the experimental chamber, the time for the animal to return to the starting box of the chamber slightly increased (the animal was easily distracted, looked around, sniffed the barrier of the chamber) - from 4.23 ± 0.07 seconds to 8, 57±0.08 sec. An increase in stimulation parameters led to the occurrence of the reactions described above directly during stimulation and continued after the cessation of the stimulus. In connection with prolonged washing, the time of the latent period of the reaction to the conditioned stimulus increased from 1.2±0.07 to 3.1±0.07 sec. An increase in stimulation parameters did not affect the amount of water drunk. A subsequent increase in current strength to 300 μA led to rage.

Recording the amount of water consumed showed that it remained at the level of background indicators. Electrical stimulation of the AC nucleus of the amygdala at low stimulation parameters (10-50 μA; 5 Hz; 0.5 ms) did not affect execution drinking developed skill. The rabbits were completely calm, all parameters of the conditioned reflex skill remained at the level of background indicators. An increase in stimulation parameters (50-100 μA; 5-10 Hz; 0.5 ms) did not lead to drastic changes in the behavior of the animals. The rabbits were alert, an increase in general motor activity was noted, which was accompanied by an increase in the time of the latent period of the reaction to

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the conditioned stimulus (from 1.23±0.07 to 3.4±0.09 sec). The remaining parameters of the execution of the conditioned reflex skill remained at the level of background indicators: jump-run - 3.27±0.07 sec, lapping - 20.23±0.15 sec, reverse return - 4.25±0.29 sec.

A further increase in the parameters of the stimulating current - current strength up to 100-200 μA, frequency - 10-50 Hz, stimulus duration 0.5 ms led to the emergence of a state of an aggressive-defensive nature: the animal became shy, it was difficult to pick it up, shuddered at the applied conditioned stimulus, was very mobile. This state could be attributed to an emotionally excited state. The execution of skills was not disturbed: the animal reacted to an undelivered signal, performed all components of the conditioned drinking reflex. It should be noted a slight increase in the time of the latent period of the reaction to the conditioned stimulus from 1.23 ± 0.07 to 3.53 ± 0.09 sec and the return return - from 4.2 ± 0.07 to 8.73 ± 0.07 sec, and the time spent on jumping and lapping remained at the level of background indicators and, respectively, was equal to: 3.23 ± 0.07 and 20.2 ± 0.15 seconds.

Recording the amount of water consumed showed that it remained unchanged. Observations of animal behavior have shown that under conditions of electrical stimulation of the amygdala nucleus AB, an orienting-exploratory reaction of an emotionally positive type is noted, accompanied by licking, washing, salivation, while exposure to similar parameters of the irritating current on the AC nucleus of the amygdala provokes the appearance of aggressive-defensive behavior. Our data are consistent with the studies of some authors, who also observed the appearance of orienting-exploratory behavior upon stimulation of the nucleus AB and an aggressive defensive reaction upon stimulation of the AC nucleus of the amygdala complex [12].

At the same time, some scientists noted the onset of an alert reaction, turning into an orienting reaction, with threshold stimulation of the amygdala. With an increase in the parameters of stimulation of AL and AC of the amygdala nuclei, the alertness reaction could be replaced by a fear reaction, and when stimulated by AB, by a rage reaction [13]. In addition, in experiments on rabbits, stimulation of the amygdala caused changes in the emotional state of various nature. Motor acts of sniffing, licking, chewing and salivation were noted by scientists during stimulation of the anteromedial part of the amygdala and refer these symptoms to sexual and parental activity [14].The effects of electrical stimulation of AB and AC nuclei of the amygdala showed that its different nuclei are related to opposite manifestations of emotional states, which can be divided into three groups: search behavior of an emotionally positive type (licking, sniffing, salivation), reaction of alertness and aggression.

Conflict of Interest

No conflict of interest with any institution/organization.

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