Changes in rats cardiovascular parameters caused by ultrasonic vocalization presentation (description for the general public)

Emotional arousal in humans is caused by changes in our physiological state evoked by perceived stimuli. One of the prominent physiological manifestations of our emotional state is the heart rate. In the states of emotional excitation, HR usually rises and it also usually decreases in a relaxed state. The signaling pathway between the central nervous system and the heart is the vagus nerve which also goes to the larynx – where it is responsible for speech modulation. Also, some aspects of human speech and HR are a result of excitation of the same parts in the brain. This is why in a state of strong emotional arousal, humans not only have a rise in HR but also speak louder and with a higher pitch. A similar correlation has also been described in animals.

Rodents, for example rats, communicate mainly in the ultrasonic spectrum, in frequencies that cannot be heard by humans. Their ultrasonic vocalizations (USV) are classified into two categories: 22 kHz (appearing in unpleasant situations like fear, pain or predator scent) and 55 kHz (in pleasant situations: playing with other rats, courtship behaviors). This way rats can associate a particular sound frequency with a positive or negative situation.

In this project, we plan to register and measure the HR and behaviors of animals, including emitted USV, as a reaction to ultrasounds presented from a speaker. It is unknown if changes in HR can be caused by not only experiencing the situations in which USV are produced but also by hearing USV related to pleasant/unpleasant situations.

The aim of the study is to investigate for the first time changes in cardiovascular parameters and rat behaviors caused by USV playback presented to animals with different states of the autonomous nervous system excitation. The measured parameters will include: heart rate, arterial blood pressure, USVs produced by the animals and other behaviors. We will use the following experimental setups: rats housed in different social context, rats living in subchronic stress, pharmacological blocking of the autonomous system and rats with inherited genetic tendency for faster development of the sympathetic system.

Social context. USV are a mean of communication between rodents. We propose a hypothesis, that the response to heard USV will be different in rats living in different social context, e.g. single housed or kept in pairs as well as towards USV of familiar vs unfamiliar animals.

Subchronic stress. It is believed that living in chronic stress causes HR rise. However, when the stressful stimulus appears for couple of days in a row, but not long enough, a contrasting result is observed, paradoxically – HR significantly decreases. This phenomenon is explained by the increase of the vagus nerve stimulation, which slows down the heartbeat. Such shift seems to be an adaptation of the body to stress. However, it is time-restricted and disappears after a couple of days. Then changes related to persisting stress begin to occur in the organism, and these changes are difficult to reverse. The decrease in HR in rats has been observed for five days. We want to expand these studies. Investigating the HR and USV during increased vagus nerve stimulation will broaden our knowledge about the development of stress.

Blocking of the autonomous system. This system is independent from our will, it is the part of the nervous system, which regulates the work of internal organs (e.g., HR, digestion etc.). For example, by looking at the heart, it is easy to observe the two contradicting elements of the autonomous system – one stimulates the heart to beat (sympathetic system), while the other decreases the heart rate (parasympathetic system whose element is the vagus nerve). The two systems are in a subtle dynamic balance, shifting toward one or another depending on a situation. To block the sympathetic system, we will use atenolol, a drug used in arterial hypertension. To block the parasympathetic system, we will use atropine, commonly used to widen the pupils before eyesight checkup. We propose a hypothesis that variations in HR resulting from inhibiting one element of the autonomous system, will translate to changes in the perception of USV in rats, both in their behavior and calls emitted.

Rats with inherited domination of the sympathetic system are considered to be an ADHD model most similar to human patients – as in humans with ADHD, these rats do not show hyperactivity in a new environment and also react to the same pharmacological compounds. Investigating reactions of these animals to USV presented may help us to understand the mechanisms of impaired communication with persons with ADHD.

Combining the measurement of cardiovascular parameters with a stressful situation and registration of USV, with social communication functions, has a significance in research concerning the physiology of hearing, communication, emotions, motivation, social neurobiology as well as models of fear, depression, autism, addiction and Parkinson disease.