# Electroencephalography in Determining Mood in Animals

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## ABSTRACT

Electroencephalography is one of the most common methods used in the interpretation of neurological activities in the brain of humans and various model animals. With the electroencephalography method, it is possible to obtain information about the various changes that occur in the model creature, its relationship between species, and its emotional state. It is observed that various behaviors are exhibited in model animals due to some factors such as mood, sleep disorder, epilepsy, depression, pain, drug use, addiction, genetics, and environmental.

When these behaviors are examined in the studies; neurodevelopmental disorders, mood disorders, olfactory disorders, visual attention dysfunction, sleep disorders, brain dysfunction, learning disorder, various adjustment, autistic-like behavioral disorders, autism, attention deficit, hyperactivity, anxiety, aging, traumatic brain injury, repetitive grooming It has been observed to cause various behaviors such as social deficits, decreased activity, anxiety, fear conditioning, calmness, staring, anxiety, fear, learning disability, intermodal recognition memory, and depression.

*Keywords:* model animal, behavior, neuroscience, mood, electroencephalography.

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# Electroencephalography in Determining Mood in Animals

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## ABSTRACT

*Electroencephalography is one of the most common methods used in the interpretation of neurological activities in the brain of humans and various model animals. With the electroencephalography method, it is possible to obtain information about the various changes that occur in the model creature, its relationship between species, and its emotional state. It is observed that various behaviors are exhibited in model animals due to some factors such as mood, sleep disorder, epilepsy, depression, pain, drug use, addiction, genetics, and environmental.*

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*The results of the studies show that these behaviors are closely similar to electroencephalographic humans and various model animals. This study, it is aimed to give information about the state of hearing between humans and various model animals with the method of electroencephalography.*


*Keywords:* model animal, behavior, neuroscience, mood, electroencephalography.

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## I. INTRODUCTION

From the moment of their existence, animals exhibit innate and acquired behaviors. Innate behavior; is an instinctive stereotyped movement pattern or reflex-type behavior that occurs due to a stimulus without the need for experience (Aydemir and Bilge 2022). For example, the female animal suckling her young after pregnancy. Apart from this, it is observed that animals exhibit behaviors such as the defense of the area, competition behaviors, and communication in social groups.

It is observed that they exhibit various behaviors for temporary periods that occur under the influence of illness, pain, and medication. But; as a result of factors such as anxiety and stress, they exhibit abnormal behaviors such as phobia (Aydemir and Bilge 2022). Such behaviors are passed down through generations through genes specific to the species.

In many behaviors, it can be acquired later with environmental adaptations (Aydemir and Bilge 2022). Apart from the normal behavior typical of all animals species; aggression behaviors in line with environmental effects such as fear, different light wavelengths, different sound frequencies, heat, stress (status-related attack, intermale attack), predatory attack, idiopathic anger attack (idiopathic rage), fear-based attack (fear-induced), territorial and instinctive attack (maternal), environmentally damaging behaviors, coprophagia, social behavior and agonistic behaviors, urination or defecation outside the designated place, urine marking, wool (cloth) sucking, abnormal behaviors such as aggression are exhibited (Sambraus 1998; Blackshaw 1991;

Aydemir and Bilge 2022). For example; in animals, abnormal behaviors are exhibited due to many physiological changes such as an increase in corticosterone levels, and immune, metabolic, and sleep disorders (Wang et al. 2017; Dolensek et al. 2020).

All these behaviors exhibited are a psychological indicator of the emotional state of the animal (Bilge and Aydemir 2022; Aydemir and Bilge 2022; Aydemir et al. 2021). These psychological indicators are very similar to humans. For example; Behaviors such as depression, social avoidance, anhedonia, passive coping, and learned helplessness observed in humans are similar to the behaviors exhibited in animals (Tye 2018; Muir et al. 2018). Moreover; is observed that many model animals such as mice and monkeys exhibit similar behaviors in many diseases such as depression, chronic stress, sleep disorders, and epileptic seizures observed in humans (Brittlebank et al. 1993; Grandjean et al.

2016; Gadad et al. 2013) and Crawley 2012; According to Jaramillo et al. 2016; Dhamne et al. 2017; Citraro et al. 2019; Roebuk et al. 2020; According to Cai et al. 2020; According to Gandal et al. 2010; Dringenberg 2000). This gives information about the behavior between humans and animals. Various behavioral tests, biomarkers, and Electroencephalograms are used to measure this information (Roach et al. Mathalon, 2008; Koenig et al., 2005).

Electroencephalograms (EEG) are a non-invasive technique that allows the measurement of electrical brain activity in a human or model animal. It can also record brain signals thanks to its high temporal resolution (Ward 2003; Lopes and MEG 2013). These recorded signals are a good source for obtaining information about the neurological status of the model creature (Saminu et al., 2021).

## II. ELECTROENCEPHALOGRAPHY (EEG) IN MODEL ANIMALS

Electroencephalography in model animals is a method used to functionally examine the electrical signals produced as a result of neurological activities in the brain (Ward 2013-2015; Bear et al. 2016; Lopes and MEG 2013). Thanks to this method, information is obtained about normal and abnormal functioning in the brain.

Electroencephalography reflects the total slow dendritic potentials of many cortical pyramidal neurons. EEG rhythms in different frequency bands arise from dynamic interactions between populations of neurons and are associated with several different cognitive processes. With this association, EEG recordings show abnormalities in brain functioning (Ward 2013-2015; Bear et al. 2016; Lopes and MEG 2013).

It has also been used in the diagnostic criteria of various psychiatric disorders such as schizophrenia, bipolar disorder, sleep disorder, attention-deficit/hyperactivity disorder (ADHD), and Alzheimer's disease, especially in recent years (Roach et al. Mathalon, 2008; Yordanova et al., 2001; Koenig et al., 2005). It is known that the Prefrontal, Orbitofrontal, and Insular Cortices mPFC and its inputs/outputs are involved in behaviors related to anxiety and mood in psychological and psychiatric diseases such as these (Kheirbek et al. 2012; Kheirbek and Hen 2014). Polysomnography, which is used in the diagnosis of sleep disorder, provides information about brain electrical activity (EEG), sleep stages, sleep quality, muscle activity (EMG), respiratory rate, eye movements (EOG), heart rhythm (ECG) and physiological states of activities in sleep stages (Boulos). et al. 2019; Weber and Dan, 2016; O'Donnell et al. 2018). Recording the electrical activity of the brain with electrodes placed on the scalp is called Electroencephalography (EEG).

They observed that repetitive grooming, social deficits, decreased activity, anxiety, learning problems, reduced fear conditioning, olfactory disorders, hyperactivity, and various autistic-like behavioral disorders occur in the model animal (Jaramillo et al. 2016; Dhamne et al. 2017; Balzamo). et al. 1998; Gadad et al. 2013; Crawley 2012; Cao et al. 2020; Radyushkin et al. 2009; Liu et al. 2017).

Thanks to the electroencephalography obtained from these behavioral disorders, it is possible to comment on the relations between the species.

## III. DISCUSSION

When many studies on animals and humans are examined; is observed that there is a close relationship between the emotional states of animals and humans. As an indicator of this close relationship; is stated that facial expressions in mice reflect internal emotional states, just like facial expressions in humans (Dolensek et al. 2020; Stringer et al. 2019).

There are many examples like this. Electroencephalography of these samples is functionally obtained by electroencephalography of the electrical signals produced as a result of neurological activities in the brain (Ward 2013-2015; Bear et al. 2016; Lopes and MEG 2013; Gandal et al. 2010; Dringenberg 2000).

In the results of many studies, they reported that neuronal activities were similar between human and animal experiments according to electroencephalography recordings (Videman et al. 2016; Fedor et al., 2010; Colas et al., 2005; de Vries et al., 2005).

For example; It is stated that close similarities are observed in the electroencephalography of pathological conditions such as neurode-velopmental disorders, autism, attention deficit hyperactivity, mood disorder, anxiety, and adjustment disorders, brain dysfunction, learning disability, aging, and traumatic brain injury (Fedor et al., 2010; Colas et al., 2005). ; de Vries et al., 2005).

### *3.1 Mood*

Brittlebank et al. (1993) in the results of a study; In the case of depression, people are prejudiced against overgeneralization; reported that animals exhibit simple behaviors such as avoidance and approach as an indicator of their internal emotional state. In the results of another study, Grandjean et al. (2016) determined that increased amygdala-PFC functional connectivity and white matter structural changes in the cingulum showed similarity in mice and humans against chronic stress. The results of a study by Xunxun Chu (2019) reported that the naturally induced depression models in macaques are very similar to the human depression model.

### *3.2 Sleeping Disorder*

When examining studies on sleep disorders, Gadad et al. (2013) and Crawley (2012) reported in the results of the study that there is a similarity between the symptoms of sleep disorders between animal models and humans. According to Jaramillo et al. (2016) and Dhamne et al. (2017) as a result of sleep disturbance in Shank3 knockout mice; they observed the emergence of repetitive grooming, social deficits, decreased activity, anxiety, learning problems, and various autistic-like behavioral disorders.

In another similar study, Cao et al. (2020) reported that abnormal behaviors and seizures due to sleep disturbance were observed in Neuroligin-2 knockout mice. Radyushkin et al. (2009) and Liu et al. (2017), it was observed that Neuroligin-3 knockout mice preferred reduced fear conditioning, olfactory disorders, and hyperactivity, as well as reduced ultrasound vocalization and social innovation due to sleep disturbance. On the other hand, Monassi et al.

(2003), Andersen and Tufik (2003), in the results of the studies against a living thing that affects from the outside; observed that they exhibit temporary or permanent changes in behavior.

Moreover; they also found that their mice showed sleep disorders. Armitage (2007) found in a study that electroencephalography findings were more than 80% of patients with depression and that these people had sleep disorders.

### *3.3 Epilepsy*

Citraro et al. (2019) examined the development of epileptic seizures and behavioral changes in mice with EEG. In the results obtained by the study results; They reported that it could represent a promising new therapy to prevent and treat the epileptogenic process and associated behavioral and cognitive changes. In another similar study, Roebuk et al. (2020) reported that the results of genetic absence epilepsy EEGs in mice include behavioral stagnation, staring, anxiety, fear, learning disability, and dysfunction in intermodal recognition memory and visual attention.

Electroencephalography is an important tool for characterizing epilepsy in tuberous sclerosis complex mouse models (Magri et al., 2011; Zeng et al., 2008). Background EEG spectral analysis is commonly used to investigate.

### 3.4 Some Environmental Factors

In addition to all these, when studies conducted in line with environmental effects such as fear, different wavelengths of light, different sound frequencies, temperature, and stress are examined, Gavales et al. (1970) studied the effects of low-level, low-frequency electric fields on monkeys' behavior and EEGs. In the results of the study, monkeys under 7 c/s fields reported significantly faster reciprocal response time in 5 of the 6 experiments. In addition, the results of the analysis of the EEG data showed that the average differences between open and closed areas were more than 0.4 seconds; reported that all monkeys showed a relative power peak in the frequency of the areas (10 c/sec and 7 c/sec) for the hippocampus. In some studies, Stephenson et al.

(2012), Glickman et al. (2006), Strong et al. (2009), Cajochen et al. (2000), and Beersman (2003), on the other hand, examined the relationship between daylight and behavior. In the results of the study, they reported that electroencephalography data affected mood, depression, behavior, sleep disorders, and physiological and chemical functions.

In another study, Hallaschmid et al. (2002) examined whether reward in humans is associated with EEG synchronization similar to that seen in animals. In the results of the study, the researchers reported that increased beta activity during drinking and sucking in thirsty subjects likely reflects nonspecific activation related to the motivational power of sensorimotor regulation during consumption behavior.

They also stated that low alpha synchronization due to thirst after drinking, which is created not only by water consumption but also by surrogate oral stimuli, is a reflection of the impulse-reducing and rewarding qualities of oral stimulus and consumption behavior.

### 3.5 Genetic

Among the factors affecting behavior in model animals; genetic factors, age, gender, physiological, and hormonal conditions are included. In the results of a study using mice as model animals, Cambiaghi et al. (2012) reported that tuberous sclerosis complex caused by benign tumors in different organs and serious neuropsychiatric symptoms such as epilepsy, intellectual disability, autism, anxiety, and depressive behavior can be determined by EEG method. Also, Cambiaghi et al. (2012) found that anxiety and depression were reduced in mutant mice treated with rapamycin in their EEG power spectrum results.

Carter (1978) reported that it produced a trance-like stupor in all monkeys associated with marked EEG changes and hypothermia in adult and preadolescent rhesus monkeys. Researchers have also found that characteristic EEG and behavioral changes are age-related. In another study, Cai et al. (2020) examined expression networks, locomotive, and cognitive behaviors, and EEG and gene-circuit-behavior analyses in genetically modified monkeys. The results of the study; reported that decreased β-synchronization in front-parietal-occipital networks was associated with abnormal locomotive behaviors.

Blackburn-Munro (2004), who conducted a study on genetically manipulated animals, stated that there are many pathological changes similar to various chronic pain in humans in animal models of chronic pain, using it together with classical physiological and biochemical measurements according to EEG results. Moreover; reported that the evaluation of pain and stress with the EEG method in animals is an alternative method.

Tuberous sclerosis Complex is a multisystem genetic disorder caused by mutations in the Tsc1 or Tsc2 genes that lead to hyperactivation of the m TOR pathway, a key signaling pathway for synaptic plasticity.

### 3.6 Pain

Joyce and David (2019), who conducted a study on rats, mice, and monkeys, examined the electroencephalography of acute and chronic pain.

In the results of the study, the researchers observed that the transition from acute pain to chronic pain resulted in significant changes in brain function.

Moreover; they reported that brain activations in acute pain are related to the sensory aspect of noxious stimuli, including the primary somatosensory cortex, insula, cingulate cortex, thalamus, retrosplenial cortex, and periaqueductal gray.

Ong et al. (1997) measured acute pain in sheep and examined changes in both the electroencephalogram frequency spectrum and behavioral responses to increased electrical stimulation in sheep.

In the results of the study, they stated that the human acute pain model can be applied to sheep and that these electroencephalogram changes can provide a good measure for acute pain in sheep.

### 3.7 Medicine

Van Lier et al. (2004), Graversen et al. (2012) Leocani et al. (2000), and Barry et al. (2009); In the studies conducted by Cambiaghi et al. (2012) Baumann et al. (2006) stated that the changes in the brain caused by the drug efficacy in humans and animal models are closely related to behavior.

They reported that these relationships are a frugal indicator between EEG data and behavior. They found a slight but significant reduction in theta and alpha mean dominant frequency (MDF) with behavioral changes in rapamycin-treated wild-type mice, suggesting a mild brain dysfunction associated with the drug treatment studies by Salinsky et al. (2004), Leocani et al., (2000, 2010), Klimesch (1999), and Klimesch, (1997). They reported that this resulted in a mild brain dysfunction associated with drug therapy.

They also observed that EEG slowing in humans is associated with neurological disorders or even lower working memory, IQ or drug-induced lethargy, and cognitive impairment in healthy subjects.

### 3.8 Dependence

Howard (2000) examined the electroencephalography of the brain functioning in various animal models with alcohol dependence. The researcher reported that there are physiological and behavioral advantages and disadvantages to alcohol withdrawal syndrome. The researcher also stated that it may affect enhanced autonomic nervous system activation, sensory hyperreactivity, convulsions, anxiety, and dysphoria.

When other similar studies are examined, Walker and Zornetzer (1974), Ehlers and Chaplin (1991), Poldrugo and Snead (1984), and Perrin et al. (1975) reported that EEG abnormalities were associated with alcohol withdrawal in various model animals, including mice, rats, cats, and primates.

## IV. CONCLUSIONS

There are various behaviors that they exhibit depending on the various moods observed in humans and various model animals. These behaviors vary depending on some factors such as mood, sleep disorder, epilepsy, depression, pain, drug use, addiction, genetics, and environmental.

Neurodevelopmental disorders, mood disorders, olfactory disorders, visual attention dysfunction, sleep disorders, brain dysfunction, learning disorders, various adjustment, and autistic-like behavior disorders, autism, attention deficit, hyperactivity, anxiety, aging, traumatic brain injury in various model animals. It has been observed that various behaviors such as repetitive grooming, social deficits, decreased activity, anxiety, fear conditioning, calmness, staring, anxiety, fear, learning disability, intermodal recognition memory and depression are exhibited.

It has been observed that these behaviors closely resemble each other among various species of electroencephalography.

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