Dean&Francis

ISSN 2959-6157

Animal Emotions and Mental Health: Evolutionary Foundations and Measurement Methods

Xiru Chen[1, *]

[1]Shanghai Pinghe Bilingual School, Shanghai, 201206, China
*Corresponding author: kitty_amy2007@outlook.com

Abstract:

Understanding animal emotions has become one of the key and hot topics in the past few decades of cognitive science and behavioral ecology research. More and more evidence show that many animals have emotional capacity that affect their survival and reproduction. This paper reviewed the evolutionary basis, brain mechanism and measurement method of animal emotions and affective states. First, we analyzed how the experience of emotions serves as an individual's adaptive behavior function and social regulation mechanism for the individual to understand the outside world and self-awareness. Based on comparative neuroanatomy and evolution studies, it was found that important emotional circuits such as amygdala and prefrontal cortex evolved in vertebrates, as well as similar affect mechanisms in birds. This review summarizes the most used methods, which include many different forms from psychological or behavior perspective such as the emotional cognition based on psychological bias or emotion cognitive and decision-making (emotional decision making and cognitive test based), including cognitive bias method and preference choice methods and others. In addition, the specific cognitive paradigm method such as the cognitive bias method is discussed for measuring animals' subjective feelings and affective states more effectively. We hope this review would help foster human perception of animals' subjective emotional experiences, establish theoretical basis and improve the research approach about animal feeling, animal welfare and mentality as well as facilitate our knowledge to find clues on the evolutionary origin of human and other animal emotions.

Keywords: Animal Emotion; Affective States; Evolutionary Neuroscience; Cross-Species Comparison.

1. Introduction

The last decades animal emotions have drawn a great deal of attention, and it becomes a hot area in cognitive science and the study of behavior ecology. Now more and more studies show that complex emotional capabilities of animals affect their survival and reproduction [1], such as chimpanzees hug each other to reduce the post-conflict stress after aggression, rodents with negative stimuli will have positive bias and so on. These all suggest that emotions are not unique phenomena existing in human beings only. Although the publishing quantity of papers about animals' emotions has exploded with, debates among scientists remain unresolved. Whether some species really have emotion or not; why some do but others don't; what is the physiological mechanism of emotion and its characteristics in different species. All these debates were answered in fact through animal psychology and behavioral experiments step by step, and finally, people gradually accepted one universal law that emotion was a natural phenomenon conserved for promoting the individual's or animal's fitness. As mentioned previously, emotions are ultimately products of the nervous system, because it was through emotions that individuals would respond flexibly to the changes around them and act in a manner in line with needs to survive. For example, fear may trigger flight responses; it may be happiness makes us move around… emotions played an important role in body as we dealt with various conditions effectively. It would directly affect our immediate physical survival in any ways, or involved in memory and decisions, participating in long-term learn processes and affecting brains structure by changing. It even communicated messages by faces expression for cohesions of same group animal members, resolving conflicts of animals inside same group or between different groups, then promoting cooperation in other aspects, as among socially live animals [2]. For that reason, a lot of scholars believe it is that emotions were evolutionary preserved mechanisms that enhance adaptive fitness not only on the individual level but also on the group levels. At the same time, many animal experts focus on studying how mammals feel environment around them, to keep more comfortable or less stressful living environments and higher adaptability; while the interest lies in researching animals' feelings, especially non-human mammals, who has been popular both in academic discussions and for keeping zoos for public comprehension about animals. So far scholars began have renewed efforts to explore the nature and mechanisms of meaning of animals' emotions from new perspectives comprehensively; especially focusing upon differences between animals or between mammals and other species, and considering meanings about emotional evolution from neural base, behaviors, patters, comparing methods [3], etc. Present research mainly focuses upon three problems and questions, i.e., the origins and the adaptive significances about emotions; emotional neuroscience and mechanisms of different animals' emotions; evolution and conservation mechanisms in different animals. And for the measuring means for emotion states of the animals by using kinds of behaviors testing instruments or measuring neurophysiological indicators to judge whether animals do have real emotions, of them common tools for doing experiments with behavioral methods are emotional biases or tendency test, and complicated ones are facial encoding and codification methods, [4, 5]. All of these have faced lots of challenging in methodology utilizing in experimental research on emotions of animals and applicability ranges of different animals also have challenges, especially it might be really complicated to define and measure animal emotions precisely, especially emotions of non-mammals.

New doors to the study of animal affect have been opened by approaches such as neuroscience, ethology, endocrinology, artificial intelligence, etc., and new methods will gradually enter the research field on emotions and affective states in animals. For example, wearable biosensors and machine learning algorithms can be used to monitor subtle changes in animal behavior and physiology, providing continuous and accurate measurements of the emotional states of animals [6]. Therefore, this review attempts to summarize current research on animal emotions and understand the nature, regulation, and methods of emotional evaluation. We raise three questions. To begin with, what exactly forms the foundation of emotion within species? Are there any shared mechanisms through which they manage their emotional states across various species? Is it possible that emotional states could act as indicators of mental health for animals? By providing answers to these questions, we aim to offer a more lucid perspective on the essence of animal emotions and establish a foundation for the examination of mental health in different animals.

2. Evolutionary Foundations of Animal Emotions

2.1 Adaptive Functions: From Survival Responses to Social Regulation

Emotions enable animals to make decisions within complex environments. Take the case of a wild rabbit; upon spotting an animal, fear arises within it. Following this, the rabbit runs off and conceals itself. Furthermore, emo-

ISSN 2959-6157

tions can trigger their own physiological states, which offer a greater chance of survival for the animals (for instance, fight-or-flight hormones like cortisol cause an increase in blood sugar levels, heart rates, and breathing). These alterations are also crucial aspects of emotional behaviors. Emotions aren't merely individualistic; they possess group characteristics that promote group activities in certain social species. For example, chimps might present their bodies towards one another to feel comfortable with each other or employ physical contact after conflicts to calm themselves down and mend the relationships among chimps [6]. Emotions also have evolutionary origins as "internal cognitive mechanisms," functioning as tools for humans to act swiftly and reactively in response to complex situations for the purpose of making adaptations, thereby achieving better adaptability to survive and reproduce. For instance, when people see enemy faces, fear makes them run away from danger. Anger makes people aggressive to attack others and compete with resources. Positive affect may encourage prosocial behaviors such as food sharing, which fosters group cohesion. This helps enhance survival, competition or cooperation with other individuals (see Figure 1) [7].

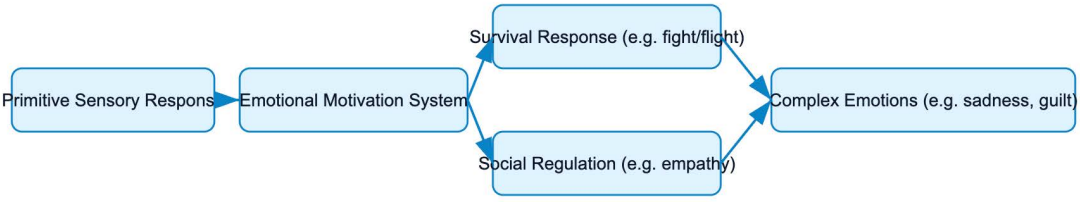

Fig. 1 A schematic diagram of the evolutionary pathway and adaptive functions of animal emotions [7]

Therefore, emotions cause complicated psychological and physiological behaviors of animals for achieving success in both survival and promotion. Some attachment behaviors (e.g., maternal bond, pair bonding) also had profound evolution origins. For prosocial emotional systems in promoting positive behaviors (like love/attachment), emotions may mediate those mechanisms, possibly through some neuropeptides (such as oxytocin, vasopressin and so on). These functions support offspring survival and reproduction and enhance social development and promote cooperation between individuals within society, so that promote social communication, alliance and cohesion in communities, or even help obtain food via cooperative behaviors for members in the same community. That kind of interaction, which occurs when many animals of some social kinds (like lions, wolves and dolphins) gather and live together (multi-female groups), perhaps including different types of roles (like hierarchies among leadership systems), may take place extremely significantly and advantageous.

2.2 Neural and Molecular Mechanisms: Cross-Species Commonality and Variation

Emotion is also largely shared among species, even if not every neural circuit is directly homologous. For instance, the amygdala is involved in the processing of fear, the prefrontal cortex controls emotional intensity and behaviors inhibiting emotion, dopamine systems relate to the reward mechanism, the serotonergic systems play a role in anxiety, and the release of the hormone cortisol mirrors stress and fear [2]. Functional imaging and lesions in primates and rodents show that these parts of the brain involved in emotion are activated during such experiences as emotionally significant or rewarding social interactions, but when the amygdalar structures are removed, these animals become more anxious, have reduced memory capacity and may even show abnormal aggressive behavior. As other studies on animal species have indicated, there are comparable brain structures and similar emotions in birds and even non-mammals (see Table 1).

Table 1. Comparison of emotion-related brain regions across species

Function	Mammals (e.g., mice, humans)	Birds (e.g., corvids)
Fear processing	Amygdala	Amygdala-like regions (midbrain)
Emotion regulation	Prefrontal cortex (PFC)	Nidopallium caudolaterale (NCL)
Reward system	Midbrain dopamine system	Ventral tegmental area (VTA)
Social emotion	Limbic system, mirror neurons	Forebrain social behavior circuits

For example, just as fear was measured in higher vertebrates, it can be shown that even lower organisms experience this kind of condition; similar affective traits exist in mammals, including social reptiles, fish, even lower vertebrates. At the very least, even if there is still some doubt about whether some animals actually feel emotions in the same way as humans do, comparative data on different species, from cephalopods up to insects suggest that there might have been more widespread affective qualities long before the emergence of human beings themselves .When receiving the paper, we assume that the corresponding authors grant us the copyright to use the paper for the book or journal in question. When receiving the paper, we assume that the corresponding authors grant us the copyright to use.

2.3 Evolutionary Conservation and Species-Specific Differences

Different organisms have different anatomies, but the emotional responses to fear, threats, rewards and social exchanges are very similar. This "functional convergence" supports the view that emotional systems are evolutionarily stable strategies [8]. For example, birds show aggression during mating season; elephants show sorrow and compassion for dead friends. These behaviors may not mean human feeling experiences, but they imply feelings in controlling behavior.

3. Methods for Assessing Animal Emotions and Mental Health

3.1 Behavioral Indicators

Researchers use natural observation and standard paradigms (for example, open-field test, cognitive bias tests and so on) to explore the emotional states of animals. For example, in open field tests, anxious mice or rats tend to remain close to the walls (also called thigmotaxis), while more relaxed ones prefer to explore the center. Similarly, the preference test is based on offering animals a choice between environments or stimuli that would result in a positive or negative consequence. Harding et al. found that when rodents are placed in an unpredictable environment, they may be more prone to make pessimistic judgments when faced with an ambiguous cue (see Figure 2) [4].

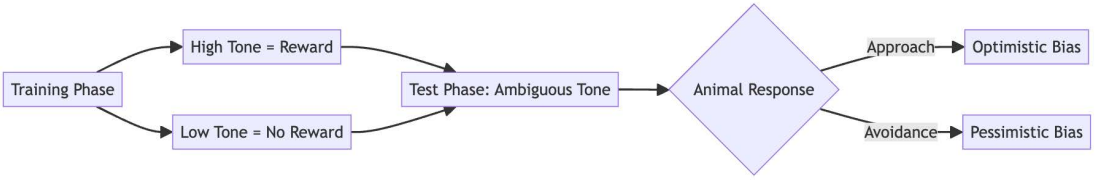

Fig. 2 Workflow of Cognitive Bias Tes t[4]

Open field testing, especially social isolation experiments, remains a central paradigm in animal emotion study. In open field tests, animals were typically placed in a new, enclosed area and given time to explore freely. Depending on the hypothesis of the experiment, scientists studied the behavioral features (such as time spent in center vs periphery, etc.) of each participant to analyze their anxiety levels. Socialization experiments investigate the effects that take place when conspecifics are taken out of these rodents' everyday lives. The rodents generally show lower movement speed, reduced exploration behaviors, vocalizations, etc., under such conditions, indicating higher levels of anxiety. Recently, attention selective tasks have been used to determine animals' emotional response abilities. In such experiments, the way that animals distribute their attention towards more threatening compared to less threatening stimuli (which they can distinguish because of their learning process) can indicate their affective condition.

3.2 Physiological and Biochemical Indicators

Hormones, including cortisol, oxytocin, and dopamine, are all closely related to emotional states [2, 9]. Heart rate variability (HRV) is a measurement that characterizes the function of the autonomic nervous system. HRV is particularly useful since it gives an indirect assessment of the activity of the parasympathetic nervous system, with low levels of HRV associated with negative emotional states (stress/fear). Novel measures of these states exist such as pro-inflammatory cytokines and the gut microbiota or derived metabolites, which may serve as biomarkers when evaluating chronic emotional states [1, 10]. There has been increasing interest in examining the interactions between the gut and brain and whether components of the gut microbiome affect emotional behaviors either through neuroimmune-related mechanisms or via microbial metabolite-dependent routes. As an example, stress-induced changes in microbiome composition may contribute to the development and exacerbation of anxiety-like behaviors within rodent models.

ISSN 2959-6157

3.3 Neuroscientific Methods

Advanced techniques such as functional magnetic resonance imaging (fMRI) [3], electroencephalography (EEG) [11], optogenetics, and calcium imaging are commonly applied to monitor neural activity during emotionally salient experiences. For example, using optogenetics to manipulate the responses of subjects related to emotions (activating or silencing different populations of neurons in real time), researchers can investigate the relationship between specific neural circuits in the brain and subjects related to fear and reward expression by testing and recording the brain's response after manipulating these neurons at certain parts. Some basic technologies reveal more information about circuits related to emotions, which can compare with the results from animals and humans in a meaningful way.

3.4 Automated and Emerging Technologies

AI and deep learning are now used to identify facial expressions and body postures in animals, forming the basis for automated emotion recognition systems and pain scoring tools [12]. Projects such as "DeepLabCut" and "ZooFace" use pose estimation algorithms to track subtle micro-expressions, tail flicks, ear positions, and gait changes that correlate with emotional states. Wearable sensors and remote monitoring platforms enable continuous tracking of behavior and physiological states in natural environments [1]. Such technologies are especially valuable in agricultural and conservation contexts, where stress levels in livestock or endangered species can be monitored without human interference (see Table 2).

Table 2. Comparison of methods for assessing animal emotions

Dimension	Example Methods	Advantages	Limitations	Applicable Species
Behavioral	Open-field, cognitive bias tests	Non-invasive, ecologically valid	Subjective, hard to standardize	All animals
Physiological	Cortisol, HRV, oxytocin	Quantifiable and objective	Sample collection may cause stress	Mammals, birds
Neuroscience	fMRI, EEG, calcium imaging	High resolution, mechanistic	Costly, invasive	Rodents, primates
Automation/AI	Facial detection, sensors	Long-term, scalable	Model-dependent, species-limited	Livestock, primates

While each method offers unique insights, no single approach is sufficient to capture the full complexity of animal emotion. A growing consensus in the field emphasizes the importance of multimodal approaches that combine behavioral, physiological, and neurological data to improve reliability and ecological validity. For example, pairing facial expression analysis with heart rate sensors can distinguish between fear and arousal states that might appear behaviorally similar.

4. Conclusion

Research on animal emotions and mental health has evolved from single behavioral observations to integrative, multi-dimensional assessment systems. This transformation reflects a broader shift in cognitive science towards embodied and enactive models of emotion, which view affect not as isolated brain events but as distributed processes involving body, brain, and environment. In this review, we briefly introduced the evolutionary foundation of emotion, the mechanisms of action, and the experimental approaches for measuring the emotional status in animal organisms and highlighted the significance and future directions of the subject. Emotions serve as both adaptive responses and conserved mechanisms within neural and physiological aspects across different species. Traditionally, investigations were primarily centered around observing behavioral patterns and conducting hormone tests; however, they have since evolved to encompass modern technologies like imaging scans, artificial intelligence techniques, wearables, among others. Going forward, these methods ought to be crafted to establish species-specific emotional paradigms leveraging cross-disciplinary integrations. Furthermore, by combining various data sources with distinct characteristics and creating open-access emotional databases, it would facilitate laboratory verifications in cross-laboratory collaborations. Cross-species comparative studies along with cognitive bias approaches can provide a fresh perspective on examining the internal experiences of non-human animals. Research should concentrate on devising standardized methods, fostering data sharing via multiple research platforms, and

developing AI big data applications for animal emotion research, which could considerably enhance the accuracy of welfare status assessments for non-humans and shed light on the origins of human feelings throughout evolution. Ethical considerations also assume critical importance. Recognizing that animals can experience emotions might challenge the ethical assumptions in protection, treatment, and utilization areas. If animals feel fear or joy and endure mental anguish in captivity or during routine procedures in laboratory and agricultural settings, this raises ethical concerns about current animal use practices. For the sake of empathy and science, there's a need to reassess and refine existing strategies. Studying animals' emotions isn't merely a scientific topic but a moral one too. As we amass overwhelming evidence regarding their emotional experiences, we must reevaluate the ethical implications of disregarding animal emotions. It becomes even necessary if animal emotions affect our perception of life.

References

[1] Adelman Jeffrey Scott, Martin Lynn Bevin. Stress and disease ecology: A behavioral ecological approach. Integrative and Comparative Biology, 2009, 49(3): 202–214. https://doi.org/10.1093/icb/icp028

[2] Sapolsky Robert Morris. Why Zebras Don't Get Ulcers (3rd ed.). Holt Paperbacks, 2004.

[3] LeDoux Joseph Edward. Rethinking the emotional brain. Neuron, 2012, 73(4): 653–676. https://doi.org/10.1016/j.neuron.2012.02.004

[4] Harding Emma Jane, Paul Elizabeth Sarah, Mendl Michael. Animal behaviour: Cognitive bias and affective state. Nature, 2004, 427(6972): 312. https://doi.org/10.1038/427312a

[5] Mendl Michael, Burman Oliver Henry Paterson, Paul Elizabeth Sarah. An integrative and functional framework for the study of animal emotion and mood. Proceedings of the Royal Society B, 2009, 276(1667): 2895–2904. https://doi.org/10.1098/rspb.2009.0203

[6] De Waal Frans Bernardus Maria. Chimpanzee politics: Power and sex among apes. Johns Hopkins University Press, 2003.

[7] Nesse Randolph Martin. Evolutionary explanations of emotions. Human Nature, 1990, 1(3): 261–289. https://doi.org/10.1007/BF02692193

[8] Anderson David John, Adolphs Ralph. A framework for studying emotions across species. Cell, 2014, 157(1): 187–200. https://doi.org/10.1016/j.cell.2014.03.003

[9] Paul Elizabeth Sarah, Harding Emma Jane, Mendl Michael. Measuring emotional processes in animals: The utility of a cognitive approach. Neuroscience & Biobehavioral Reviews, 2005, 29(3): 469–491. https://doi.org/10.1016/j.neubiorev.2005.01.002

[10] Boissy Alain, Manteuffel Gabriele, Jensen Margit Bak, Moe Ragnhild Overland, Spruijt Bas, Keeling Linda Jane, Winckler Christoph, Forkman Björn, Dimitrov Ivaylo, Langbein Jan, Bakken Morten, Veissier Isabelle, Aubert André. Assessment of positive emotions in animals to improve their welfare. Physiology & Behavior, 2007, 92(3): 375–397. https://doi.org/10.1016/j.physbeh.2007.02.003

[11] Davidson Richard J. Anxiety and affective style: Role of prefrontal cortex and amygdala. Biological Psychiatry, 2002, 51(1): 68–80. https://doi.org/10.1016/S0006-3223(01)01328-2

[12] Emery Nathan John, Clayton Nicola Susan. The mentality of crows: Convergent evolution of intelligence in corvids and apes. Science, 2004, 306(5703): 1903–1907. https://doi.org/10.1126/science.1098410