Journal of Drug Discovery and Health Sciences, 2024;1(2):113-123 e-ISSN- 3048-8842

Journal of Drug Discovery and Health Sciences

journal home page : https://jddhs.com/index.php/jddhs/index

Review Article

Cognitive Complexity and Decision-Making in Social Structures: An In-Depth Analysis of Laboratory Animal Behavior Patterns

Amit Pal, Rahul Vishwakarma, Deepika Gupta*, Shikhar Verma

Maharishi School of Pharmaceutical Sciences, Maharishi University of Information Technology, Lucknow, Uttar Pradesh, India.

ARTICLE INFO

Article history:
Received: 12 July, 2024
Revised: 22 July, 2024
Accepted: 12 August, 2024
Published: 28 August, 2024

Keywords:
Cognitive complexity, Social structure, Behavior patterns, Human decision-making, analysis of sociological, Physiological studies

DOI:
10.21590/jddhs.01.02.07

ABSTRACT

The study of cognitive complexity and decision-making within social structures is paramount in understanding animal behavior patterns. Cognitive complexity and decision-making are fundamental aspects of social structure and behavior across various animal species. This review synthesizes current knowledge on cognitive complexity and decision-making processes in the context of social structures, focusing on animal behavior patterns. By exploring research across disciplines such as ethology, cognitive psychology, and neuroscience, this review highlights the intricate interplay between cognitive abilities and social dynamics in diverse animal communities. We discuss how factors, including environmental cues, social relationships, and individual traits, shape decision-making processes within social groups. Furthermore, we examine the role of cognitive complexity in mediating social interactions, cooperation, conflict resolution, and hierarchical organization within animal societies. Insights from this review contribute to a deeper understanding of the evolutionary roots and adaptive significance of cognitive processes in shaping social structures and behavior patterns across the animal kingdom. Additionally, we identify gaps in current knowledge and propose directions for future research aimed at elucidating the mechanisms underlying cognitive complexity and decision-making in social contexts. It also identifies gaps in current knowledge and suggests avenues for future research to unravel the mechanisms governing cognitive complexity and decision-making in animal behavior.

Introduction

Cognitive aging impacts various functions, such as learning, memory, and attention. This study aims to address a less-explored area: the basic perceptual decision-making in animal models of cognitive aging, which may also extend to humans. By examining decision-making processes in aged mice, this research sheds light on the neurobiological underpinnings of age-related changes in decision components and analyzes behavioral data through a computational decision-theoretical lens. Decision-making involves selecting an option or course of action from available information, such as determining the ripest berries based on color.

Research has shown that the decision-making models effectively explain simple perceptual decisions. The diffusion decision model, for instance, utilizes observable and psychologically relevant variables to create a computational framework for understanding decision-making. This model is based on several assumptions:

***Corresponding Author:** Deepika Gupta

Address: Maharishi School of Pharmaceutical Sciences, Maharishi University of Information Technology, Lucknow, Uttar Pradesh, India.

Email ✉**:** deepika26009@gmail.com

Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

- Sensory evidence is inherently noisy due to environmental conditions, sensory limitations, or neural activity.
- Over time, sensory data supporting different options accumulate and integrate.
- Decision time is determined by the time it takes for the integrated evidence to reach one of the predefined thresholds, each representing a different option.

In human psychology and cognitive science, decision-making often involves conscious deliberation and intentional action. However, even in humans, many decisions are driven by goal-directed, model-based processes that do not necessarily involve consciousness (Gur *et al*., 2020). These fields emphasize broad, general mechanisms like Bayesian analysis or heuristic principles (e.g., tallying) to explain rational decision-making across various scenarios. Rationality here means choosing the optimal option given the constraints, which may involve considering the decision-maker's neurological processes and perspective (Budaev *et al*., 2019).

In today's dynamic, information-rich environment, decision-making is inherently challenging due to uncertainty and incomplete knowledge. This complexity is compounded by cognitive biases, especially under changing environmental conditions. Effective decision-making thus requires navigating these biases to thoroughly explore and implement changes (Acciarini *et al*., 2020).

As individuals age, the ability to make decisions in complex social environments becomes crucial for their adaptability and performance. This involves considering multiple perspectives, evaluating the surroundings, and anticipating future events (Stanovich *et al*., 2013).

The Importance of Understanding Social Structure and Behavior Patterns

Speaking and sucking are intricate sensorimotor processes vital for breathing and overall health. The tongue, a complex organ, plays a crucial role in maintaining open airways, safely managing food and liquids, and rapidly adjusting its position and shape during speech. Often described as a muscular hydrostat, the tongue's function can be impaired by age, disease, trauma, or adverse drug reactions. Therefore, developing models of both normal and compromised lingual function is critical for basic and translational research, requiring a comprehensive understanding of the neurological control of the tongue. Accessing the tongue's tissues and movements during awake behavior has been challenging without using invasive techniques. Consequently, advancing this field involves creating simulation systems, tools, and tests to assess tongue function during activities like drinking, licking, and lapping, including evaluating tongue force and timing. The primary aim of this work is to review significant advances in translational science, highlighting improvements in measures of tongue behavior in conscious rats and mice (Fig. 1), including innovative methods (Gatti *et al*., 2024).

In the past decade, mouse-tracking has gained persistent popularity across various cognitive science disciplines due to its methodological and theoretical advantages. Compared to traditional metrics like reaction times (RTs), mouse-tracking has proven highly reliable in capturing response conflict dynamics by analyzing the directness of participants' decision-making paths. Mouse-tracking allows for the quantification of the decision-making process. In mouse-tracking tasks, participants typically start from a predetermined position, usually at the bottom center of the screen, and choose an option from menus displayed in the upper corners. The software records hand or mouse movements alongside the decision-making process, facilitating the measurement of choice conflict and its progression. This approach provides insights into decision dynamics that are unattainable through reaction time analysis alone (Sharbaugh *et al*., 2003).

Guinea Pig Nutrition and Health Recommendations

Given the abundance of information accessible to guinea pig owners, it is crucial for practitioners to stay updated on the latest findings when advising clients about pet nutrition. Key recommendations include providing a well-balanced dry food formulated specifically for guinea pigs, ensuring unrestricted access to forage, and offering daily servings of fresh vegetables high in vitamin C. Fruits should be given sparingly, possibly as occasional treats, or avoided altogether if a wide variety of fresh vegetables are available. A common-sense approach, similar to those used with other species, should be employed to reduce the transmission of genetic defects. This involves avoiding the breeding of animals with congenital issues or those that have produced offspring with such deformities. More research is needed to understand how nutrition influences the development of diseases like bone and eye

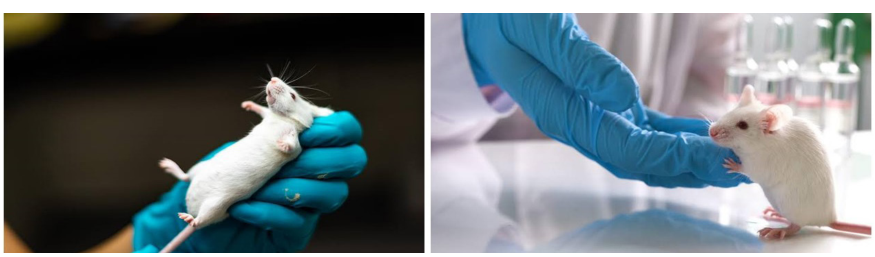


Fig. 1: Handling technique of albino mice in the laboratory

abnormalities in guinea pigs. It is imperative to effectively inform owners about these findings so they can take appropriate actions (Franco & Olsson *et al*., 2014).

Research Objectives and Scope

To expand our understanding of cumulative culture and its potential in other species, experimental approaches are essential. Relying solely on human studies provides limited insights into cumulative culture. Animal studies are necessary to provide data and determine the scope of these impacts on non-human species (Caldwell *et al*., 2020). Animal experimentation is integral to many scientific projects. The research team, veterinary professionals, institutional animal caregivers, and animal ethics committee members must consider various factors to ensure the proper planning and execution of studies involving experimental substances administered to animals. Carefully monitoring every detail and considering the administration route can enhance experimental precision and minimize negative effects on animals (Balcombe *et al*., 2021).

Components of Cognitive Complexity

Cognition, scientifically defined, involves the ability to acquire knowledge through attention and decision-making processes. Understanding cognitive function in practical terms is crucial. Cognitive complexity encompasses learning, memory, and attention processes (Owen & Lindley *et al*., 2010). Learning is characterized as a relatively enduring change in behavior resulting from practice or experience. Memory refers to the permanent retention of acquired knowledge. Attention includes various behavioral aspects, such as impulsivity, activity level, sensitivity to delay, sustained attention, and the ability to regulate reward delay (Gatti *et al*., 2024).

Complexity

Complexity refers to the condition of being difficult to separate, analyze, or solve. In scientific and philosophical contexts, a distinction is made between complex and complicated systems (Gür *et al*., 2020). Laboratory animals exhibit a wide range of behaviors that can be intricate and multifaceted, including social interactions, foraging, mating, and responses to environmental stimuli. Their physiological systems, such as nervous, endocrine, and immune systems, display intricate interactions and regulatory mechanisms. Understanding these complexities is crucial for research in neuroscience, pharmacology, and toxicology. Laboratory animals have complex genetic and molecular profiles that influence their behavior, physiology, and disease susceptibility. Studying these genetic and molecular complexities helps researchers understand disease mechanisms and develop treatments. Understanding complexity in laboratory animals is essential for meaningful research across biomedical, behavioral, and environmental sciences. It requires an interdisciplinary approach considering interactions between genetics, physiology, behavior, and environment.

Cognitive Abilities in Animals

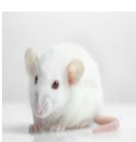
Limited support for general intelligence in non-human animals suggests shifting focus towards investigating patterns of covariation among cognitive abilities. Understanding how cognitive traits are organized and how selection operates independently on each trait is essential before drawing conclusions about cognitive evolution (Greenhough & Roe *et al*., 2019). The concept of 'g' assumes positive correlations among individual cognitive abilities. Weak correlations among measured traits might indicate scant evidence for general intelligence. However, if traits do not consistently show near-perfect repeatability, phenotypic correlations may deviate from individual-level covariation patterns (Franco & Olsson *et al*., 2014). Additives like tartrazine, monosodium glutamate, sunset yellow, and sodium benzoate negatively impact biochemical indicators, particularly in vital organs such as the liver and kidneys, with sunset yellow being the least detrimental (Fargali *et al*., 2018). Few studies have used multilevel mixed models to explore covariance patterns across biological levels in animal cognition research. Examining the phenotypic multilevel trait structure advances understanding of general intelligence and its components. Caution is necessary when drawing evolutionary conclusions from phenotypic variance patterns (Brønstad *et al*., 2016). The 'phenotypic gambit' assumption underpins many animal cognition and behavior studies. Comparing phenotypic and genetic correlations among cognitive traits will enhance understanding of factors sustaining individual diversity in cognitive traits and potential overarching structures (Poirier *et al*., 2020).

Laboratory animals should be recognized not merely as research tools but as valuable contributors whose needs and rights deserve respect. The expanding exploration of animal emotions and cognitive abilities underscores the moral significance of laboratory animals, prompting institutions to advance ethical standards and ensure animals experience quality and value in their lives (Codecasa *et al*., 2021). Cognitive behavior refers to learning and memory processes, with tests assessing an animal's ability to create mental representations of the external environment, influencing behavioral responses to different stimuli and situations. Animals must be motivated to engage in learning tasks and exhibit behaviors related to memory recall (Sousa *et al*., 2006).

Organization and Structure of the Review Article

To ensure clarity and coherence, organize the review article with logical sections such as an introduction, literature review, discussion, and conclusion. Use headings and subheadings to guide the reader through the content effectively.

Table 1: Various laboratory animals and their behavior patterns

S. No	*Animal*	*Behavior pattern*	*Reason*	*References*
1	Albino Mice 	Fear and Anxiety Response	Exhibit fear and anxiety in response to novel stimuli or threatening situations. Behaviors associated with fear and anxiety include freezing and increased heart rate.	(Gulinel *et al*., 2014)
		Feeding behavior	Mice exhibit food-related behaviors such as sniffing, nibbling, and food caching.	(Crawley, J. N. *et al*., 2007)
		Stereotypic behaviors	Develop stereotypic behaviors such as repetitive grooming, bar-biting, or pacing, which can indicate stress or boredom.	(Jacob, H. J., & Fox, J. G. *et al*., 2011)
2	Hamster 	Cheek pouching	To store food for later consumption.	(Carere, C *et al*., 2019)
		Aggression	Biting and chasing when housed with other hamsters.	(Hurnik, J. F *et al*., 1985)
		Stress	Experience stress due to handling, transportation, or experimental procedures.	(Carere, C *et al*., 2019)
3	Guinea pig 	Vocalizations	Include chirping, squealing, purring, and teeth chattering. These vocalizations can convey emotions such as excitement, contentment, fear, or aggression.	(Hedrich, H. J. *et al*., 2012)
		Play behavior	Guinea pigs are playful animals and enjoy engaging in various playful activities such as chasing each other.	(Richard S. *et al*., 2012)
		Grooming	Groom themselves and spend a significant amount of time doing so.	(Quesenberry *et al*., 2012)
4	Rat 	Sleeping behavior	Sleep during the day and show increased activity levels during the night, exhibiting characteristic sleep patterns such as rapid eye movements.	(Manning *et al*., 2007)
		Exploratory behavior	Explore their environment, especially when placed in a novel setting, to familiarize themselves with their surroundings.	(Barnett, S. A. *et al*., 2007)
		Nesting behavior	Gather bedding material, such as paper or cloth, and construct nests.	(Blumberg, *et al*., 2012)
5	Rabbit 	Alertness and startle responses	Highly alert to their surroundings due to their acute senses of hearing and smell. They may exhibit startle responses, such as sudden movements or thumping their hind legs, in response to perceived threats or environmental changes.	(Kong, H. E., *et al*., 2007)
		Eye blinking behaviors	Especially when feeling comfortable and secure, rabbits may exhibit playful behaviors such as eye blinking.	(Mullan, S. *et al*., 2007)
		Reproductive behavior	Female rabbits exhibit nesting behavior and maternal care if they give birth. Male rabbits exhibit courtship behaviors towards females during mating, including chasing and mounting.	(Marino, L *et al*., 2019)

Animal Study Design

This study utilized 40 mature male albino rats (*Rattus norvegicus*) weighing 100 to 110 g. The rats were kept under standard laboratory conditions with unrestricted access to a standard diet and water. Before treatment, they underwent a 12-hour fasting period, during which water was available. The rats were randomly divided into four groups. The first and third groups, each with 20 rats, served as control groups. The second group, consisting of 10 rats, received an oral dose of 50 mg/kg body weight/day of allure red for 10 days. The fourth group, also with 10 rats, received the same dose for 40 days. After the treatment periods, the rats were sacrificed for analysis. Blood samples were collected: one part in heparinized capillary tubes for hematocrit value determination and another in EDTA for hematological analysis. Red and white blood cell counts were conducted using an improved hemocytometer, and hemoglobin concentration was measured using established methods. Mean corpuscular volume and mean corpuscular hemoglobin were also calculated.

Selection Criteria for Animal Behavior Studies

This study investigates the impact of the azo dye allure red on various physiological and biochemical markers in male albino rats. Previous studies have shown that azo dyes can be toxic and carcinogenic in animals. Hematological indices are valuable for assessing drug-induced damage, with red blood cell counts being particularly useful for evaluating erythrocyte indices such as mean corpuscular volume and mean corpuscular hemoglobin. In this study, significant reductions in RBC count and hemoglobin levels were observed after 10 and 40 days of treatment, suggesting that allure red may suppress erythropoiesis in the bone marrow, leading to decreased erythrocyte counts and hemoglobin content at all tested doses.

Challenges and Limitations in Research Methodologies

During this investigation, the group treated with allure red showed a significant increase in creatinine concentration, aligning with earlier research indicating that organic azo dyes, such as fast green, can elevate serum creatinine and urea levels. Similarly, tartrazine was found to increase serum creatinine and urea levels in animals (Amin *et al.*, 2010). Elevated plasma creatinine or urea levels typically indicate renal failure. The study found that allure red caused significant disturbances in physiological and biochemical markers, underscoring the need for further research on the safety of azo dye additives, especially allure red.

Eye-Blink Conditioning

Eye-blink conditioning is a model system for studying the neural mechanisms of learning and memory. Consistent patterns of eye-blink response acquisition, retention, and extinction have been observed across species, including humans, monkeys, rabbits, rats, cats, and mice. Research using pharmacological, lesion, and stimulation techniques has identified the brain systems and structures involved in eye-blink conditioning.

Comparable Measures of Cognitive Function

Neurobehavioral toxicologists aim to develop sensitive tests that can distinguish between normal individuals and those exposed to neurotoxins. While cognitive function tests can be applied across different species and age groups, this review focuses on studies involving rats, non-human primates, and human neonates aged 0 to 12 months.

Means-End Problem-Solving Task

Effective problem-solving involves following a series of deliberate steps to achieve a goal. By six months of age, children begin to exhibit means-end behavior, which includes planning, sequencing actions, focusing on goals, and understanding appropriate means-end relationships.

Model in Biomedical Research

In biomedical research, a model refers to an experimental framework used to replicate human physiological, pathophysiological, or behavioral traits in non-human species. These models are crucial for studying diseases and testing treatments. In mathematics and physics, a model is a theoretical construct for deriving and testing hypotheses. Animal models of psychiatric disorders can embody both types of models (Benato *et al.*, 2019).

Roof Rats Opening Pinecones

Studies have shown that laboratory rats can efficiently extract energy from pine seeds by removing the protective scales. Starved adult rats from pine forest environments naturally developed this skill. Juvenile rats, when taught by adults or humans mimicking the technique, learned the efficient scale removal method. Over 70% of juvenile rats adopted this behavior when completing the scale removal started by adults or humans (Terkel, 1996).

Theoretical Perspectives on Animal Behavior Patterns

The tongue exhibits remarkable versatility, capable of moving in multiple directions due to its muscular structure and selective muscle activation. Impaired or inadequate activation of these muscles can lead to dysarthria. This innovative approach could potentially treat clinical conditions characterized by reduced tongue muscle activity, such as obstructive sleep apnea. Awareness can be understood as a recognition of others' actions, providing context for one's own behavior. We propose that future preclinical studies should focus on the selective activation of extrinsic tongue muscles and the assessment of airway openness during photostimulation. Additionally, the application of lingual optogenetics to conditions like dysarthria and dysphagia appears promising due to the precise temporal and spatial control offered by optogenetic techniques.

There is growing recognition of the inherent issues with restricting rodents from engaging in their natural behaviors, such as exploring, foraging, running, escaping, hiding, and maintaining hygiene. Current research highlights increased gender disparities in food drive performance, relative spleen weight, and relative heart weight. Conversely, other studies have noted heightened sex differences in growth rate, performance in the Elevated Plus Maze, and relative spleen weight while observing a reduction in sex differences in relative kidney weight.

Cognitive Complexity in Human Decision-Making

Solving highly complex problems requires all involved parties to reach a shared understanding initially. This challenge is exacerbated by the divergent interests and conflicting emotions and desires that parties often bring to the table. These factors complicate the search for solutions to complex issues. While the significant challenges of our era are clearly difficult to resolve, identifying the root causes contributing to these problems is less straightforward. The current "Special Corner: Complex cognition" explores often overlooked inquiries within the realm of "complex cognition," encompassing mental functions such as thinking, reasoning, problem-solving, and decision-making. These processes typically depend on the integration and interaction of more basic cognitive functions like perception, learning, memory, and emotion. "Complex cognition" refers to mental activities like thinking, problem-solving, or decision-making that rely on other cognitive functions such as perception, working memory, long-term memory, and executive processes. These cognitive processes often intertwine with other mental processes, such as emotion and motivation. The term also applies to situations where the conditions are complex, requiring conclusions to be drawn, problems to be solved, or decisions to be made (Gonciarov & Coman *et al*., 2015). Combining these aspects, "complex cognition" encompasses all mental processes individuals use to generate new insights from existing information, aiming to solve problems, make decisions, and formulate plans. A crucial aspect of "complex cognition" is its occurrence under intricate conditions, where numerous cognitive processes interact with each other or with non-cognitive processes (Knauff & Wolf *et al*., 2010).

Laboratory animals are frequently used as models or surrogates for humans or other species. A model represents the target being studied, possessing characteristics similar to the target while potentially differing significantly in other respects. For example, rabbits were once extensively used as models for diabetic humans to evaluate insulin potency, as insulin effectively reduced blood glucose levels in both species. Despite many differences between rabbits and humans, these discrepancies were irrelevant for this particular purpose. Although this model was well-validated, it has since been replaced by chemical methods.

Case Study Illustrating Cognitive Complexity in Social Structure

In a task involving pigs, one pig required more reinforcement than others, spending more time on the task. This pig exhibited unique behaviors, such as body stretches not observed in others and did not wag its tail. All pigs were highly socialized and comfortable around humans, accepting treats and complying with handlers. There was initial consideration of including a group of non-socialized, clicker-trained pigs. Ultimately, training pigs with positive reinforcement methods, such as clicker training or luring, resulted in their willingness to perform novel tasks without showing fear-related behaviors like fleeing. One pig showed signs of anxiety, possibly due to heightened sensitivity to the novel test situation and lack of the positive mental state associated with tail wagging. However, most pigs, including those trained with clicker methods and some luring-trained pigs, displayed tail wagging, indicating a positive state of mind. In summary, training pigs with positive reinforcement before potentially fear-inducing tests ensures cooperative behavior, with pigs completing tasks readily and willingly without coercion or delay (Jønholt *et al*., 2021).

Decision-Making in Social Contexts

Theories on sensemaking and situational awareness, along with empirical studies, suggest that understanding plays a crucial role in effective decision-making. However, our study did not find a consistent correlation between the depth of structural knowledge and decision-making task performance. Traditionally, rats have been the primary choice for studying the neurophysiological underpinnings of behavior, while mice have been preferred for genetic manipulations. When choosing between rats and mice for investigating the neural mechanisms of complex behaviors, various factors must be considered. Rats, being larger, are preferable for implanting devices and targeting specific brain regions. Conversely, mice, due to their smaller size, are more economical to house and require less maintenance time (Jaramillo *et al*., 2014). Inbred strain mice tested in our experiments solved the extrapolation task with a performance proportion indicating randomness (Moscow *et al*., 2014). Survey responses indicated occasional discomfort regarding the degree of pain or distress experienced by research animals (Kangas *et al*., 2022). The study also analyzed antinociception and tolerance in male and female rats during chronic high-dose morphine administration using a thermal assay, markers of microglia and neurons, and the transcriptome of microglia in the spinal cord.

Cognitive Abilities in Animals

Given the limited support for general intelligence in non-human animals highlighted by this study, we propose shifting towards investigating patterns of covariation among cognitive abilities. It is crucial to understand how cognitive traits are organized and how selection operates independently on each trait before drawing conclusions about the evolution of cognitive abilities (Greenhough & Roe *et al*., 2019). The concept of general intelligence (g) assumes positive correlations among individual cognitive abilities. If measured traits exhibit weak correlations, it might suggest scant evidence for general intelligence. However, unless all traits consistently show near-perfect repeatability, there remains the possibility that phenotypic correlations deviate from the underlying pattern of covariation at the individual level (Franco & Olsson *et al*., 2014).

Certain food additives, such as tartrazine, monosodium glutamate, sunset yellow, and sodium benzoate, have been found to negatively impact and modify various biochemical indicators, particularly those associated with essential organs like the liver and kidneys. Among these additives, sunset yellow appears to induce the least detrimental effects. Few studies have employed Multilevel Mixed Models to explore covariance patterns across biological levels in animal cognition research. Investigating the phenotypic multilevel trait structure represents a significant step forward in understanding general intelligence and its components. However, studies examining correlation structures among cognitive abilities should be cautious when drawing evolutionary conclusions from phenotypic variance patterns. This implicit assumption, often referred to as the 'phenotypic gambit,' underpins many studies in animal cognition and behavior but often remains unstated. As more studies provide genetic insights, comparing phenotypic and genetic correlations among cognitive traits will enhance our understanding of the factors sustaining individual diversity in cognitive traits and potential overarching structures (Poirier *et al*., 2020).

Laboratory animals deserve greater recognition and should not merely be seen as tools for research; their needs and rights deserve respect. The expanding exploration of animal emotions and cognitive abilities underscores the moral significance of laboratory animals, prompting institutions to advance ethical standards while ensuring that animals experience lives of quality and value. Cognitive behavior refers to the processes of learning and memory. Tests on cognitive behavior assess an animal's ability to create mental representations of the external environment, which influence changes in behavioral responses when confronted with different stimuli and situations. Animals must be motivated to engage in a learning task and exhibit behaviors related to memory recall (Sousa *et al*., 2006).

Examination of Decision-Making Process in Social Animals

Our basic meta-analytical model, which does not account for random effects, estimated the mean correlation coefficient among cognitive traits. When incorporating random effects in a multilevel meta-analytical model, we observed a comparable overall correlation between performances across cognitive tasks. These findings suggest that the shared variance between pairs of cognitive abilities, represented as r-squared, spans a specific range (Poirier *et al*., 2020).

Experiments involving animal models of "state" anxiety, which are the standard in studies of emotional processes, have demonstrated that the individual's emotional state can influence decision-making in social animals. On the other hand, models of "pathological" anxiety, which often rely on gene-targeting technology, are being utilized more frequently to understand the underlying mechanisms of anxiety disorders.

In social animals, decision-making processes are often complex and influenced by various cognitive and emotional factors. The shared variance in cognitive abilities indicates that different cognitive traits may interact in ways that influence decision-making outcomes. This interaction is critical for understanding how social animals make decisions in group settings, where individual and collective behaviors must be balanced.

Furthermore, the utilization of gene-targeting technology in models of pathological anxiety has provided deeper insights into how genetic and environmental factors interact to influence decision-making processes. These models help researchers understand how anxiety can impact cognitive functions and social interactions, which are crucial for survival and reproduction in social animals.

Overall, the examination of decision-making processes in social animals requires a multifaceted approach, considering both cognitive abilities and emotional states. By integrating meta-analytical models and experimental research, we can gain a more comprehensive understanding of the factors that drive decision-making in social contexts. This knowledge is essential for developing strategies to manage and mitigate anxiety-related disorders and improve the well-being of social animals in both natural and controlled environments.

Empirical Studies Exploring Cognitive Complexity in Social Structure

Experimental setup and methodology

A total of sixty adult male albino rats (Rattus norvegicus), weighing between 100 and 110 g, were obtained from Theodor Bilharz Research Institute's Schistosoma Biological Supply Program. These rats were maintained under standard laboratory conditions and provided with regular food and water. Each rat fasted for 12 hours prior to any treatment, with water available throughout the fasting period. The experimental group of 40 rats was subdivided into two equal subgroups of 20 rats each, while the control group consisted of 20 rats.

The first subgroup of the experimental group received an oral dose of amaranth at 25 mg/kg body weight per day, and the second subgroup received a dose of 75 mg/kg body weight per day. After 30 days of treatment, ten randomly chosen rats from each group were sacrificed for analysis. The remaining rats underwent a recovery period of thirty days without further treatment, after which they were also sacrificed for analysis. Hematocrit levels were measured from blood samples taken in heparinized capillary tubes and EDTA, which included counts of red and white blood cells using an improved hemocytometer.

Research Findings on Decision-Making in Animal Behavior Patterns

Exposure to food additives led to the suppression of the hypothalamic-pituitary-testis axis, reducing GnRH hormone levels, subsequently inhibiting the secretion of Luteinizing Hormone and Follicle Stimulating Hormone from the pituitary gland, and decreasing testosterone levels. There was also a decline in antioxidant enzyme levels, triggering oxidative stress and increased lipid peroxidation processes. Utilizing recent technological advancements alongside behavioral assessments of decision-making holds promise for enhancing our understanding of the mechanisms behind the decision-making process, offering unprecedented neural and neurochemical specificity. However, contemporary neuroscience studies do not validate the concept of a singular central “decision-making region” (Winstanley & Floresco, 2016).

In our study, we measured the proficiency of mice and rats in an adaptive decision-making exercise known as the flexible sound categorization task, which required animals to alternate between two potential interpretations of a stimulus to effectively obtain a reward.

Implications for Understanding Social and Animal Behavior

Supplementation with royal jelly helps alleviate metabolic changes induced by food additives by inhibiting oxidative stress and reducing lipid peroxidation. As more advanced statistical methods became feasible, research in genetics shifted from traditional approaches to alternative statistical tools like structural equation modeling and multivariate genetic analyses. Our findings suggest that royal jelly could restore glucose levels to normal and mitigate the harmful impacts of food additives on liver and kidney functions. These positive effects are attributed to the potent antioxidant properties of royal jelly, contributing to its beneficial impact on metabolic disorders.

Researchers can manipulate various factors in controlled environments to observe how changes affect social dynamics, providing insights into how different social systems emerge and evolve. These insights can be extrapolated to understand human social dynamics, such as leadership and group cohesion. Findings from studies on laboratory animals can be translated into practical applications for addressing challenges. Studying social structure and behavior patterns in laboratory animals provides valuable insights into the fundamental principles underlying human behavior and societal organization. Understanding social behaviors in laboratory animals can inform research on human mental health, including social anxiety, depression, and addiction. By addressing the biological, psychological, and social factors that shape behavior, researchers can tackle a wide range of societal issues and improve human well-being.

Empirical Studies and Theoretical Frameworks

In rats administered with a high dose of amaranth, alterations in erythrocyte count, hemoglobin levels, and mean corpuscular hemoglobin concentration were observed. These effects persisted even after the recovery period. The changes in these parameters induced by amaranth could be attributed to the inhibition of erythropoiesis in the bone marrow, potentially hindering the synthesis of red blood cells.

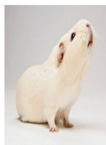
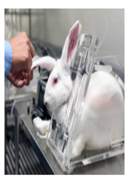
Evaluating and measuring pain in rabbits can pose difficulties in clinical settings. Rabbits typically conceal clinical signs of pain, and the absence of a comprehensive composite pain scale hinders accurate pain assessment and the evaluation of analgesic effectiveness. Many analgesic medications commonly used in companion animals like cats and dogs have not undergone testing specifically for rabbits, limiting their applicability in this species. While anecdotal reports exist, only a few analgesic protocols are backed by research studies demonstrating complete pain relief and the restoration of normal rabbit behavior.

Comparison of Cognitive Complexity and Decision Making across Human and Animal Contexts

Over the past decade, there has been a substantial expansion in the field of behavioral ethics, greatly improving our understanding of the factors influencing individuals’ decisions to behave unethically and the circumstances under which such decisions occur. We contend that despite the significant contextual differences in economic decision-making between humans and animals, economic theory remains applicable to both. We emphasize the importance of critically evaluating economic theory through decision-making experiments and stress the necessity of including animal models in our research efforts.

Even if results from animal studies merely confirm those from human research, it would still bolster existing theories. However, comparative research may uncover discrepancies in choice behavior between humans and

Table 2: Various animals used in laboratory

S. No	*Laboratory animals*	*Picture*	*Applications used in research study*
1	Albino mice		Immunology Toxicology Neuroscience Drug development
2	Hamster		Cardiac rhythm Reproduction Infectious disease Cancer research
3	Guinea pig		Allergic reactions Asthma Tuberculosis Wound healing
4	Rat		Neurological disorders Pharmacology Genetic study Instrumenting drug effects
5	Rabbit		Cardiology Vaccine development Auto-immune disease Allergies

animals, leading to a more nuanced understanding of decision-making and potentially prompting a reassessment of economic theory in light of evolutionary influences. One potential challenge with this approach is that findings from human and animal choice paradigms may only superficially align in replicating each other's results and may diverge in the underlying cognitive mechanisms involved in economic decision-making. However, this should be viewed as an opportunity to integrate the fields of biology, psychology, and economics more closely, inviting further investigation into the neural basis of economic decision-making across species.

Recap of Key Findings and Insights

In this review, we study the following key points:

- Concept of cognitive complexity, its importance, social structure, and behavior patterns.
- Theoretical models of decision-making in social structure.
- Theoretical perspectives on animal behavior patterns.
- Cognitive complexity and decision-making in human social structures.
- Cognitive complexity and decision-making in animal behavior patterns.
- Methodological approaches.
- Empirical studies and findings, discussion.
- Future directions and research implications.

Studies have revealed the neural mechanisms underlying decision-making in laboratory animals. Neuroimaging techniques such as functional magnetic resonance imaging and electrophysiological recordings have identified brain regions involved in decision-making processes, including the prefrontal cortex, amygdala, and striatum. Research on cognitive complexity and decision-making in laboratory animals has provided valuable insights into the cognitive processes underlying animal behavior. By employing a multidisciplinary approach encompassing behavioral experiments, neurobiology, and comparative cognition, scientists continue to deepen our understanding of how animals perceive, evaluate, and respond to their environment.

Insights into Cognitive Processes

Studying behavioral patterns in laboratory animals can yield valuable insights into human behavior and cognition. Many fundamental cognitive processes and behavioral tendencies observed in animals have parallels in humans, making animal models essential for understanding human psychology and neurobiology.

Improving Animal Welfare

Understanding behavioral patterns can also contribute to enhancing animal welfare in laboratory settings. By identifying signs of stress, discomfort, or pain through behavioral analysis, researchers and caretakers can implement measures to improve the housing, handling, and enrichment of laboratory animals, thereby promoting their well-being.

Advancements in Research Techniques

Advances in technology, such as video tracking systems, wearable sensors, and automated behavioral analysis software, have revolutionized the study of behavioral patterns in laboratory animals. These tools enable researchers to collect large volumes of high-resolution behavioral data efficiently, facilitating more detailed and comprehensive analyses.

Conclusion

The analysis of behavioral patterns in laboratory animals is a multifaceted endeavor with far-reaching implications for our understanding of animal cognition, human behavior, and animal welfare. By employing rigorous scientific methods, ethical considerations, and interdisciplinary collaboration, researchers can continue to unravel the mysteries of animal behavior and its underlying mechanisms. Studying cognitive complexity in laboratory animal behavior patterns offers valuable insights into the cognitive abilities of different species. However, it requires careful experimental design, interpretation, and an appreciation for the complexity and diversity of animal cognition. It emphasizes the importance of considering the cognitive abilities of laboratory animals in research settings and acknowledging their capacity for experiencing pain, suffering, and stress. Laboratory animals exhibit cognitive abilities and complexities that were previously underestimated, with significant implications for animal welfare, experimental design, and the interpretation of research results.

When observing behavior in laboratory animals, researchers typically employ various methods, including controlled experiments, behavioral assays, and observational studies. These approaches help scientists understand how animals perceive and interact with their surroundings, navigate challenges, and exhibit forms of social behavior.

References

Gür, E., Duyan, Y. A., Türkakın, E., Arkan, S., Karson, A., & Balcı, F. (2020). Aging impairs perceptual decision-making in mice: integrating computational and neurobiological approaches. Brain Structure and Function, 225(6), 1889–1902.
https://doi.org/10.1007/s00429-020-02101-x

Budaev, S., Jørgensen, C., Mangel, M., Eliassen, S., & Giske, J. (2019). Decision-making from the animal perspective: Bridging ecology and subjective cognition. Frontiers in Ecology and Evolution, 7(May) https://doi.org/10.3389/fevo.2019.00164

Acciarini, C., Brunetta, F., & Boccardelli, P. (2020). Cognitive biases and decision-making strategies in times of change: a systematic literature review. In Management Decision (Vol. 59, Issue 3, pp. 638–652). Emerald Group Holdings Ltd. https://doi.org/10.1108/MD-07-2019-1006

Stanovich, K. E. (2013). Why humans are (sometimes) less rational than other animals: Cognitive complexity and the axioms of rational choice. Thinking and Reasoning, 19(1), 1–26. https://doi.org/10.1080/13546783.2012.713178

Gatti, D., Marelli, M., & Rinaldi, L. (2024). Predicting Hand Movements With Distributional Semantics: Evidence From Mouse-Tracking. Cognitive Science, 48(1). https://doi.org/10.1111/cogs.13399

Sharbaugh, C., Viet, S. M., Fraser, A., & McMaster, S. B. (2003). Comparable measures of cognitive function in human infants and laboratory animals to identify environmental health risks to children. In Environmental Health Perspectives (Vol. 111, Issue 13, pp. 1630–1639). Public Health Services, US Dept of Health and Human Services. https://doi.org/10.1289/ehp.6205

Franco, N. H., & Olsson, I. A. S. (2014). Scientists and the 3Rs: Attitudes to animal use in biomedical research and the effect of mandatory training in laboratory animal science. Laboratory Animals, 48(1), 50–60. https://doi.org/10.1177/0023677213498717

Caldwell, C. A. (2020). Using Experimental Research Designs to Explore the Scope of Cumulative Culture in Humans and Other Animals. Topics in Cognitive Science, 12(2), 673–689. https://doi.org/10.1111/tops.12391

Balcombe, J. P. (n.d.). Laboratory environments and rodents' behavioral needs: a review www.pcrm.org

Owen, J., & Lindley, L. D. (2010). Therapists' cognitive complexity: Review of theoretical models and development of an integrated approach for training. Training and Education in Professional Psychology, 4(2), 128–137. https://doi.org/10.1037/a0017697

Greenhough, B., & Roe, E. (2019). Attuning to laboratory animals and telling stories: Learning animal geography research skills from animal technologists. Environment and Planning D: Society and Space, 37(2), 367–384. https://doi.org/10.1177/0263775818807720

Fargali, S. H. M., Tawfek, N. S., Amin, H. M., & Abdalla, A. A. (n.d.). Adverse Effects of Some Food Additives in Adult Male Albino Rats

Brønstad, A., Newcomer, C., Decelle, T., Everitt, J. I., Guillen, J., & Laber, K. (2016). Current concepts of harm-benefit analysis of animal experiments - Report from the AALAS-FELASA working group on harm-benefit analysis - Part 1. Laboratory Animals, 50(1), 1–20. https://doi.org/10.1177/0023677216642398

Poirier, M. A., Kozlovsky, D. Y., Morand-Ferron, J., & Careau, V. (2020). How general is cognitive ability in non-human animals? A meta-analytical and multilevel reanalysis approach: Not-so general animal intelligence. Proceedings of the Royal Society B: Biological Sciences, 287(1940). https://doi.org/10.1098/rspb.2020.1853

Codecasa, E., Pageat, P., Marcet-Rius, M., & Cozzi, A. (2021). Legal frameworks and controls for the protection of research animals: A focus on the animal welfare body with a french case study. In Animals (Vol. 11, Issue 3, pp. 1–16). MDPI AG. https://doi.org/10.3390/ani11030695

Sousa, N., Almeida, O. F. X., & Wotjak, C. T. (2006). A hitchhiker's guide to behavioral analysis in laboratory rodents. In Genes, Brain and Behavior (Vol. 5, Issue SUPPL. 2, pp. 5–24). https://doi.org/10.1111/j.1601-183X.2006.00228.x

Gulinello, M., & LeDoux, M. (2014). "Behavioral and cognitive animal models in neuropsychiatric research." Springer Science & Business Media".

Crawley, J. N. (2007). "What's Wrong With My Mouse?: Behavioral Phenotyping of Transgenic and Knockout Mice." John Wiley & Sons

Jacob, H. J., & Fox, J. G. (2011). "The Mouse in Biomedical Research: Normative Biology, Husbandry, and Models".

Carere, C., & Maestripieri, D. (Eds.). (2019). "Animal Personalities: Behavior, Physiology, and Evolution." University of Chicago Press.

Hurnik, J. F., Dostalova, A., & Humpal, J. (1985). "The Behavior of the Syrian Golden Hamster." Elsevier.

Hedrich, H. J. (Ed.). (2012). "The Laboratory Guinea Pig." Academic Press.

Richardson, V. C. G., & Hurst, J. L. (Eds.). (2012). "The Laboratory Guinea Pig." CRC Press.

Quesenberry, K. E., & Carpenter, J. W. (2012). "Ferrets, Rabbits, and Rodents: Clinical Medicine and Surgery." Elsevier Health Sciences.

Manning, A., & Dawkins, M. S. (2007). "An Introduction to Animal Behavior." Cambridge University Press.

Barnett, S. A. (2007). "The Rat: A Study in Behavior." University of Chicago Press. This book provides a comprehensive overview of rat behavior, covering topics such as social behavior, learning, and communication.

Blumberg, M. S., Freeman, J. H., & Robinson, S. R. (2012). "Oxford Handbook of Developmental Behavioral Neuroscience." Oxford University Press. This handbook includes chapters on various aspects of rat behavior, including development, neural mechanisms, and behavioral plasticity.

Kong, H. E., & Liebich, H.G. (2007). "Anatomy of the Rabbit." In "Anatomy of the Rabbit" (pp. 1-8). Elsevier.

Mullan, S., & Main, D (2007). "Behavioral and Welfare Aspects of the Domestic Rabbit." Veterinary Record, 160(2), 53-59.

Marino, L., Colvin, C. M., & Allritz, M. (2019). "How Anthropomorphism is Used to Deceive the Public About Animal Welfare." Animals, 9(12).

Fargali, S. H. M., Tawfek, N. S., Amin, H. M., & Abdalla, A. A. (n.d.). Adverse Effects of Some Food Additives in Adult Male Albino Rats

Benato, L., Rooney, N. J., & Murrell, J. C. (2019). Pain and analgesia in pet rabbits within the veterinary environment: a review. In Veterinary Anaesthesia and Analgesia (Vol. 46, Issue 2, pp. 151–162). Association of Veterinary Anaesthetists and American College of Veterinary Anesthesia and Analgesia. https://doi.org/10.1016/j.vaa.2018.10.007

Terkel, J. (1996). Acquisition of pine cone stripping behavior in black rats (Rattus rattus). **Animal Behavior, 52**, 205-214. https://doi.org/10.46867/C4KW2H

Gonciarov, M., & Coman, C. (2015). General Principles Concerning the Harmonization of Romanian Legislation with the European Union in the Field of Protection of Animals Used for Scientific Scope. Agriculture and Agricultural Science Procedia, 6, 336–341. https://doi.org/10.1016/j.aaspro.2015.08.089

Knauff, M., & Wolf, A. G. (2010). Editorial: Complex cognition: The science of human reasoning, problem-solving, and decision-making. In Cognitive Processing (Vol. 11, Issue 2, pp. 99–102). https://doi.org/10.1007/s10339-010-0362-z

Jønholt, L., Bundgaard, C. J., Carlsen, M., & Sørensen, D. B. (2021). A Case Study on the Behavioral Effect of Positive Reinforcement Training in a Novel Task Participation Test in Göttingen Mini Pigs. https://doi.org/10.3390/ani

Jaramillo, S., Zador, A. M., & Jaramillo, S. (2014). Mice and rats achieve similar levels of performance in an adaptive decision-making task. Frontiers in Systems Neuroscience, https://doi.org/10.3389/fnsys.2014.00173

Moscow, I. P., Profile, S., Zorina, Z. A., & Poletaeva, I. I. (2014). A Genetic Approach to the Study of Simple Cognitive Abilities in Animals. A Genetic Approach to the Study of Simple Cognitive Abilities in Animals. In The Russian Journal of Cognitive Science (Vol. 1, Issue 3). www.cogjournal.org

Kangas, B. D. (2022). Examining the effects of psychoactive drugs on complex behavioral processes in laboratory animals. In Advances in Pharmacology (Vol. 93, pp. 243–274). Academic Press Inc. https://doi.org/10.1016/bs.apha.2021.09.001

Winstanley, C. A., & Floresco, S. B. (2016). Deciphering decision making: Variation in animal models of effort- and uncertainty-based choice reveals distinct neural circuitries underlying core cognitive processes. Journal of Neuroscience, 36(48), 12069–12079.

HOW TO CITE THIS ARTICLE: Pal, A., Vishwakarma, R., Gupta, D., Verma, S. (2024) Cognitive Complexity and Decision-Making in Social Structures: An In-Depth Analysis of Laboratory Animal Behavior Patterns. *J. of Drug Disc. and Health Sci.* 1(2):113-123. DOI: 10.21590/jddhs.01.02.07