Journal of Biosciences and Medicines, 2026, 14(6), 429-440
https://www.scirp.org/journal/jbm
ISSN Online: 2327-509X
ISSN Print: 2327-5081

Stereotypic Behavior, Grooming, and Behavioral Disorganization in Animals: Neurobiological and Ethological Perspectives

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How to cite this paper: Andronikashvili, G., Okujava, M., Gurashvili, T., Bagashvili, T., Kvernadze, G., Gogeshvili, K., Chipashvili, S., Akhobadze, N., Nikolaishvili, M. and Natadze, D. (2026) Stereotypic Behavior, Grooming, and Behavioral Disorganization in Animals: Neurobiological and Ethological Perspectives. *Journal of Biosciences and Medicines*, **14**, 429-440.
https://doi.org/10.4236/jbm.2026.146029

Received: April 27, 2026
Accepted: June 23, 2026
Published: June 26, 2026

Abstract

Stereotyped and stereotypic behaviors represent related but distinct phenomena in animal behavior. In ethology, organized behavioral sequences such as grooming, mating displays, and prey-capture patterns are often species-typical actions with adaptive value. In contrast, abnormal stereotypy is generally defined as repetitive, morphologically similar behavior with no obvious current goal or function, frequently emerging under restricted, stressful, or impoverished conditions. Behavioral disorganization is used here to describe a loss of normal ordering, coordination, or goal-directed structure within a behavioral sequence, whereas fragmentation refers more specifically to the breakdown of a normally complete sequence into omitted, repeated, interrupted, or incorrectly transitioned elements. These concepts differ from stereotypy because they concern the internal structure and completeness of an action sequence, rather than repetition alone. This review synthesizes classical ethological concepts and neurobiological evidence on fixed action patterns, grooming chains, and behavioral disorganization. Particular attention is given to rodent grooming as a model of sequential motor syntax and to the role of evolutionarily conserved neural systems, including the basal ganglia and associated motivational circuits, in organizing action sequences. The review also discusses how stress, social isolation, neurological dysfunction, and pharmacological manipulation can fragment normally ordered behavioral patterns. By distinguishing adaptive behavioral stereotypes from pathological stereotypy, animal models of grooming and other fixed action patterns may provide useful insight into

human neuropsychiatric conditions involving disrupted action sequencing, including obsessive-compulsive disorder, Tourette syndrome, and Parkinsonian syndromes.

Keywords

Stereotypy, Stereotypic Behavior, Behavioral Stereotypes, Fixed Action Pattern, Grooming, Basal Ganglia, Behavioral Disorganization, Fragmentation, Ethology

1. Introduction

Repetitive behavior occupies an important but sometimes confusing place in the scientific literature on animal behavior. In this manuscript, the preferred term stereotypy is used for abnormal, repetitive, morphologically similar behavior that has no obvious current goal or adaptive function and that commonly appears under adverse, restricted, or impoverished conditions. The phrase stereotypic behavior is used only in this pathological sense. By contrast, behavioral stereotypes refers to organized, recurrent, species-typical behavioral sequences that may be repetitive but retain structure, context, and function. This distinction is important because superficially similar repetitive movements may represent either normal ethological organization or pathological behavioral rigidity.

Behavioral disorganization refers to a loss of normal order, coordination, or functional structure within a behavioral sequence. Fragmentation is a more specific form of disorganization in which a normally complete behavioral chain is broken into omitted, repeated, interrupted, or incorrectly transitioned elements. These terms differ from stereotypy because they describe the internal organization and completeness of behavior, rather than repetition alone. For example, an animal may perform many movements without completing the normal sequence to which those movements usually belong. In such cases, the amount of activity may be preserved or even increased, while the syntactic structure of behavior is impaired.

Stereotypy, in the pathological sense, is often reported under conditions such as cage confinement, social deprivation, predictable feeding schedules, or other forms of environmental limitation. In both humans and animals, stereotypy may be associated with maladaptation, self-injury, reduced reproductive success, poor welfare, and interference with behavioral experiments [1]-[3].

This pathological meaning should be distinguished from behavioral stereotypes and fixed action patterns (FAPs), which are organized, species-typical behavioral sequences. Such behaviors are composed of elementary motor acts and postures that are expressed in relatively predictable order, often with a recognizable beginning and end [4]-[8]. Grooming in rodents is a major example: it is repetitive and highly organized, but in ordinary ethological context it is not necessarily pathological. Instead, it can serve hygienic, thermoregulatory, motivational, and stress-

related functions while also providing a useful experimental model for studying the syntax of action sequences [3] [9]-[13].

Operationally, adaptive repetitive behavior can be separated from pathological stereotypy by considering four main criteria: context, flexibility, sequence completeness, and apparent function. Repetition is more likely to be adaptive when it occurs in an appropriate ethological context, remains flexible in response to environmental change, preserves the normal order and completion of the behavioral sequence, and serves an identifiable function such as hygiene, feeding, mating, defense, exploration, or thermoregulation. Repetition is more likely to represent pathological stereotypy when it is context-inappropriate, rigid, incomplete or excessively invariant, and lacks an obvious current function.

Classical ethology described innate behavioral acts as patterns released by specific stimuli and supported by internal motivational states [14] [15]. Once triggered, some fixed action sequences tend to proceed toward completion even if the initiating stimulus is reduced or removed [5] [6]. Later ethological and neurobiological work showed that these patterns are not always as rigid as early models suggested, but they remain valuable for analyzing how nervous systems generate structured behavioral output [16]-[19].

The purpose of this article is to clarify the relationship between stereotypy, behavioral stereotypes, fixed action patterns, behavioral disorganization, and fragmentation, and to summarize how grooming and related action sequences can be used to study neurobiological organization, stress-induced sequence disruption, and the translational relevance of animal behavior models.

2. Materials and Methods

2.1. Study Design

This manuscript was prepared as a narrative review and conceptual synthesis. It does not report a new controlled experiment, quantitative meta-analysis, or systematic review. Instead, it integrates classical ethological sources, comparative behavioral literature, neurobiological studies of action sequencing, and illustrative behavioral material from the authors' experimental observations.

The authors' experimental observations are not treated as an independent evidence base for the conclusions of this review. They are included only as illustrative material to demonstrate examples of grooming structure, behavioral sequence organization, and possible sequence disruption. Therefore, the interpretive conclusions of the review are based primarily on the cited ethological, behavioral, and neurobiological literature.

2.2. Source Material and Selection Approach

The reviewed material was organized around three major themes: 1) definitions and terminology of stereotypy, stereotypic behavior, behavioral stereotypes, and fixed action patterns; 2) grooming as a model of sequential motor organization and neurobehavioral syntax; and 3) disruption of organized behavioral sequences under

stress, social isolation, neurological dysfunction, or pharmacological influence.

Because this article is a narrative review, sources were selected to provide conceptual breadth rather than exhaustive systematic coverage. The literature was drawn from classical and modern ethology, comparative animal behavior, behavioral neuroscience, neurobiology of action sequencing, rodent grooming research, and translational studies of repetitive or compulsive behavior. The approximate coverage of the cited literature extends from foundational ethological and comparative works published in the mid-20th century to recent neurobiological and translational studies published up to 2024.

Sources were selected when they contributed directly to one or more of the following aims: defining key terminology; describing fixed action patterns and organized behavioral chains; characterizing rodent grooming syntax; explaining basal ganglia involvement in behavioral sequencing; documenting stress-related or disease-related fragmentation of behavior; or supporting translational links with human disorders involving repetitive, compulsive, tic-like, or Parkinsonian motor patterns. Priority was given to peer-reviewed articles, established monographs, and widely cited conceptual works relevant to ethology and behavioral neuroscience.

2.3. Ethological and Neurobiological Framework

Behavior was considered at the level of elementary motor acts, organized behavioral chains, and broader functional contexts. Particular emphasis was placed on grooming chains because they allow the investigator to evaluate both the presence of individual behavioral elements and the order in which these elements occur. Disorganization was considered in terms of omitted elements, repeated elements, abnormal transitions, incomplete chains, or disrupted cephalo-caudal progression [3] [13] [20].

For the purposes of this review, behavioral sequence integrity was interpreted through four operational features: context, flexibility, sequence completeness, and apparent function. These features were used to distinguish adaptive repetitive behavior from pathological stereotypy and to evaluate when repetitive behavior may instead reflect fragmentation or disorganization of an otherwise structured action pattern.

2.4. Ethical Statement

No new animal procedure is described in this review. The manuscript does not present new experimental animal data requiring separate ethical approval. Any original photographic or observational material included for illustration should be confirmed by the authors as compliant with institutional and journal requirements before final submission.

3. Results and Discussion

3.1. Distinguishing Pathological Stereotypy from Adaptive Behavioral Stereotypes

A central problem in the literature is that similar words are used for different be-

havioral phenomena. In this manuscript, stereotypy and stereotypic behavior are used in the pathological sense to refer to frequent, repetitive, morphologically similar behavior with no clear current function. Stereotypy often develops in animals kept in restricted, monotonous, or socially deprived environments and may indicate poor welfare or altered dopaminergic and motivational regulation [1]-[3]. In laboratory settings, abnormal stereotypy can also complicate behavioral testing because it may mask or distort responses to experimental manipulation.

By contrast, behavioral stereotypes are not necessarily pathological. They are organized, recurrent behavioral chains that contribute to species-typical adaptation. The behavioral chain usually has a recognizable structure, and its elements can be described as elementary movements, postures, or acts [4] [7] [8]. A hunting sequence, for example, may include orientation, pursuit, approach, grasping, attack, killing, and prey handling. A grooming sequence may include licking of the forepaws, face washing, head grooming, body grooming, and transitions between these phases.

The distinction between adaptive repetitive behavior and pathological stereotypy can be made operationally by evaluating context, flexibility, sequence completeness, and apparent function. Repetitive behavior is more likely to represent an adaptive behavioral stereotype when it appears in an appropriate ecological or physiological context, remains modifiable by environmental conditions, preserves the expected beginning, transitions, and completion of the sequence, and serves an identifiable function. Repetitive behavior is more likely to represent pathological stereotypy when it is context-inappropriate, highly rigid, resistant to interruption or redirection, incomplete or excessively invariant, and lacks an obvious current function.

This distinction is important because an externally repetitive act may either indicate normal species-typical organization or pathological loss of behavioral flexibility, depending on context, function, and sequence structure.

3.2. Fixed Action Patterns and the Organization of Behavioral Chains

A fixed action pattern is a genetically prepared behavioral sequence that is released by an appropriate stimulus and expressed with relatively stable composition and order [5] [6] [14] [15]. In classical ethology, the releasing stimulus initiates a coordinated action complex that may continue after the original stimulus has ceased. Such patterns are more complex than simple reflexes because they include multiple coordinated motor elements rather than a single stimulus-response unit.

The main features of fixed action patterns can be summarized as follows:

1) They are species-typical and largely innate.

2) They consist of multiple coordinated motor elements.

3) They are expressed in a broadly similar form among individuals of the same species, sex, age, and physiological state.

4) They are usually triggered by relatively specific external stimuli together with

internal motivational readiness.

5) Once initiated, they tend to proceed as an organized sequence rather than as isolated movements.

6) Their expression may still be modified by maturation, experience, environment, and physiological state.

Modern ethology has softened the older view that fixed action patterns are completely rigid. Many action patterns show variation, and some authors prefer terms such as modal action pattern, action complex, or motor pattern. Nevertheless, the FAP concept remains useful because it draws attention to the sequential organization of behavior and to the neurobiological mechanisms that generate structured action.

3.3. Grooming as a Model for Studying Sequential Motor Syntax

Rodent grooming is one of the clearest experimental models for studying the syntax of sequential behavior. A typical grooming chain includes forepaw licking, symmetrical or elliptical forepaw movements around the mouth, unilateral and bilateral forepaw movements around the head, and body grooming [9]-[12] (**Figure 1**).

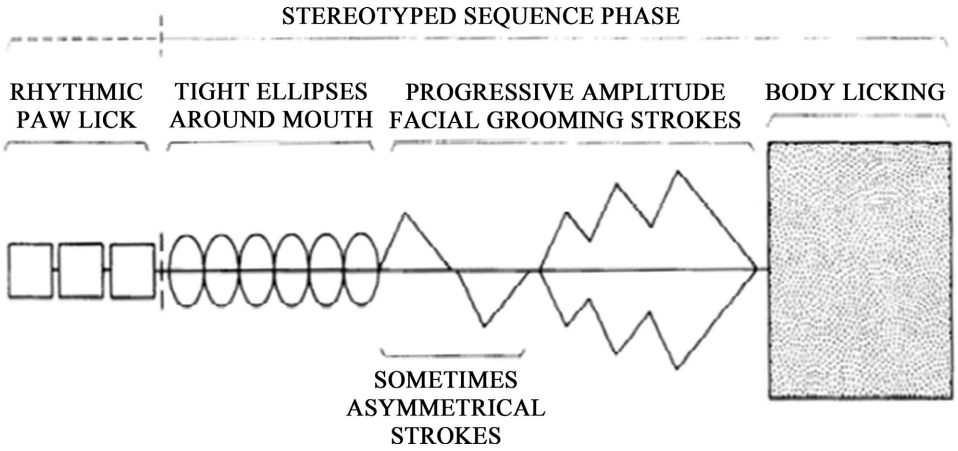

Figure 1. Stereotyped sequence of phases in the rodent grooming chain: 1) licking of the forelimbs, 2) elliptical movements of the forelimbs around the mouth, 3) unilateral and bilateral movements of the forelimbs during head grooming, and 4) body grooming. Adapted from Berridge and Fentress [9].

Although grooming can occur under comfortable conditions, it is also sensitive to stressors such as novelty, bright illumination, water spray, exposure to predators, and pharmacological or hormonal manipulation [3] [13] [20]. Because the sequence is well organized, disruptions can be measured with considerable precision. Investigators can assess whether the animal omits phases, repeats elements, performs incorrect transitions, interrupts the chain, or fails to maintain normal cephalo-caudal progression. In this context, fragmentation does not simply mean that grooming becomes less frequent. Rather, it means that the normal chain loses its internal continuity. An animal may still perform grooming-related move-

ments, but the expected order, transitions, or completion of the chain may be disrupted. This makes grooming useful for separating quantitative changes in activity from qualitative changes in sequence organization (**Figure 2**).

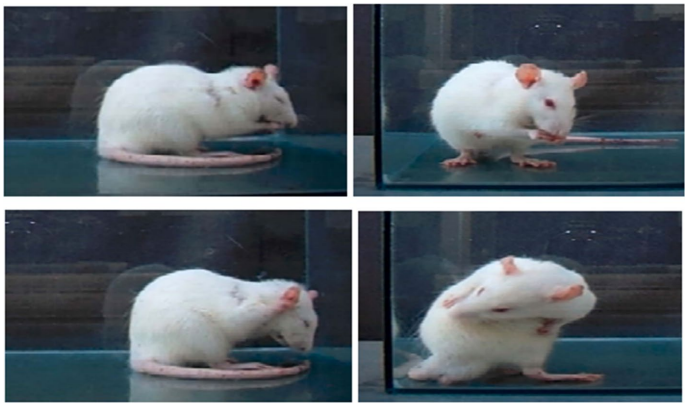

Figure 2. Sequential alternation of grooming phases. Photo material from the Experimental Neurology Laboratory of the Iv. Beritashvili Center for Experimental Biomedicine.

3.4. Basal Ganglia and the Neurobiology of Action Sequencing

Clinical evidence indicates that the basal ganglia, particularly the striatum and substantia nigra, play a major role in action sequencing and behavioral syntax [10]-[13] [21]. These circuits help organize sequential movement in animals and are also relevant to human functions that require ordered action, thought, and speech. Basal ganglia circuits are especially important for selecting, initiating, linking, and terminating action units, allowing separate motor elements to be organized into larger behavioral "chunks" or performance units [22] [23]. Human motor-learning studies also show that distinct basal ganglia territories participate during the acquisition and later execution of motor sequences, supporting the view that these structures contribute to both early sequence formation and automatized sequence performance [24].

Dysfunction of basal ganglia-related systems has been associated with obsessive-compulsive disorder, Tourette syndrome, and Parkinsonian motor disturbances [2] [13] [21]. The study of grooming therefore has translational value. In animals, grooming provides a visible and measurable sequence of motor acts. In humans, related neural systems contribute to the organization of motor routines, cognitive sequences, and repetitive or compulsive behavior. Disruption of sequence generation in animal models may therefore illuminate broader principles of neuropsychiatric dysfunction.

3.5. Stress, Fragmentation, and Behavioral Disorganization

Stressful conditions can transform an organized behavioral chain into a fragmented or incomplete pattern. In laboratory rats, transfer to a novel environment, exposure to bright light, and other stressors can disrupt grooming by causing omitted elements, abnormal repetitions, incorrect phase transitions, and incom-

plete chains [13] [20] [25]. Similar principles have been described in other behavioral domains. For example, social isolation in young wolves has been associated with fragmentation of social behavior [26].

Fragmentation should not be interpreted only as reduced activity. An animal may perform many movements, but if the order and syntactic structure are disrupted, the behavior no longer expresses the normal organized chain. This is why sequential analysis is especially valuable: it measures not only how much behavior occurs, but also how behavior is assembled.

Behavioral disorganization therefore refers to a broader loss of coordination, order, or functional structure, whereas fragmentation refers to the specific breakdown of a normally complete sequence into partial or incorrectly connected elements. In grooming analysis, this distinction allows researchers to ask whether stress changes the probability of grooming, the duration of grooming, or the internal syntax by which grooming actions are assembled.

3.6. Predatory Behavior and Evolutionary Examples of Action Sequences

Predatory behavior provides another example of structured behavioral organization. In the comparative ethological model of Eisenberg and Leyhausen, prey-capture behavior in members of the cat family and related carnivores includes orienting, approach, grasping, positioning of the prey, and a final killing bite [14] [17]. The so-called neck or "death" bite is considered a more specialized and efficient prey-killing act than repeated unspecialized biting (**Figure 3**).

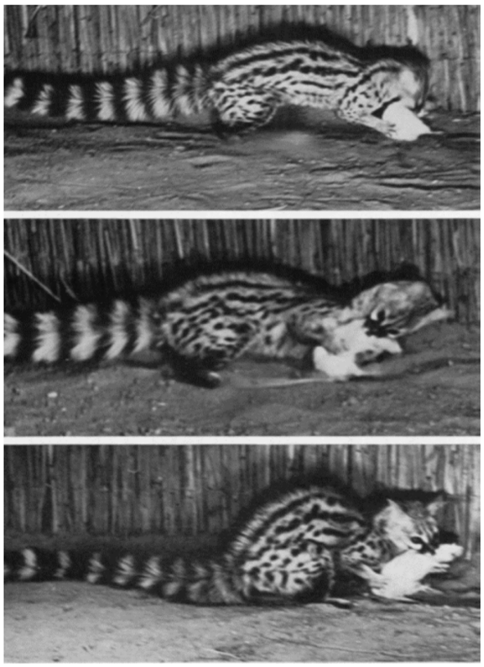

Figure 3. Sequential hunting behavior patterns in genets, including forepaw grasping, approach, and delivery of a precise bite to the neck region. Adapted from Eisenberg and Leyhausen [27].

The development of such sequences is gradual. Individual components such as mouth opening, closing, grasping, and prey positioning may appear early, but coordinated execution depends on maturation, motivational activation, experience, and exposure to appropriate developmental conditions. Innate action components can therefore coexist with learned modifications, producing behavior that is both biologically prepared and experience-dependent.

3.7. Clinical and Translational Relevance

Animal models of grooming and other action sequences are useful for studying human disorders in which repeated actions, compulsive routines, tics, or disrupted movement syntax are prominent. Grooming analysis has been applied in models of stress, anxiety-like states, obsessive-compulsive behavior, Tourette-like phenomena, and Parkinsonian dysfunction [2] [3] [13]. The value of these models lies not in assuming direct equivalence between animal and human behavior, but in identifying conserved principles of action sequencing, motor control, motivation, and behavioral flexibility.

The translational relevance becomes clearer when each human condition is related to a specific type of sequence disruption. In obsessive-compulsive disorder, the most relevant parallel is not ordinary repetition itself, but the excessive persistence or re-initiation of action routines despite limited current function. This resembles a failure to terminate or flexibly update a behavioral sequence, particularly when compulsive actions become rigid, context-inappropriate, and resistant to interruption [23] [28]. Experimental evidence from compulsive-grooming models further supports the involvement of orbitofronto-striatal circuitry in pathological repetitive behavior [28].

In Tourette syndrome, the relevant disturbance is different. Tics can be interpreted as brief, repetitive motor or vocal fragments that are released outside the normal organization of a complete behavioral chain. This pattern resembles abnormal selection or disinhibition of motor fragments rather than the orderly completion of an adaptive sequence. Basal ganglia and frontocortical circuit dysfunction have long been implicated in tic generation, and more recent models emphasize broader basal ganglia-cerebellar-thalamo-cortical interactions [29] [30].

In Parkinsonian syndromes, the disruption is again distinct. Dopaminergic dysfunction in basal ganglia circuits can impair the initiation, scaling, smooth transition, and automatic execution of sequential motor acts. In behavioral terms, this may correspond to delayed initiation, slowed progression, freezing, interrupted transitions, or incomplete execution of action chains. Thus, Parkinsonian motor disturbance is especially relevant to the study of sequence initiation and transition failure rather than to pathological repetition alone [24] [31].

Together, these comparisons show why behavioral sequence analysis may be more informative than measuring repetition alone. OCD-like phenomena emphasize excessive persistence and impaired stopping; Tourette-like phenomena emphasize inappropriate release of motor fragments; and Parkinsonian phenomena

emphasize impaired initiation, transition, and automatic execution. Rodent grooming does not reproduce these human disorders directly, but it provides an experimentally tractable model for analyzing how neural circuits assemble, maintain, interrupt, and terminate structured behavior.

4. Limitations

This article is a narrative review rather than a systematic review. Therefore, it does not include a formal database search strategy, predefined inclusion and exclusion criteria, risk-of-bias assessment, or quantitative synthesis. As a result, the manuscript should be interpreted as a conceptual and integrative synthesis of selected ethological, behavioral, and neurobiological literature rather than as an exhaustive evaluation of all available evidence.

The conclusions are limited by the scope of the cited sources, the heterogeneity of behavioral terminology across ethology and neuroscience, and the difficulty of directly translating animal behavioral sequences to human neuropsychiatric conditions. The illustrative behavioral observations and photographic material included in the manuscript are used only to support explanation and visualization; they do not constitute new experimental evidence.

Future systematic or experimental studies would be useful for testing the proposed operational distinction between adaptive repetitive behavior, pathological stereotypy, behavioral fragmentation, and broader behavioral disorganization across different species, stress models, and neurological conditions.

Acknowledgements

The authors acknowledge the Experimental Neurology Laboratory of the Iv. Beritashvili Center for Experimental Biomedicine for the illustrative grooming material used in this manuscript.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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