Animal behavior as a conceptual framework for the study of obsessive–compulsive disorder (OCD)

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Research on affective disorders may benefit from the methodology of studying animal behavior, in which tools are available for qualitatively and quantitatively measuring and assessing behavior with as much sophistication and attention to detail as in the analysis of the brain. To illustrate this, we first briefly review the characteristics of obsessive–compulsive disorder (OCD), and then demonstrate how the quinpirole rat model is used as a conceptual model in studying human OCD patients. Like the rat model, the study of OCD in humans is based on video-telemetry, whereby observable, measurable, and relatively objective characteristics of OCD behavior may be extracted. In this process, OCD rituals are defined in terms of the space in which they are executed and the movements (acts) that are performed at each location or object in this space. Accordingly, OCD behavior is conceived of as comprising three hierarchical components: (i) rituals (as defined by the patients); (ii) visits to objects/locations in the environment at which the patient stops during the ritual; and (iii) acts performed at each object/location during visits. Scoring these structural components (behavioral units) is conveniently possible with readily available tools for behavioral description and analysis, providing quantitative and qualitative measures of the OCD hallmarks of repetition and addition, as well as the reduced functionality in OCD behavior. Altogether, the concept that was developed in the context of an animal model provides a useful tool that may facilitate OCD diagnosis, assessment and treatment, and may be similarly applied for other psychiatric disorders.

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1. What is OCD?

Obsessive–compulsive disorder (OCD) is a severe disabling psychiatric affliction with a strong impact on life quality [1]. It was recognized as early as the 16th century, and is now known to have a prevalence rate of 1–3%, which is almost twice that of schizophrenia.
2. Obsessions refer to recurring, persistent thoughts, impulses or images that inappropriately intrude into awareness and cause marked distress or anxiety. Compulsions are the need to repeat physical behaviors such as checking or mental behaviors such as counting things, and occur as a response to an obsession or in accordance with strictly applied rules (DSM-IV; [4]). The most common subjective clinical features of obsessional thoughts are doubts and indecision, excessive fear of dirt and contamination, or concern with arrangement or symmetry. The two most common compulsive behaviors are checking and washing [5,6], including an irresistible urge to wash (particularly the hands) or clean, to check doors to confirm that they are locked, to return repeatedly to appliances to make sure they are turned off, to touch, to repeat, to count, to arrange, or to hoard. These compulsive behaviors, also referred to as “rituals”, may be performed for hours and in extreme cases may prevent the subject from sleeping or leaving home: “Mary had been unable to leave her house for the last four years. She would get anxious upon leaving the house, fearing something terrible would happen. She spent hours checking that the stove, oven, appliances, light switches, and faucets were all turned off, and all doors were shut. She also had to make sure that the bed was made, everything was organized, the toilet was flushed, and her lingerie and sexual paraphernalia were hidden” ([7]; p. 86). This example highlights the difference between OCD behavior and rituals or repetitive thoughts in otherwise healthy people: for OCD patients, obsessions and/or compulsions are associated with marked distress, are time-consuming, and interfere with occupational functioning and social activities and relationships. OCD is paradoxical in that the patients’ quest for order results in a disorder of mentality [8]. The urge to display complex activity in a particular order is disabling and impairing [9,10], and patients who perform more rituals are typically more anxious and more bothered by their intrusive thoughts [11]. That is, in the case of OCD, the more ordered rituals and behavioral routines, the more severe is the mental disorder. Another paradox in OCD is that the patients’ awareness of the irrationality or excess of the obsessions and compulsions is accompanied by an inability to control them. For example: “If I started to clean the apartment, Tim told me, I could never stop... as soon as I stepped through the door, the cleaning had to begin.” [Rapoport, 1989 #116; p.134]. In other words, despite their understanding that their obsessive-compulsive behaviors are irrational, patients are unable to control their compulsions, and attempts to prevent access to the specific location/object of checking (for example, by blocking/removing it) result in a displacement of the compulsion to a new location/object [12,13].

2. What is the quinpirole rat model of OCD?

The quinpirole rat model is based on the finding that after 10 repeated injections of 0.5 mg/kg of quinpirole (a D2–3 dopamine agonist), spaced at 3–4 day intervals, rats in a large arena become sensitized to the drug. These rats display a high level of activity that is confined to a restricted portion of the arena, seemingly reflecting shrinkage of the attended space [14]. In the restricted portion of the arena, the rats scuttle from place to place, seemingly exploring the environment with unbounded curiosity. Indeed, quinpirole rats keep on repeatedly visiting the same few places without habituation or fatigue [15]. The concept for the analysis of behavior in quinpirole rats was based on the notion that their behavior is comprised of (i) stops at specific places, and (ii) routes that connect these stopping places [16,17]. Indeed, behavior of quinpirole rats is characterized by: i) one or two places/objects to which the rats return markedly more often than to other places/objects in the environment; ii) the time to return to these preferred places/objects is markedly shorter than to other places/objects; iii) very few other places are visited in between returns to the preferred places/objects; iv) a characteristic set of acts is performed at the preferred place/object, which differs from the acts performed at other locations/objects; and v) activity is altered when the environmental properties of the places/objects are changed [14]. These characteristics of quinpirole-treated rats were suggested to be also applicable to compulsive rituals in human patients [14]. Previous studies have displayed the parallel between human OCD rituals and the quinpirole model [15,18], where the potential of applying the descriptive framework of the rat model to OCD human patients is discussed. However, regarding the present discussion, it should be stipulated that the behavior of quinpirole rats is comprised of traveling along relatively fixed routes that connects specific objects or locations [14]. Their compulsive-like performance is limited to these preferred locations (stopping places), whereas in other, non-preferred locations, their behavior does not differ from that of saline-treated rats [19]. In other words, compulsive-like behavior in quinpirole rats is coupled with a few specific locations. This spatio-temporal organization of behavior in rats, as visits to specific locations/objects and the acts performed at each object/location, constituted the conceptual framework for the analysis of compulsive rituals in human patients suffering from OCD, and for comparing their behavior with that of non-OCD humans.

3. Where do OCD behavior and animal behavior (ethology) intersect?

The term ‘ethology’ comes from the Greek term ‘ethos’, which means custom or habit, combined with the term logos, which means knowledge. This is the biological study of animal behavior, aimed at understanding the proximate (immediate) and the ultimate (survival value) causes of behavior. Immediate causes include external stimuli, internal physiological mechanisms, ontogenesis and genetic basis, while the ultimate consequences include the evolutionary origin and changes (phylogeny) of behavior [20]. In general, animal behavior is described or measured in terms of movement patterns (for example, head scratching), functions (for example, courtship), or consequences (for example, territoriality). A variety of versatile tools and technologies have been developed for animal behavior description. One of the relevant methodologies is the use of “ethograms”. The term ‘ethogram’ refers to a behavioral inventory, a list of behaviors that the observer may label and score as a sequence of labels. Currently, ethograms are computerized and are typically based on video-recording the behavior and encoding the behavioral categories during playback of the video files. The synchrony of the video file with scoring software provides the beginning and end of each behavioral component, facilitating extraction of incidence and duration. As detailed below, this methodology of scoring behavior is similarly applicable for studying OCD behavior.

Compared with other psychiatric disorders, OCD is exceptional in that repetitive and seemingly compulsive behavior also naturally occurs in animals. An in-depth survey on the occurrence of relatively rigid motor habits in animal behavior in the wild, in captivity, and under administration of psychoactive drugs, is available elsewhere [18]. Indeed, the rigidity of motor rituals in animals is already apparent in early ethology. In observations on the water shrew (Neomys anomalus) Konrad Lorenz [21] described how they traveled in fixed paths: “Once the shrew is well settled in its path-habits, it is strictly bound to them as a railway engine to its tracks” (p.128). Lorenz’s water-shrews had been used to jumping over a stone blocking their familiar path, and they kept jumping even after removal of the stone, as if the performance of a motor template was overriding the sensory input that the stone was no longer there, as summarized by Lorenz: “alteration in the habitual path threw the shrews into complete confusion... the animal actually disbelieves its
senses if they report a change of environment which necessitates a sudden alteration of its motor habits” (p. 128). This is reminiscent of Tim, who could not stop cleaning his apartment: “If I started to clean the apartment (Tim told me), I could never stop. As soon as I stepped through the door, the cleaning had to begin. I started missing classes and my grades were starting to slip. So finally (Tim went on), I took to sleeping in the streets. (Wasn’t it worse – I mean dirtier – sleeping outdoors? I asked). No. That’s the funny thing. Of course I felt dirty, and pretty peculiar. It was the strangest thing.” [13]p. 134–135. Lorenz, who anthropomorphized his observations on animal behavior [22], was aware that breaking habits frustrates humans: “...how tenaciously little children cling to every detail of the accustomed, and how they become quite desperate if a story-teller diverges in the very least from the text of familiar fairy-tale” [Lorenz, 1966 #39]. Moreover, the relevance of these animal rituals to psychiatry was obvious to Lorenz, who suggested that his examples of animal behavior would remind the psychiatrist of the neurosis symptom of compulsive repetition of acts [23]: p. 160). Although the similarity between animal and human rituals could provide OCD researchers with a unique opportunity to study the mechanism by which an evolutionary-adaptive etiological factor could cause OCD, so far no such attempt has been made. A possible reason for the lack of such study is that psychiatry is based on the interrogation and self-reporting of patients, which is not possible in animals, thus precluding a comparison of human and animal behavior. However, the opposite is still possible: to study human rituals by means of the tools used in studying animal behavior, and thereby to establish the basis for a search for the natural history and evolutionarily adaptive values pertinent to repetitive and rigid behavioral display.

4. Rituals—a functional definition

General textbooks of psychiatry or books devoted to OCD define rituals in various ways. In the Comprehensive Textbook of Psychiatry [24], ritual is described as a ‘formalized activity practiced by a person to reduce anxiety, as in OCD’ (p. 857). Similarly, in the Lexicon of Psychiatry [25], a ritual is an “elaborate, systemized compulsive behavior” (p. 563). Finally, in the Shorter Oxford Textbook of Psychiatry [26] rituals are “repetitive and seemingly purposeful behaviors, performed in a stereotyped way” (p. 20). In a comprehensive review on ritualized behavior [11] it was suggested that: “There is no precise definition of ritual in any of the three fields that deal with its typical manifestations. Cultural anthropologists generally accept a very vague definition of the term as scripted, stereotypic forms of collective action. Ethologists use criteria such as repetition and stereotypy. Clinical psychologists’ descriptions of OCD pathology, as in the DSM-IV, mention ‘ritualistic behaviors’ without more precision.” Perhaps the most accurate definition is that of the dictionary Ethology, suggesting that ritualization, which is the process of development of motor rituals, occurs through an “increase in conspicuousness by simplification and ‘exaggeration’ of form, repetition (usually rhythmical), emphasis of particular components, slowing down or speeding up of performance, addition of morphological support such as coloration and stereotypy. In contrast to their unrealized antecedents, ritualized behavior patterns typically show considerable constancy in the vigor and rapidity with which they are performed” [20] p. 255. This definition, which was formulated on the basis of detailed studies in animal behavior, is also applicable to compulsive behavior in OCD patients [18], as illustrated in an excerpt from the diary of a patient with OCD, describing a ritual of switching on the TV: “Before I start to turn it on, I have to wash and dry my hands. Then I go and touch the corner curtain followed by touching the side of the TV two times. Then I have to go back and wash my hands. When I am finished with that I will look behind the lamp 2 times, go back and wash my hands, come back, move the lamp to the left and look behind it, move the lamp two times to the right and look behind it, go back, wash my hands, and then look in back of the TV on the left 4 times, washing my hands in between each one. Then I look in back of the TV on the right 8 times, wash my hands, and put the TV on channel 6. Then I turn the knob from channel 6 to 7, 4 times, and from channel 6 to channel 8, 4 times. Then finally I turn it on. The whole thing probably takes around half an hour.” [27]p. 28. As can be abstracted from the diary, this ritual took place at two key locations/objects, the TV and the bathroom, with the patient traveling repeatedly between them, paying 10 visits to the TV and 9 visits to the bathroom. At each location, a typical set of acts was performed – for example, there were 17 repetitions of looking behind the lamp/TV. Altogether, the above ritual was described by that patient as “turning on the TV”; that is, the patient ascribed a specific task to a set of acts that were performed according to strict rules. Accordingly, in our OCD studies we define a ritual as the set of movements performed to accomplish a task as specified by the performer. It should be noted, however, that the ascribed function is used purely as a framework for analysis and is not considered as a necessarily true label of the real motivation or understanding of performance.

5. Rituals—a temporal definition

A ritual is defined here as the set of movements that accompany the performance of a specific function (task), as described above. In other words, a ritual includes all the movements displayed at the locations and/or objects within the functional action. The beginning and end of a ritual are determined by time. For example, when the person arrives at a specific place, performs a set of acts there, and departs from that place, the start and the end of the ritual are respectively the time of arrival and the time of departure from the place. However, there are rituals in which the experimenter must make a judgment to define the boundaries. For example, in a nose-blowing ritual, the start could be set at the point when the person takes a tissue, and the end could be set at the point when the person discards the used tissue and starts to operate the TV. In such a case, the experimenter’s decision might be that the TV is not a part of the nose-blowing ritual. However, if the person touches the TV during the ritual (i.e., between taking and discarding the tissue), then touching the TV would also be considered as part of the nose-blowing ritual.

6. Rituals—a spatial definition

Once the beginning and the end of a ritual have been determined, the spatial domain of the ritual can be determined. This is the set of sites or objects at which the ritual is performed. For example, a ritual of making tea comprised the following locations/objects: electric pot, cup, tea-bag box, tea bag, and sugar jar. Accordingly, rituals are conceived as a set of visits to objects/locations. This follows the basic notion that was first raised by [16] and then used for the study of the behavior of rats in the quinpirole model, where behavior is mainly described as the set of visits to specific objects/locations.

7. Rituals—a component definition

By definition, between-visit intervals in the quinpirole model are merely comprised of locomotion. That is, when the rat stops, its behavior is defined as a visit to that location. During visits, rats could perform various acts and activities, whereas between visits they merely locomoted. The same is applicable for OCD, where patients may execute various activities at each location/objects in the ritual’s domain. Furthermore, by following the methodology of
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**Fig. 1.** Preparation for a meal in an OCD patient and a non-OCD (control) individual, both performing the same task. Columns describe the locations/objects that the patient and the control individual visited, and the acts performed at each object/locations are depicted along the columns from top to bottom and left to right. As shown, the OCD ritual comprised repetition of acts, as well as addition of acts that were not performed by the control individual.

In the quinpirole model, it was possible to describe OCD ritual as a set of visits to objects/locations, and the set of acts performed during each visit, as illustrated in Fig. 1. It is noteworthy that this methodology is not confined only to OCD rituals, but is also applicable for any other motor performance in humans. Indeed, the same analytic approach was applied in studying the structure and functionality during daily motor routines in humans [28]. In the present context, the methodology was also applied in studying the behavior of non-OCD individuals who were requested to perform a specific task on-demand. Specifically, each OCD ritual was compared with the performance of a non-OCD control individual of the same age, gender, and social/educational
background, who was requested to perform the same task that the OCD patient ascribed to that ritual. For example, if an OCD patient displayed a ritual that he labeled as “washing hands”, we asked a non-OCD person of the same age and background to perform “washing hands” on camera. Both performances (OCD and non-OCD) were then compared quantitatively and qualitatively, as described below.

8. Repetition, addition, and reduced functionality—the hallmarks of OCD behavior

We studied 43 rituals of patients meeting DSM IV [4] and SCID criteria for OCD and who had compulsions with obvious motor rituals. Rituals were video-recorded at each patient’s home, where that patient routinely performed its rituals. YBOCS (Yale-Brown Obsessive Compulsive Scale) scores were 15–32, ages were 21–44, and durations of OCD were 10–31 years. A matched healthy individual of similar age and gender was asked to perform the same task that formed the OCD ritual. For example, if a patient described his/her ritual as “I lock my car”, the respective control was requested to “lock your car”.

Clearly, overall ritual duration in OCD patients was longer than that of the respective controls (paired t-test; \( t_{42} = 3.55; p < 0.001 \)). Similarly, the duration of visits to objects/locations was longer in OCD (\( t_{42} = 2.32; p = 0.025 \)). However, since the duration of the acts performed at each visit/object did not differ between OCD patients and their respective controls (\( t_{42} = 0.74; p = 0.46 \)) (Fig. 2), visits and rituals could become longer in duration only by the performance of more acts. Indeed, OCD patients performed significantly more acts (79.2 ± 18.8 and 27.8 ± 8.5, respectively; \( t_{42} = 3.7; p < 0.001 \)). In other words, the longer duration of OCD rituals was not a product of bradykinesia.

The performance of more acts in OCD raised the question of whether these acts were similar to those of the control individuals, which would mean that both patients and controls have the same repertoire and that the patients display repetition of the same acts. Alternatively, it could be that the larger number of acts in OCD was a result of a larger repertoire, which would mean an addition of act types in OCD repertoire. Yet another option is that both processes occur, and OCD patients display both repetition and addition of acts.

Repetition is the hallmark of OCD behavior. Indeed, while 81% of the 504 act types in the behavior of control individuals were performed only once, only 44% of the 1035 act types in OCD patients were performed only once. The remaining act types (56% in OCD and 19% in controls) were performed repeatedly (twice or more). Indeed, repetitions were significantly greater in OCD patients (\( \chi^2(1) = 51.3; p < 0.001 \)). Thus, it is apparent that OCD rituals and visits comprised repetitive performance of acts.

In order to determine whether addition also denoted OCD behavior, we compared each of the 43 OCD rituals with its respective non-OCD control ritual. We thereby classified the behavior into shared acts that were performed by both the OCD patient and its respective control, and into idiosyncratic (unique) acts that were performed by only the OCD or the non-OCD individual. Fig. 3 depicts the results of this classification. As shown, act repertoire in the OCD patients was two-fold that of their respective controls. In both groups, act repertoire comprised shared acts that were performed by both OCD and non-OCD individuals. Additionally, act repertoire in each group comprised unique idiosyncratic acts, which were three-fold greater in OCD than in their respective controls (central bars in Fig. 3). Indeed, the mean number of unique acts in OCD was significantly greater than in the control repertoire (paired t-test; \( t_{42} = 3.7; p < 0.005 \)).

The addition of acts manifests an imperative feature of OCD: non-functionality. As shown in Fig. 1, many of the acts displayed by OCD patients were not displayed by the control individuals who performed the same task. This implies that these additional acts are not necessary for that task. Accordingly, these additional idiosyncratic acts were termed non-functional [29]. Since the rate of these acts was three-fold that of their rate in normal behavior, their abundance was used as an indication of OCD behavior being pessimal (the antonym of optimal). Altogether, these data, which offer a major expansion of a previous report on only 11 OCD rituals [8], unequivocally demonstrate that OCD behavior is predominated by both repetition and addition of acts, and that these processes account for the longer duration and the reduced functionality in OCD. This is illustrated in Fig. 4, in which the sequential order is depicted for shared and unique acts performed by the control individual (top) and the patient with OCD (bottom). The acts are laid out as a linear chain in which each act is symbolized as a circle: a large circle indicates a shared act and a small circle represents a unique act. As shown, the control individual performed mainly shared (“functional”) acts and only one unique (“non-functional”) act. In contrast, idiosyncratic non-functional acts (small circles) predominate the sequence in the OCD patient, along with numerous repetitions of shared acts, illustrating how the functional structure
of the task is fractionated. Calculating the mean chain length of consecutive shared (large circles) and unique (small circles) in OCD and non-OCD individuals revealed that OCD behavior was comprised of long chains of unique acts and short chains of shared acts \((5.92 \pm 1.09\) and \(2.62 \pm 0.29\); mean \(\pm \)SEM of unique and shared acts, respectively). Inversely, non-OCD behavior comprised long chains of shared acts and short chains of unique, non-functional acts \((1.67 \pm 0.13\) and \(5.88 \pm 0.87\); mean \(\pm \)SEM of unique and shared acts, respectively). Again, these data of 43 OCD rituals further consolidate the previous report on 11 OCD rituals [8]. Altogether, the conceptual method, which was a translational framework of an animal model of OCD, was implemented here in a “reversed translational” study of human patients, quantitatively and qualitatively reinforcing facets of OCD that had previously been only intuitive or purely descriptive.

9. The advantage of applying video-telemetry for OCD rituals

OCD rituals are heterogeneous, including a large variety of tasks such as tooth-brushing, coffee-making, room-cleaning, car-locking, nose-blowing, hand-washing, arranging shirts in the closet, etc. Such variation has made it virtually impossible to lump together rituals for quantitative analysis. Moreover, in the lack of a concrete pathology in OCD, diagnosis, assessment and treatment are based solely on evaluation of behavior [36]. Indeed, the psychiatry literature on diagnosis and treatment of OCD is generally based on using various behavioral rating scales; for example, Leyton Obsessional Card Inventory, Maudsley Obsessive–Compulsive Inventory, Yale-Brown Obsessive Compulsive Scale (YBOCS), patients are asked to rate the time spent on, the interference and distress from, and the resistance or control over, obsessions and compulsions. They are also asked to classify their obsession and compulsion to specific subtypes of aggression, contamination, religious, hoarding/saving, need for symmetry, cleaning/washing, checking, etc. Obviously, it is difficult to use rating scales to objectively analyze and quantify OCD rituals. Video-telemetry [31] aims to diminish the gap between subjective and objective information by creating a detailed description of the behavior as the patient performs it. Results of studying OCD with video-telemetry have been described elsewhere [8,29,32], demonstrating in a relatively small population (11–14 cases) that compulsiveness emanates from the expansion of repeats of some acts and visits, and from the addition of superfluous act types. It was found that the maximal number of act repeats was found to best discriminate between OCD and normal activity (90.9% success; \(R^2 = 0.77\); [8]. The expansion of the original study population in the present project consolidated the previous findings, further suggesting that applying video-telemetry is useful in objective assessment of psychiatric disorders [8]. Indeed, there is a large overlap between forms of motor symptoms in other emotional disorders, an overlap that impedes the definition of disorders on the basis of their phenotypes [33–35]. In the field of OC spectrum research, substantial efforts are being made in order to clarify the differences between one spectrum of disorder and another. It has already been found that OCD has a high comorbidity level with some mental disorders that are also characterized by repetitive behaviors, such as Tourette’s syndrome, OC personality disorder, autism and PANDAS (pediatric autoimmune neuropsychiatric disorders associated with streptococcus) [36]. This raises the question of whether therapists have the means by which to distinguish OCD from each of the above disorders, when eliminating OCD. In this context, video-telemetry may provide behavioral phenotypic markers for emphasizing differences between OCD and other disorders. However, video-telemetry is useful only as a secondary tool, after diagnosis with the current rating scales that provide simple, convenient and reliable means for initial diagnosis. In the second phase, video-telemetry may serve as a “behavior fractionating method” to put each component of the behavior under a magnifying glass in order to determine the severity of compulsions and the exact symptoms description. We also suggest that observing the personal video recordings of rituals may promote the efficacy of cognitive behavioral therapy [8]. Along with repetition, which is a key characteristic of OCD, video-telemetry highlights another salient feature: the addition of superfluous, seemingly irrelevant acts and visits. While the acts shared by the OCD patient and his or her respective control can be considered as the minimum set required to perform the task of the ritual, the other idiosyncratic acts are unnecessary for task completion, or “non-functional”, since the other individual did not require them in order to perform the task. Thus, along with measuring repetition and addition, video-telemetry provides a means by which to measure the reduced functionality in OCD behavior, along with assessing socio-cultural components [32] and phenotyping [31]. The concept behind the present application of video-telemetry is the quinpirole rat model [14,37] in segmenting OCD behavior into three levels: rituals, visits to objects/locations, and acts performed at these objects/locations. This segmentation provides a noteworthy support to the hypothesis that ritualized behavior, such as that of OCD patients, is a result of activating two systems. One system is that of ‘inferred threats to fitness’, and the second is of ‘action-parsing’ [11]. In OCD rituals, the manifestation of movement parsing is overt, and the actions that comprise rituals are visible and measurable by virtue of video-telemetry, which revealed facets that coincide with the question raised by [11], as to “why ritualized behavior?”. Specifically, action parsing is described at three levels that correspond to those offered by Zacks and colleagues as: i) simple gestures; ii) behavioral episodes; and iii) script [38,39]. Boyer and Lienard [11] hypothesized that an excessive focus on the level of simple gestures is what happens in cultural and individual rituals, in contrast to spontaneous focusing on the mid-ranged behavioral episodes in normal behavior. Indeed, the parsing categories became obvious when described in the context of the location or object at which they were performed (Fig. 1).
especially since OCD rituals carry a remarkable spatial component with a strong affinity between compulsion and specific location or object [18]. Specifically, the space in which a ritual (=behavioral episode) is carried out may be viewed as the set of sites or objects at which actions (=movements or gestures) are performed. Behavior is then scored by noting the movements at each location/object, as illustrated in Fig. 1, illustrating that, as suggested by Boyer and Lienard [11], OCD rituals consist in excessive focus on simple gestures (movements). Our current data add to this a spatio-temporal component: gestures are coupled with specific locations, and gesture repetition and addition account for the extended ritual duration and goal demotion. Thus, the in-depth discussion of “why ritualized behavior?” [11] is further supported by video-telemetry by addressing the questions of ‘where’ and ‘how’ ritualistic behavior occurs; with ‘where’ referring to the coupling between rituals and specific locations or objects, and ‘how’ referring to the high concentration involved in compulsive performance [18,28]. Altogether, video-telemetry provides a means by which to extract measurable knowledge that may prove useful in OCD research, treatment, and diagnosis before and during treatment.

10. The potential of video-telemetry application for other psychiatric disorders

In psychiatry, diagnoses of mental disorders are established on the basis of behavior and, therefore, the assessment of movement patterns provides a common baseline for the comparison and study of different syndromes. This seems especially true for autism, which is primarily associated with motor stereotypes, repetitive behaviors, and rigid routines. Indeed, the application of movement notation to the study of motor disturbances in infants that were later diagnosed with autism or with Asperger’s syndrome, revealed evidence of movement disturbances in these infants (e.g., in lying, righting, sitting, and crawling). Such movement disturbances may play a fundamental predictive role for autism, an assessment tool for probable treatment outcome [40], or detecting earlier signs [41]. In other words, autistic patients are most likely to evidence the kind of ritualized behavior and motor stereotypes that are amenable to the methodology of video-telemetry. Moreover, the presumed common genetic base of autism spectrum disorders, as manifested in stereotypes and the ritualized behavior associated with autism may also manifest itself in common principles of overt motor behavior. The strong evidence for a genetic link between autism and other mental disorders, and the likely role that the basal ganglia play in these disorders, suggest that there may be considerable overlap in the repetitive motor behavior associated with various disorders. Here, a fine-grained analysis by video-telemetry may enable the novel and heuristic segmentation of rituals into structural units, which may also help in the nosology of obsessive- and autism-spectrum disorders. Another potential diagnostic application of video-telemetry lies in resolving the debate over whether complex tics in Tourette’s syndrome are indeed tics, or compulsions. Altogether, video-telemetry of motor activity in psychiatric disorders may add a novel means for heuristic sub-typing of endo-phenotypes and comorbidity, enable better differentiation among disorders, and support the development of objective tools for assessment of observable stereotypes.

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