

Obsessive–compulsive disorder: a disorder of pessimal (non-functional) motor behavior

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Obsessive–compulsive disorder: a disorder of pessimal (non-functional) motor behavior.

Objective: To determine whether in addition to repetitiveness, the motor rituals of patients with obsessive–compulsive disorder (OCD) involve reduced functionality due to numerous and measurable acts that are irrelevant and unnecessary for task completion.

Method: Comparing motor rituals of OCD patients with behavior of non-patient control individuals who were instructed to perform the same motor task.

Results: Obsessive–compulsive disorder behavior comprises abundant acts that were not performed by the controls. These acts seem unnecessary or even irrelevant for the task that the patients were performing, and therefore are termed ‘non-functional’. Non-functional acts comprise some 60% of OCD motor behavior. Moreover, OCD behavior consists of short chains of functional acts bounded by long chains of non-functional acts.

Conclusion: The abundance of irrelevant or unnecessary acts in OCD motor rituals represents reduced functionality in terms of task completion, typifying OCD rituals as pessimal behavior (antonym of optimal behavior).

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Key words: compulsive ritual; compulsive content; functional impairment; sequential order; temporal order; ritualization

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Accepted for publication February 11, 2009

Significant outcomes

- This is the first study to present a measurable reduced functionality for obsessive–compulsive disorder (OCD) behavior, suggesting that OCD is a disorder of pessimal motor behavior (repetitiveness and non-functionality).
- Together with repetitions, the non-functional acts are the motor hallmark of OCD behavior, and once identified they may serve as a bed-side sign for defining OCD and its severity.

Limitations

- The definition of non-functionality was based on comparison with controls, which may not be practical for clinical use.
- Similarly, the application of video analysis, which is advantageous in basic research, may not work in the clinic.
- An alternative for the videotaping and comparison with controls is using intuitive taxonomy of the acts in a certain task, but this is not as objective and perhaps not measurable.

Introduction

In the present study, we examined the sequential (temporal) structure of motor behavior in patients suffering from obsessive–compulsive disorder (OCD). OCD is a chronic psychiatric problem (1, 2), with a lifetime prevalence of 1–3% (3, 4). *Obsessions* are recurring, persistent thoughts,

impulses or images that intrude into awareness and cause marked distress or anxiety. *Compulsions* are repetitive physical behaviors such as checking or mental behaviors such as counting things, and occur in response to an obsession with strictly applied rules (DSM-IV; 5). The most common OCD behavior is that of compulsive checking (6, 7), which may be performed for hours and in

extreme cases may prevent the subject from sleeping or leaving home. Despite their understanding that their obsessive–compulsive behaviors are irrational, patients are unable to control the compulsions, and blocking their access to the specific location/object of checking results in a displacement of the compulsion to a new location/object (8, 9). Altogether, OCD is a disabling disorder with a severe impact on life quality (10).

The diagnosis and assessment of OCD are generally based on patient's introspection or their self-reporting (e.g. the Leyton Obsessional Card Inventory, Maudsley Obsessive–Compulsive Inventory, Yale-Brown Obsessive–Compulsive Rating Scale, and DSM-IV; 11). Similarly, research into OCD dimensions and subtypes has been based entirely on factor-analytic studies of clinical rating scales (12). The heterogeneity of OCD rituals and their controlling mechanisms (12–14), makes it difficult to use rating scales to analyze and quantify rituals, except perhaps to obtain information on duration, subjective anxiety, and the relative prevalence of subtypes. This is, for example, the problem we face in finding a common thread among diverse rituals such as hand washing, cigarette lighting, nose blowing, car locking and closet arranging. Indeed, current research on OCD phenomenology is limited to mentioning the apparent repetitive nature of rituals, measuring their duration, and subtyping them into categories such as 'cleaning' or 'checking'. Here we approached OCD behavior from a different perspective, namely, human ethology (15), which examines behavior on the basis of observations made by the experimenter rather than on the basis of evidence provided by the subjects' own introspective observations.

Using the approach of human ethology, we recently implemented tools derived from previous studies in an animal model of OCD (16–18) to study motor rituals in OCD patients (19). For this, we videotaped OCD rituals performed by patients in their own home, and compared these rituals with the behavior of healthy individuals instructed to perform the same rituals. The videotaped rituals were deconstructed into visits to specific locations or objects (ritual space), and to the acts performed at each location/object (ritual basic components). Quantitative analyses revealed that compulsiveness emanates from the expansion of repeats for some acts and visits, and from the addition of superfluous act types (19). We also found that while only 20% of the acts in control individuals were repeated, more than 50% of the acts in OCD patients were repeated twice or more (19). While the study of Zor et al. (19) quantified repetitions of the behavioral

'building blocks' of OCD (amount and duration of repetitions on acts), the present study expanded the previous analysis by focusing on the sequential-temporal structure of OCD behavior.

Aims of the study

We posed three questions: i) what are the characteristics of the acts that are repeated in OCD behavior; ii) what is the temporal (sequential) order of the repetitions; and iii) how does the repetition of acts interfere with and hinder normal functioning.

Material and methods

Subjects

OCD patients. Ten male and four female adult out-patients, meeting DSM-IV (5) and SCID criteria for OCD with insight, and having compulsions with obvious motor rituals were videotaped at their homes, where they routinely perform rituals. Y-BOCS scores were 26 ± 2.5 (mean \pm SEM; median 24 and mode 22), ages were 37 ± 4.6 (mean \pm SEM; median 32), and durations of OCD were 19 ± 3.7 years (mean \pm SEM, median 18). After a complete description of the study to the subjects, written informed consent was obtained. The study was approved by the Helsinki Committee of Geha Mental Health Center.

Control individuals. 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 'lighting a cigarette', the respective control was requested to 'light a cigarette'.

Procedure

The psychiatrist (H.H.) and experimenter arrived at the patient's home, described the research and asked again for the patient's approval to participate and be videotaped. It was stipulated to the patients that he/she are requested to display recent and frequent ritual. After an explanation of the videotaping equipment and procedure, videotaping commenced and lasted for 1–2 h, with only the experimenter following the patient with a handheld camera. When asked after the session to rate the degree of similarity, patients reported a medium or higher degree of closeness of the videotaped ritual to their off-camera compulsion. Consistent with the patients' high ratings, we noted that once patients started to

perform their rituals, performance took over and they paid no further attention to the observer or the camera but only to performing the ritual itself (see videoclip in ref. 20).

Data acquisition and analysis

A ritual was defined as the set of movements performed to accomplish a task as specified by the patient. For instance, for a patient who described a motor performance as 'lighting cigarette', this was taken by the experimenter to be the performed function and the ritual was labeled as 'cigarette lighting'. The ritual included all the acts displayed within the task. The beginning and end of a ritual were determined by the patient's activity – for example, when the patient arrived at a specific location, performed a set of acts there, and departed from that location, the start and end of the ritual were respectively arrival and departure from the location. However, when a ritual was less clearly demarcated by spatial location, the patient's behavior was used to identify the start and end of the ritual – for example, in a 'nose-blowing' ritual, start was the point when the patient picked up a tissue paper and end was set when the patient cleaned his/her shirt from pieces of the tissue paper and switched to operating the TV with a remote control. In such a case, it was considered by the experimenter that the remote control is not part of the 'nose-blowing' ritual. However, had the patient touched the remote control before cleaning the shirt, then touching the remote control would have been considered as part of the 'nose-blowing' ritual. It should be noted that the ascribed function was used as a framework for analysis and not for deciphering the patients' motivation or understanding behind their performance. Motor behavior was scored during playback of the video records. Briefly, we listed the *acts* that comprised each ritual, and this list served in scoring of behavior at the various locations at which these acts were performed (19). Behavior was scored using the OBSERVER (Noldus Information Technology, Wageningen, the Netherlands), a software for ethological descriptions.

Shared and unique acts. For each OCD patient and her/his matched control individual, we divided the acts to those performed by both individuals, and to acts that were performed by only the OCD patient or by only the matched control. Acts performed by both were classified as 'shared', and were considered as being essential to the performance of the task. Acts that were performed by only the OCD

Table 1. The ritual of filling up a pet's water bowl in OCD patient and in the behavior of a matched control individual who was instructed to execute the same function (filling up a pet's water bowl)

OCD patient		Control person
Unique acts	Shared acts	Unique acts
Shake bowl	Pick up bowl	Check water
Slide bowl	Drain water	Touch tap
Move away	Open tap	
Check bowl location	Fill water	
Lean over	Close tap	
Wave hands	Put down bowl	
Slide bowl		
Touch floor		
Check bowl location		
Slide bowl		
Move away from		
Check bowl location		
Rise up		

The central column lists acts that were shared by both actors, whereas the lateral columns list the 'unique' acts that were performed by only one of the actors.

patient or by only the control individual were classified as 'unique', and were considered as being not compulsory for the task, as the other person skipped that act or used an alternative act. An example of this act classification is shown in Table 1.

For each OCD ritual and matched control performance, the following parameters were extracted from the video files: ritual duration; incidence and duration of all acts; acts repertoire (number of different acts, excluding repetitions); incidence and mean duration of shared and unique acts; chain length of consecutive shared acts and chain length of consecutive unique acts; incidence of switching between shared and unique acts; frequency distribution of act durations.

Statistics

To compare the performance of patients and non-patients controls, each dependent variable was analyzed using a two-way ANOVA, with one between-group factor (OCD patients vs. non-patient controls) and one within-group factor (shared acts vs. unique acts). A significant interaction effect was followed by independent *t*-tests to evaluate group differences for shared and unique acts separately, and similarly, paired *t*-tests were used to compare shared and unique acts within each group. For dependent variables that did not include a distinction between shared and unique acts, OCD patients and non-patients controls were compared using *t*-tests. Statistical analysis was performed using SPSS 15 for Windows and significance was set at $P < 0.05$.

Results

OCD rituals were longer and comprised more acts

Rituals in OCD patients were significantly longer than in their respective controls (162 ± 22 vs. 85 ± 26 s respectively; t -test, $t_{26} = 2.28$, $P = 0.03$). OCD rituals also included more acts than their respective control rituals (57 ± 7 vs. 18 ± 5 respectively; t -test, $t_{26} = 4.8$, $P < 0.0001$). However, mean act duration did not differ between OCD and control rituals (2.7 ± 0.4 vs. 2.3 ± 0.4 s respectively; t -test, $t_{26} = 0.9$, ns). Thus, the longer OCD rituals comprised a greater incidence of acts rather than acts with longer duration.

Shared and unique acts: repertoire, total number and total duration in ritual

Although both patients and their respective controls performed the same task (see Methods), the repertoire of acts (the set of distinctly different acts performed during the task) was greater in OCD rituals than in control rituals (13.9 ± 1.4 vs. 8.8 ± 1.4 distinct acts respectively; $t_{26} = 2.6$, $P = 0.016$). In other words, control individuals accomplished the stated OCD task by using a smaller repertoire of acts compared to the greater variety of acts used by OCD patients to accomplish the same goal.

To further scrutinize this difference, we divided the acts of OCD patients into two types: i) acts that were performed by both the patient and the patient's control individual and ii) acts that were performed by only the OCD patient and not the

patient's respective control. Similarly, we divided the control acts into the same two categories: i) acts performed by both the control individual and the OCD patient and ii) acts performed by only the control individual and not the OCD patient. We considered the acts performed by both the OCD patient and the respective control as 'shared acts' in that they appear as essential for the task ascribed to that ritual. In contrast, we considered the acts performed only by the OCD patient or only by the control individual as 'unique acts' in that they do not appear as essential in the performance of the task since apparently, the other person performed the task without these acts.

Figure 1a describes the repertoire of shared and unique acts. By definition, the repertoire of shared acts was identical in both OCD and control groups, since it was defined as only those acts performed by both. In contrast, the repertoire of unique acts was three-fold greater in OCD patients than in their respective controls ($t_{26} = 3.7$, $P = 0.001$).

The importance of unique acts in OCD behavior was even more salient when the repetition of acts was counted and the total numbers of shared and unique acts were compared (Fig. 1b). As shown, the difference between controls and OCD patients was relatively smaller for shared acts compared to the difference between the groups for unique acts (for group, $F_{1,26} = 22.8$; $P = 0.001$; for group by act-type interaction, $F_{1,26} = 7.6$; $P = 0.01$). That is, behavior of the control individuals was dominated by shared acts but the opposite was the case in OCD patients, where unique acts were signifi-

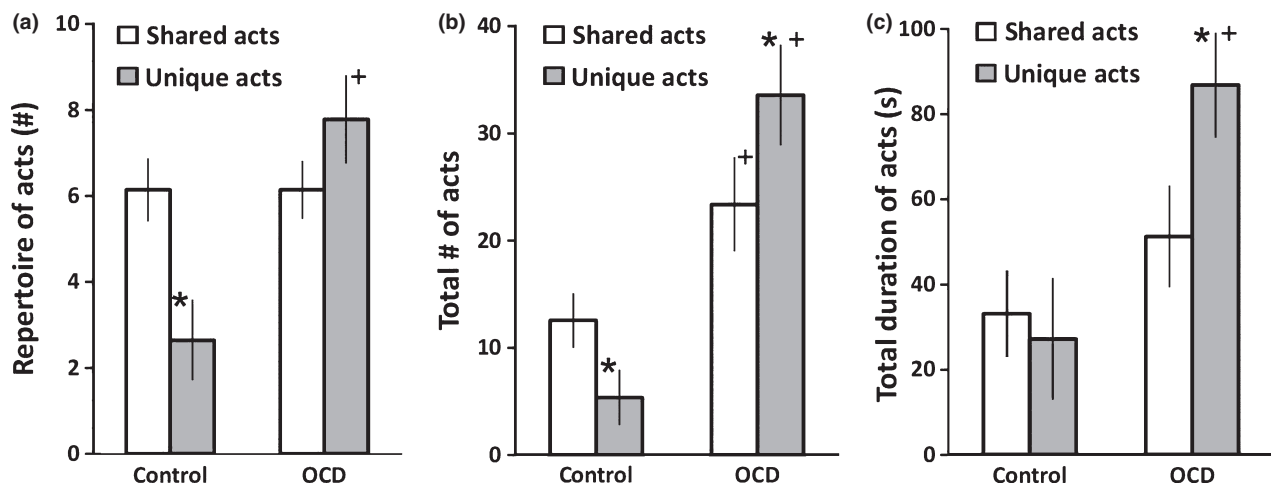


Fig. 1. Measures of shared (open bars) and unique (gray bars) acts in OCD patients and control individuals: (a) number of distinct acts comprising the repertoire of acts in a ritual; (b) the total frequency of acts performed in a ritual; and, (c) the total duration of time taken to perform the acts in a ritual. A significant Group (control vs. OCD) by Act-type (shared vs. unique) interaction was present for each dependent measure; t -tests were used for *post hoc* comparisons. * $P < 0.05$ vs. the other act type in the same group, paired t -test; + $P < 0.05$ vs. acts of same type in the other group, t -test.

cantly more frequent (Fig. 1b). The relatively greater dominance of unique acts in OCD rituals was also evident when the total duration of these acts was considered (Fig. 1c). As shown, in controls the total duration of shared acts was similar to the total duration of unique acts but in OCD patients the total duration of unique acts was significantly higher than the duration of shared ones (for group, $F_{1,26} = 4.4$; $P = 0.047$; for group by act-type interaction $F_{1,26} = 6.5$; $P = 0.019$).

The preponderance of unique acts in OCD rituals (Fig. 1a–c) may suggest that the longer overall duration of OCD behavior reflects the repeated performance of numerous unique acts. Indeed, when considering the duration of unique acts as a proportion of ritual duration, unique acts comprised about 20% of the ritual time in controls, compared with about 60% of the OCD ritual. Similarly, when considering the frequency of unique acts as a proportion of total frequency of acts in the ritual, unique acts comprised $18.6\% \pm 4.5\%$ of total acts in control individuals but $60.9\% \pm 5.1\%$ of the total acts in the rituals of patients with OCD (note, however, that both absolute duration and number of acts were higher in OCD than in controls).

Shared and unique acts: sequential order

To appreciate the sequential order with which shared and unique acts unfold during a ritual, Fig. 2a uses the ‘cigarette lighting ritual’ as an example and shows the sequential order of 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 with each act being one link symbolized as a circle: a large circle indicating a shared act and a small circle representing a unique act. As shown in Fig. 2a, the control individual showed one long chain of shared acts uninterrupted by any unique act. In contrast, the OCD patient showed varying lengths of alternating chains of shared and unique acts in the performance of the cigarette lighting task. Figure 2b provides yet another example of a ritual task, performed by the control person (*top*) and the patient (*bottom*). The same pattern of differences as in Fig. 2a is evident between the control and the OCD ritual except that in Fig. 2b not just unique acts but also shared ones were performed repeatedly (note repeats of large circles of same color in *bottom* ritual). The overall impression provided by Fig. 2 is that performance of a task by the control person is characterized by relatively long sequences of shared acts whereas performance in the OCD patient is marked by relatively short shared

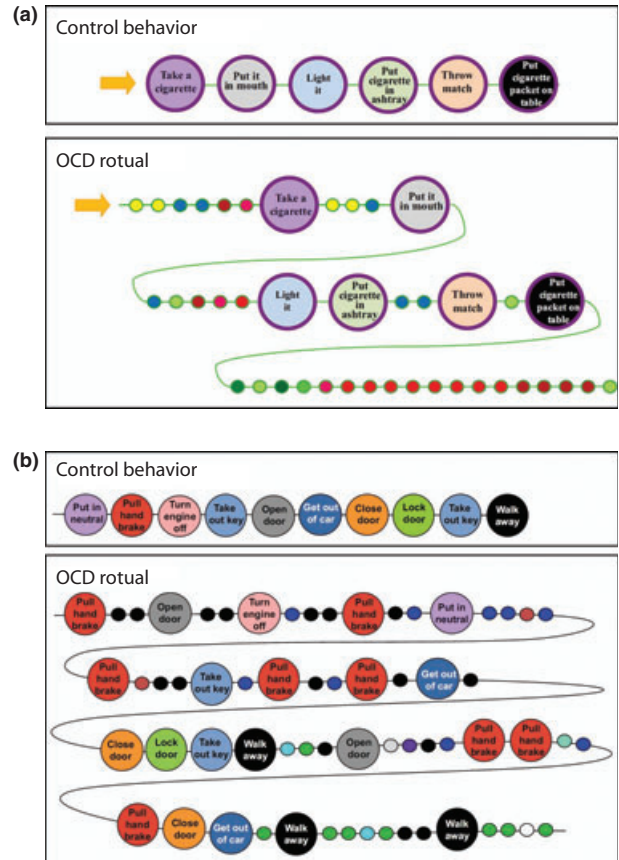


Fig. 2. The sequential order of shared (large circles) and unique (small circles) in a ritual of ‘cigarette lighting’ (a) and ‘car locking’ (b). Large circles represent shared acts, whereas small circles represent unique acts. For each of these two rituals, the control performance is depicted on top and the OCD ritual at the bottom. Similar colors indicate similar acts. As shown for the ‘cigarette lighting’ rituals (a), the control individual performed a sequence of 6 consecutive shared acts (large circles) with no unique acts. In contrast, in the OCD patient the same sequence of shared acts was interrupted with numerous unique acts, especially at the end of the ritual. A similar pattern is seen in the ‘car locking’ ritual (b), where a one chain of 10 functional acts in the control is broken by unique acts into chains with 1–3 links (shared acts), with most of them performed repeatedly.

sequences interspersed by quite long chains of unique acts.

To quantify the sequential order of shared and unique acts across the 14 rituals, we calculated the mean chain length of shared and of unique acts in each OCD and control ritual. For example, the control ritual in Fig. 2a comprises only one chain of 6 shared acts and thus the mean chain length of shared acts for this control ritual is 6 and for unique acts it is 0; the OCD ritual in Fig. 2a includes unique chains of 6, 3, 5, 2, 1, 17 acts (mean = 5.7), and shared chains of 1, 1, 2, 1, 1 acts (mean = 1.2). To evaluate whether mean chain lengths differed between groups and act-types, a group (control vs. OCD) by act-types

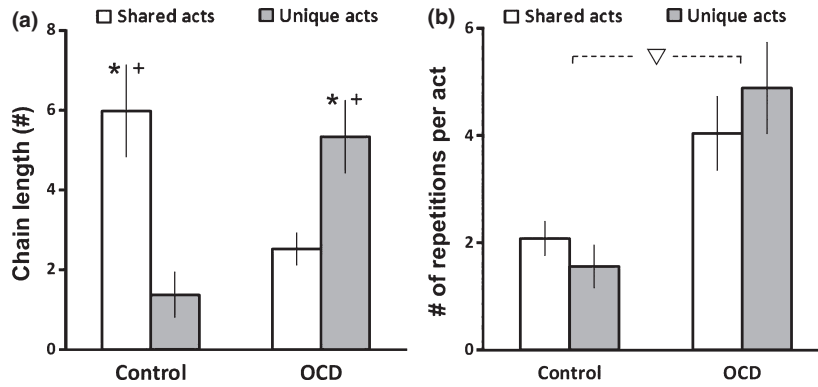


Fig. 3. Measures of shared (open bars) and unique (gray bars) acts in OCD patients and control individuals: (a) mean length of acts of one type before a switch to acts of the other type; and, (b) the rate of repetition of shared and of unique act-types as obtained from the ratio of total acts to the repertoire of different acts. A significant Group by Act-type interaction was present for the first dependent measure; *t*-tests were used for *post hoc* comparisons. * $P < 0.05$ vs. the other act type in the same group, paired *t*-test; + $P < 0.05$ vs. acts of same type in the other group, *t*-test; -∇- $P < 0.05$, only a main effect of Group was present.

(shared vs. unique) ANOVA with repeated measures on the second factor was used. Results showed that only the interaction term was significant ($F_{1,26} = 20.6$; $P = 0.001$). As shown in Fig. 3a, chains of shared acts were significantly longer in controls compared with patients ($t_{26} = 2.8$; $P = 0.009$), whereas the opposite was true for unique acts, with their chains being significantly longer in patients than in control rituals ($t_{26} = 3.7$; $P = 0.001$). Thus, the relatively long chains of shared acts that characterize the behavior of control individuals are curtailed in OCD behavior into shorter shared chains bounded by relatively long chains of unique acts. This conclusion is buttressed by the finding that the number of transitions between shared and unique chains within a ritual was significantly higher in patients than controls (17.6 ± 3.0 vs. 4.6 ± 2.5 transitions, respectively; *t*-test, $t_{26} = 3.44$, $P = 0.002$).

Duration of shared and unique acts

There was no significant difference between controls and OCD patients in the mean duration of acts, or in the duration of the shortest act performed, whether shared or unique; moreover, there was no significant difference between the mean duration of shared and unique acts in either patients or controls (data not shown). However, a significant difference between patients and controls did exist for the duration of the longest unique act that was performed (14.9 ± 4.1 s in patients vs. 3.6 ± 1.4 s in controls, $t_{18} = 2.2$, $P = 0.039$). The general lack of differences between patients and controls in parameters of act duration can be appreciated from an inspection of the distribution of act durations presented in Fig. 4. As shown, the

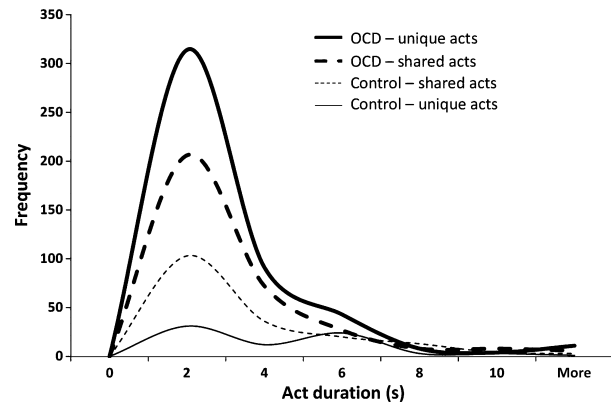


Fig. 4. Frequency distribution of act lengths for shared and unique acts in OCD patients and in control individuals.

majority of acts, regardless of their type, were relatively brief, lasting up to 2 s. However, the frequency of 2-s shared acts (dashed lines) was doubled in OCD compared to control, and the frequency of 2-s unique acts in OCD was 10-fold higher than their frequency in controls. Thus, the main difference between OCD and control behavior was not in the actual duration of individual acts but in the inflated rate of their performance, especially of unique acts. Indeed, when one transforms Fig. 4 data to a relative frequency distribution of act durations, the relative frequency of 2-s acts was high in both groups, although it was smaller in controls than in patients with OCD for either unique acts (42% in controls vs. 67% in patients) or shared acts (58% in controls vs. 63% in patients). Altogether, brief acts were abundant in OCD behavior, catching the eye of the observer by predominating performance and minimizing the share of longer acts that characterize normal behavior.

Shared and unique acts: rate of repetition

We described in Fig. 1b the total number of acts and in Fig. 1a the repertoire of distinct acts. The ratio between these two parameters is the rate of repetition per act. As shown in Fig. 3b, the amount of repetition per shared act was roughly equivalent to the amount of repetition per unique act in both controls and OCD patients (for act-type, $F_{1,22} = 0.03$, $P = 0.8$; for act-type by group interaction, $F_{1,22} = 2.87$, $P = 0.104$). However, repetition in OCD rituals was roughly twice the amount of repetition per act in controls (4.6 ± 0.8 vs. 1.8 ± 0.3 repetitions per act; group effect,

$F_{1,22} = 8.5$, $P = 0.008$). Implicit in this result is that the profound total number of unique acts (Fig. 1b) in OCD rituals is not a mere product of a higher rate of repetition (Fig. 3b) but is also a result of a much greater repertoire of distinct unique acts in OCD behavior (Fig. 1a).

Shared and unique acts: semantic content

So far, we have categorized acts only by comparing performance between OCD patients and their respective controls. Here we scrutinize the content of shared and unique acts and then categorize the acts according to their semantic meaning. Table 2 describes the various acts that were performed by either OCD patient and/or control individuals. The upper part of the Table 2a presents the top-10 most performed acts. As shown, many of these were cleaning acts, acts of moving or taking items, and checking acts. Moreover, most of the top-10 acts were performed by OCD patients (46% as unique OCD acts and 31% as shared OCD acts), and only 23% of the top-10 acts were performed by controls. As shown, unique acts of OCD patients included a profound increase in the number of checking acts and move/put/take/turn/return acts. In cleaning acts, there was a profound increase in the incidence of both unique and shared acts. Altogether checking, cleaning and move/put/take/turn/return acts comprised more than 50% of the acts in the rituals.

Table 2. Distribution of the 1068 acts performed across all rituals according to group (control vs OCD) and act type (shared vs. unique). (a) Top 10 acts in terms of number of times performed (b) All other acts

List of Acts	Control		OCD		Total acts
	Shared	Unique	Shared	Unique	
(a)					
Cleaning acts (wipe, wash, scrub etc.)	57	18	131	135	341
Move/put/take/turn/return	21	17	36	77	141
Checking acts (touch, stare, measure)	3	4	10	112	129
Open/close	27	6	37	12	82
Stretch	6	0	23	15	44
Push/pull	2	1	10	20	33
Shake	9	5	9	5	28
Collect	1	2	5	19	27
Drain/add/pour/fill	6	15	4	0	25
Exit/walk	4	0	7	8	19
Total	136	68	272	403	879
% of the total	(15%)	(8%)	(31%)	(46%)	(100%)
(b)					
Arrange	0	2	0	13	15
Lean-over/sit/rise up	0	0	0	14	14
Insert	4	0	5	5	14
Turn on/off	3	1	4	6	14
Drink	7	0	5	0	12
Dry	2	0	9	0	11
Crush	6	0	5	0	11
Tighten	0	0	0	9	9
Hold	1	1	2	5	9
Fold	2	1	4	2	9
Blow	2	0	7	0	9
Adjust	2	0	3	4	9
Tap	1	0	1	5	7
Throw	2	2	2	0	6
Cross	3	0	2	0	5
Tie	2	0	2	0	4
Mix	3	0	1	0	4
Kiss	0	0	0	3	3
Shift gear	1	0	1	0	2
Light	1	0	1	0	2
Squeeze	0	1	0	0	1
Wave hands	0	0	0	1	1
Total	50	8	62	69	189
% of the total	(26%)	(5%)	(32%)	(37%)	(100%)
Total number of acts					1068

Numbers indicate the number of times the listed act was performed.

Discussion

OCD is characterized as a disease of repetitive thoughts or acts (2, 21, 22). In this study, we asked which structural units (acts) are repeated in OCD, compared with normal behavior. For this, we studied the behavior of OCD patients compared with control individuals who were instructed to perform the same functional task as the OCD ritual. We distinguished between acts that were performed by both the OCD patient and his/her respective control (*shared acts*), and acts that were performed by only the patient or by only the control (*unique acts*). A comparison of 14 OCD patients and 14 control individuals revealed that OCD rituals comprised an excess of unique acts. Equally striking, the temporal order of shared and unique acts was altered in OCD rituals: In control individuals, there were few unique acts and thus performance of the task consisted of shared acts being emitted one after the other as a relatively long sequence or chain of shared acts. In OCD patients, the abundant unique acts were interlaced with shared acts and yielded a pattern of perfor-

mance characterized by very short chains of shared acts bounded by relatively long sequences of unique acts. In the following, we argue that the shared acts are *functional* acts in the sense of being compulsory for task performance. In contrast, as one of the actors accomplished the task without the unique acts of the other actor, we suggest that unique acts are unnecessary or even irrelevant for that task, and therefore classify them as *non-functional* acts. In light of this distinction, we argue that the abundance of unique irrelevant or unnecessary acts in OCD represents reduced functionality in terms of task completion. We therefore claim that the present findings reveal that at least some aspects of OCD may indicate a disorder of repetitive and pessimal behavior (antonym of optimal behavior).

What is repeated in OCD?

According to DSM-IV (5), obsessions refer to recurring, persistent thoughts, impulses or images that inappropriately intrude into awareness and cause marked distress or anxiety. Compulsions occur as a response to an obsession or in accordance with strictly applied rules, and include the need to repeat either physical behaviors such as checking, or mental behaviors such as counting things (DSM-IV; 5). Hence, repetition is a hallmark of both obsessions and compulsions. OCD is a complex disorder, with a wide spectrum of symptoms that obscures the possible relations between them (12). That is, different themes of obsession (fear of contamination, fear of death, etc.) or compulsions (cleaning, checking, etc.) are grouped in OCD, and the common feature of this variety of themes is the repetitive nature of OCD behavior. Indeed, repetition in OCD is so remarkable, that the diagnostic scales (for example: Y-BOCS, OCI) assess the severity by time consumption and the distress caused by the repetitive performance of obsessions and compulsions. To that well-established characteristic of OCD, the present results add another salient characteristic: performance of unique, apparently non-functional acts. Indeed, in addition to repetitions, compulsive behavior of OCD patients was dominated by brief acts that were not performed by controls who were instructed to perform the same task that the OCD patients said that they were doing. These idiosyncratic acts were not compulsory for the task as one actor skipped that act or used an alternative act. That is, the goal that OCD patients ascribed to their behavior was accomplished by controls with fewer distinct acts and fewer repetitions of them.

The present finding on the pessimal essence of overt compulsions seems to meet OCD criteria, as outlined in DSM-IV (5). Indeed, obsessions are defined as inappropriate recurrent and persistent thoughts, impulses, or images that are not simply excessive worries about real-life problems. The person attempts to ignore, suppress or neutralize the obsessions with some other thought or action, realizing that they are a product of his/her own mind (not imposed from without as in thought insertion; 5). Implicit in this definition is that obsessions are not linked to tangible, figurative or imminent matters, and in that sense may be also viewed as 'not functional' or pessimal. In the same vein, compulsions are defined as repetitive behaviors or mental acts that the person feels driven to perform in order to prevent or reduce distress or prevent some dreaded event or situation. However, these behaviors or mental acts are either not connected in a realistic way with what they are designed to neutralize or prevent, or are clearly excessive (5). This definition is refined by the present analysis by distinguishing between functional and non-functional, thereby highlighting the pessimal nature of compulsive behavior in general.

Ritualization – a process of diminished functionality

Compulsive behaviors are often termed 'rituals', which are intuitively recognizable by their stereotypy, rigidity, repetition and apparent lack of rational motivation (23). While there is no precise definition of OCD rituals, in animal behavior it is postulated that the evolutionary process of ritualization involves a transformation of non-display behavior that has an obvious function into display behavior that has a mere communicative value (24). That is, behavior gets divorced from its original function in a process that typically involves constancy in vigor, rapidity and form (24). The present results illustrate how the motor expression of OCD rituals recapitulates the evolutionary scenario. First, in terms of task performance, OCD rituals are non-functional for including numerous acts that are unnecessary, or even irrelevant for the task that the patients ascribe to their behavior. Second, the inflated rate of act repetition in OCD converges at relatively brief acts that outnumber the performance of longer acts (Fig. 4) and dominate the eye of the observer. Altogether, OCD rituals seem to divert from functionality of behavior towards the inflated performance of unnecessary acts (Fig. 1) and numerous repetitions of all act types (Fig. 3b).

Most OCD patients report a '*need to perform compulsions to quell feelings of things being not just*

right' (25, p. 188); see also (26). In consequence, patients are preoccupied in arranging, aligning, checking, measuring, moving, etc since they feel that the task is incomplete. Accordingly, it was suggested that incompleteness, or the lack of sense of task completion, is a core motivation in performing compulsions (21, 27). While the notion of incompleteness presumes an 'open-ended' or 'never-ending' task due to the repetitive manner of OCD behavior, the present results demonstrate that the incompleteness may take the form of recruiting superfluous, apparently non-functional acts that interfere and break down functional performance.

Obsessive thoughts and motor rituals occur not only in people suffering from OCD. Patients with other psychiatric disorders (28–30) as well as normal individuals, also experience obsessions or display motor rituals. Motor rituals with the same themes that are typical in OCD are also abundant in cultural rituals and in the complicated routines of many children (23, 31), where rituals seem remarkably similar to pathological compulsions (e.g. (32–35). Obsessions conceive of a train of unproductive and prolonged intrusive thoughts or ideas that are ruminated without 'a fixed end-point at which the person feels some satisfaction or relief and so can stop' (36, p. 198). The content of clinical obsessions was considered to resemble non-clinical obsessive intrusions (37), assuming that there is a continuity between abnormal and normal compulsions (38, 39); note however, (40). This similarity between normal and OCD behaviors probably originates from similarity in the core reason and/or underlying mechanisms. Indeed, as a possible mechanism, it was suggested that cultural and clinical rituals share the goal of structuring the environment: 'cultural rituals and OCD are characterized by a desire to produce order, regularity, boundaries and clearly demarcated categories' (33, p. 221), or data parsing (23). A proposed core reason for rituals is security motivation (41), harm avoidance (27) or threat to fitness (23); see also (42). Altogether, these mechanisms or core drives result in behavior with the same few themes.

Similarity in core motivation or themes does not necessitate similar motor performance. It was demonstrated that overt compulsive behaviors are highly specific to OCD patients compared with non-clinical participants and non-obsessive patients (43), and that distraction strategy in task performance is used by normal controls but not by OCD patients (44, 45). These latter studies are in line with the present results, which expound the difference between normal and OCD behaviors, as manifested in numerous unique, seemingly non-

functional acts, which do not occur in normal performance of the same task that the OCD patients performed. Apparently, the present results on repetitions along with non-functionality in task performance may help to explain why OCD is disabling, exerting a severe impact on life quality (10). However, it is noteworthy that our findings are based on OCD patients with observable or objectively measurable behaviors/acts, and not on patients with only obsessions or with mental compulsions.

What is the disadvantage in repetitions?

Boyer and Liénard (23) hypothesized the involvement of an action-parsing system in the development of rituals, by virtue of a shifted focus from mid-ranged actions to finer movements. Specifically, these authors follow Zacks and Tversky (46) in suggesting that perception and conception of events occurs at three hierarchical levels: i) simple gestures, ii) behavioral episodes and iii) scripts. For example, in a script of 'getting dressed for dinner', the mid-range episodes are 'put on a shirt', 'put on shoes', etc. Each of these episodes consists of simpler (basic) gestures; for example, 'put on shoes' comprises 'take' the shoes, 'insert' the feet into the shoes, and 'tie' the laces. Boyer and Liénard (23) proposed that rituals, including compulsive behavior of OCD patients, involve a shift of the spontaneous focus (or attention) from the mid-range episodes to the basic structural units (acts) that make up the ritual. That is, while the script of 'getting dressed for dinner' may be described spontaneously 'put on a shirt', 'put on shoes', etc, in OCD ritual the patient will refer to each act that comprise these episodes. Following this hypothesis on shift of focus to basic acts, it was assumed that since there are no obvious sub-goals for the basic components (acts), the entire script (ritual) goal undergoes a process of 'goal demotion' (23). The present results on non-functional acts seem to provide further support to the hypothesis of goal demotion. Specifically, in the present analysis, the performance of a specific task was dissected to its components (acts) and classifying them to functional acts that seem essential for the task, and non-functional acts that seem unnecessary, or at least have an alternative. We argue that since OCD patients displayed copious unique acts that were not displayed by control individuals who performed the same task, then even if the unique acts had their own targets, these targets were irrelevant for the task. This process of recruiting acts, which even if they have a goal of their own, their goals are not linked to the more general goal of the ritual

(script), seems to perfectly follow the hypothesis of 'Goal demotion', as laid out by Boyer and Liénard (23). Consequently, 'goal-demotion' is a process of increased non-functionality, a feature that we hereby suggest to be a salient characteristic of OCD rituals. All in all, the present data provides an experimental support for the hypothesis of goal demotion (23) and reduced functionality.

OCD as a disease of pessimal behavior

Aforementioned is the message of extending the hallmark of compulsive OCD rituals, to include the performance of non-functional acts together with repetitions. Together, these two characteristics of OCD convey the impression of unnecessary or senseless behavior (22). Measuring non-functionality in OCD by comparison to non-OCD behavior, as applied in this study, may seem impractical in the clinic. Nevertheless, once we are aware of the non-functionality in OCD rituals, these acts are easily discernible and may serve as a bed-sign for defining OCD and its severity (see videoclip in ref. 20). Moreover, the availability of simple computer video peripherals makes it easy to document rituals at the clinic and re-assess them from time to time in the course of treatment.

In contrast to OCD behavior, normal task performance involves a concise, typically uninterrupted chain of functional acts (e.g. – Fig. 2a,b). Accordingly, a behavior that is optimal in terms of performance conceives of only functional acts without idiosyncratic unnecessary acts. In light of this definition of optimal behavior, compulsive rituals represent the opposite extreme of *pessimal behavior* (antonym of optimal behavior; *pessimum* = 1/optimum). Following this definition, it is possible to define and scale behavior to a desired precision, accuracy or precaution. For example, we may prefer that 'locking a door' should not be optimal in terms of execution with only one performance of each functional act. Rather, for optimizing precaution we may prefer to give up some functionality by double-checking that the door is locked. We may also define that triple-checking the lock diverts from optimized performance and precaution. All in all, the rate of repetition and *pessimum* are both overt and measurable salient characteristics of OCD and may be well developed into tools or scales for assessing the severity of this malfunctioning.

The present findings suggest that OCD may reflect pessimal behavior (repetitiveness and non-functionality). Such a notion is consistent with the OCD model of Szechtman & Woody (41) which

frames OCD as a disturbance of a biologically ancient security motivation, a motivational system in which concerns about potential danger are regulated by internal variables given that signals for sufficient precautionary behaviors do not exist in the external environment. As such, 'optimality' depends on risk given potential dangers versus cost of excessive precautions. Pessimal behavior ensues when security-related precautionary behavior exceeds risk, a condition that the model postulates arises because of a disturbance in a behaviorally-generated negative feedback signal. The present findings suggest that the behavioral form of such excessive precautions includes a heightened rate of repetition as well as increased performance of non-functional acts.

Acknowledgements

We are grateful to the anonymous OCD patients and control individuals who willingly participated in this study and to Professor J. Zohar for his help and advice. This study was supported by the Adams Supercenter for Brain Studies and the Basic Research Program in TAU and by US Air Force Office of Scientific Research (AFOSR), Arlington, VA.

Declaration of interest

None.

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