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14. ABSTRACT This report results from a contract tasking Tel-Aviv University as follows: Background and aimsOur daily activities are comprised of motor routines, which are behavioral templates with specific goals, typically performed in an automatic fixed manner and without much conscious attention. Such routines can seem to resemble pathologic rituals that dominate the motor behavior of obsessive-compulsive disorder (OCD) and autistic patients. This resemblance raises the question of what differentiates and what is common in normal and pathologic motor behavior. Indeed, pathologic motor performance is often construed as an extended stereotyped version of normal everyday routines. In this study we applied ethological tools to analyze six motor routines performed by 60 adult human volunteers. We found that longer normal everyday routines included more repetitions, but not more types of acts, and that in each routine, most acts were performed either by all individuals (pragmatic acts) or by only one individual (idiosyncratic components). Thus, normal routines consist in a relatively rigid part that is shared by all individuals that perform the routine, and a flexible part that varies among individuals. The present results, however, do not answer the question of whether the flexible individual part changes or remains constant over routine repetition by the same person. Comparing normal routines with OCD rituals revealed that the latter comprise an exaggeration of the idiosyncratic component. Altogether, the present study supports the view that everyday normal routines and pathologic rituals are opposite processes, although they both comprise rigid motor behavioral sequences.

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Pragmatic and Idiosyncratic Acts in Human Everyday Routines: The Counterpart of Compulsive Rituals

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Abstract

Our daily activities are comprised of motor routines, which are behavioral templates with specific goals, typically performed in an automatic fixed manner and without much conscious attention. Such routines can seem to resemble pathologic rituals that dominate the motor behavior of obsessive-compulsive disorder (OCD) and autistic patients. This resemblance raises the question of what differentiates and what is common in normal and pathologic motor behavior. Indeed, pathologic motor performance is often construed as an extended stereotyped version of normal everyday routines. In this study we applied ethological tools to analyze six motor routines performed by 60 adult human volunteers. We found that longer normal everyday routines included more repetitions, but not more types of acts, and that in each routine, most acts were performed either by all individuals (pragmatic acts) or by only one individual (idiosyncratic components). Thus, normal routines consist in a relatively rigid part that is shared by all individuals that perform the routine, and a flexible part that varies among individuals. The present results, however, do not answer the question of whether the flexible individual part changes or remains constant over routine repetition by the same person. Comparing normal routines with OCD rituals revealed that the latter comprise an exaggeration of the idiosyncratic component. Altogether, the present study supports the view that everyday normal routines and pathologic rituals are opposite processes, although they both comprise rigid motor behavioral sequences.

Introduction

Repetitive actions are prevalent in normal and abnormal behavior [7]. In normal behavior, repetitive performance takes the form of “routines”, refering to either a motor pattern or a cognitive regularity [5]. Indeed, the term “routine” denotes an action that is executed on a daily basis and seems to take place without much, if any, cognitive control [16]. Repetitive performance also characterizes several pathologies in humans that result in what is called “ritualized” or “stereotypic” behaviors. This is the case, for instance, in autism [17], as well as schizophrenia [14, 20]. This phenomenon is salient in obsessive-compulsive disorder (OCD), in which one of the main features is the repeated and time-consuming performance of many “rituals” with little functional value [2]. Indeed, in terms of pragmatism, the behavior of OCD patients has been considered as pessimal (antonym of optimal) [26], featuring goal demotion and ritualization [6]. Ritualistic pathological behavior, such as that of OCD patients, is often intuitively understood as an exaggeration and stereotypy of normal behavioral routines. But of what do the latter consist? To what degree are they standardized in normal behavior? Are they purely pragmatic, that is, goal-driven? In the study reported here, we analyzed routines of normal human individuals, concentrating on motor routines with overt behavioral patterns.

In order to study behavioral routines, we borrowed the descriptive tools and concepts of ethology [10]. It was long assumed in ethology that the routines of an individual subject are rigid, performed automatically or even involuntarily. This assumption underlies the core concept of Fixed Action Pattern (FAP), a stereotyped behavioral pattern that is relatively constant in form [12]. The notion of FAP ignited a controversy on how "fixed" FAPs actually are [4, 18]. Subsequently, a notion of Modal Action Pattern (MAP) followed, recognizing that a behavioral pattern includes fixed but also variable components [4]. More recent research has since suggested that variation and change are inherent and endogenous in routines [5]. In light of these findings, we posed here the question of whether a certain variation is also inherent in motor routines in humans; not as individuals but as a group performing the same task? Specifically, in the present study we set out to analyze normal motor routines in terms

of the variation among individuals who perform the same everyday task. In the framework of this analysis we addressed the following questions: [a] how fixed is a motor routine performed by several individuals? [b] since OCD patients seem to have highly idiosyncratic rituals, what is the relative proportion of shared and idiosyncratic (non-compulsory) acts in normal routines? [c] are there gender differences in the performance of normal routines, as is prevalent in OCD? and [d] do longer versions of a routine include more acts, repetitions of the same acts, or simply longer acts?

Materials and Methods

Participants. Sixty healthy adult Israeli volunteers (30 women, 30 men, age 24-50 years) were recruited from the general public by personal invitation to participate in the study. Specifically, participants were asked whether they usually perform any of our target routines (detailed below), and if so, whether they were willing to perform that routine on camera.

Routines. Six routines were arbitrarily chosen to be video-recorded according to their high prevalence in everyday life. We selected routines that are prevalent, common, and widely used: (1) lighting a cigarette; (2) starting a car; (3) putting on a button-shirt; (4) making coffee; (5) putting on shoes; (6) locking a door.

Design and Procedure. After a volunteer had agreed to perform on camera a task that she/he routinely performs, the researcher went to where the volunteer usually performed the routine (home, office etc.). The volunteer was first briefed on the purpose of the study, then signed an informed consent document, and was then video-recorded with a hand-held camcorder (Panasonic SDR-H20) while performing the routine. After the video recording, each volunteer was requested to fill in a questionnaire that rated the degree of similarity between the video session and her/his usual off-camera performance of the same routine. All subjects reported a medium or high degree of similarity. The entire above session of video-recording and questionnaire completion took less than 30 min per individual. The

experimental procedure and the informed consent document were approved by the Institutional Helsinki Committee for Human Experimentation at Tel Aviv University.

Data acquisition and analysis. The analysis followed a previous method [25]. Briefly, a routine was defined as the set of acts that the individual frequently performed in order to accomplish a particular task. The beginning and end of the routine were set by the individual. Video files were transferred to a computer and analyzed by means of the Observer (by Noldus Information Technologies, NL), a behavioral coding and analysis software. The spatio-temporal analysis of each routine was divided into: (1) locations at which, or objects with which the routine took place; and (2) the acts performed at each of these locations/objects. Accordingly, we scored each act that was performed at each object/location during slow-motion playback of the video files.

For each routine we extracted the following parameters: (1) routine duration: the duration from the beginning of the first act to the end of the last act (as defined by the individual); (2) number of acts: the total number of acts performed in the routine; (3) act repertoire: the set of different acts in the routine; (4) rate of act repetition: the ratio between the total number of acts and the repertoire of different acts; (5) mean act duration: the mean duration of each act; (6) sharing index: for each act, we calculated the extent to which a given act is performed by different individuals, as $(x–1)/(n–1)$, where x is the number of individuals who performed that specific act and n is the total number of subjects performing the routine (n=10 throughout the present study).

Statistical analysis. Each of the above dependant variables was compared in: (i) a two-way ANOVA, with one between-group factor (the routines) and one within-group factor (women *vs.* men); and (ii) Pearson product-moment correlations. A one-way repeated-measure ANOVA was used to compare the frequency distribution of the rate of act-sharing (sharing index). All parameters did not significantly deviate from normal distribution in a Kolmogorov–Smirnov test. Proportion data were transformed for statistical analysis into arc sinus of their

square root. Statistical analysis was performed using STATISTICA 6 software, with alpha level set to 0.05.

Results

No difference in routines performed by women or men

Each of the six observed routines differed from the other routines in the following parameters: total duration, total number of acts, act repertoire, rate of act repetition, and in mean act-duration (Table 1). However, in each of the parameters there was no significant difference between women and men.

Table 1

Longer routines included more repetitions, not more types of acts

Some of the above parameters were in correlation (see Table 2). As shown, routine duration and total number of acts (repetitions included) were in direct correlation, but there was no significant correlation between these parameters and act-repertoire (the set of different acts in a routine, excluding repetitions). In addition, routine duration was in direct correlation with the rate of repetition. These correlations imply that longer routines included more act-repetition rather than more types of acts.

Table 2

Most acts were performed either by all individuals or by only one individual

Table 3 depicts the acts (rows) performed by the 10 individuals (columns) in the “lighting cigarette” routine. The right-hand column indicates the sharing index (computed as described in the „Methods’). As shown in the right-hand column, the maximal sharing-index of 1 (act performed by all individuals) characterized seven of the 27 types of acts (rows), and

the minimal sharing-index value of 0 (only one individual performed that act) characterized 12 out of these 27 rows. We extracted the same information on the sharing index for each of the six routines and calculated the frequency distribution, revealing that for all six routines, acts shared by 3-9 out of the 10 individuals were rare. Two peaks with low and high sharing index comprised the majority of act repertoire in each routine (Figure 1). In other words, there were only a few acts that were shared by more than two but not by all individuals. Altogether, the distribution of sharing index shown in Fig 1 is bimodal, with high frequencies at 0 (idiosyncratic acts) and 1 (shared by all) points, and minimal values in between.

Table 3 and Figure 1

Discussion

In the present study we analyzed normal motor routines performed by 60 human subjects, following past studies that had suggested routines as virtually automatic [3, 11], highly similar across individuals [8], and mostly goal-driven [1]. We found two major components in all routines: (i) acts that were performed by all individuals, and (ii) idiosyncratic (non-compulsory) acts that were performed only by one individual. This finding on routine structure is discussed below in the context of descriptions of pathologies as a “ritualistic”, distorted or stereotyped counterpart of normal routines.

Routines comprised pragmatic and individual structural components

For the overall performance of 60 routines, we observed a bimodal distribution in act-sharing, which may represent a synthesis of functionality and individuality. In this synthesis, acts that are common to all the individuals are the attributes that give the routine its label (“making coffee”, "lighting a cigarette”, etc.) and therefore are obviously connected to that routine. These acts may be considered “functional” or “pragmatic” since no individual accomplished the task without them. At the other end of the bimodal distribution are individual acts performed by only one or two individuals. These acts are idiosyncratic, and,

since most individuals accomplished the task without them, they are not compulsory for task completion (“non-functional” acts). These idiosyncratic acts characterize individuality, discerning between individuals performing the same task. We argue that the functional and individual acts also represent, respectively, rigid and variable components of motor routines.

Following past studies [4, 5] that revealed rigid and flexible components in the relatively fixed behavioral patterns, the peaks in the frequency distribution of acts (present results) may represent the rigid and the variable components in fixed behavioral patterns. The acts common to all individuals are assumed to constitute the rigid base of the routine that defines the purpose of the routine task. For example, the "start a car" routine includes common acts such as insert key, start the engine, put in gear etc., and these are necessary for task completion and for defining the task - namely, to start the car. A possible advantage of rigid performance is a low demand for cognitive control [21], deliberate memory retrieval [1] and low attention [19]. As a result, the “unused” cognitive potential can be directed towards another simultaneous task, or enable a more rapid performance of the task.

The present results also revealed that in addition to the rigid component, routines also comprised a variable component. It should be noted that by variability we refer to inter-individual differences among individuals, and not to intra-individual difference between routines of the same individual (which was not in the scope of the present study). A certain variability or flexibility is desirable in order to reduce possible loss of functionality or even to avoid a disaster that might occur in fully automated performance, as illustrated by the following examples. One example is the description of Konrad Lorenz’s water shrews, which were used to jumping over a stone blocking their path, and kept on jumping even after removal of the stone, being unable to alter their habit despite the changed sensory environmental information [13]. Another example is provided by Air Florida plane crash while taking-off from a snowy runway [9]. While performing the checklist routine after starting the engine, the first officer read each checklist item and the captain responded after checking the appropriate indicator. When the first officer asked: “anti-ice” the captain's automatic

response was “off”, which is the usual response in that routine. In other words, the crew followed their usual routine, ignoring the actual environmental conditions that required operating the anti-icing device [9]. These two examples illustrate how rigid routines that are performed automatically can override conflicting information or attendance to such information. A certain flexibility may therefore refresh the automated action and bring into consideration the relevant information. Since the present study comprised only a single repetition of a routine by an individual, further studies should analyze the repetitive performance of the same routine by the same individual, in order to reveal whether the idiosyncratic acts of that individual are preserved or vary over repetitive performance. If the idiosyncratic, “non-functional” or “non-compulsory” acts are preserved, they can be regarded as behavioral “fingerprints” that differentiate the way in which individuals vary in performing the same set of functional acts that comprise a motor routine. However, if the idiosyncratic acts vary over routine repetition, they should be regarded as the “evolutionary flexibility” that enables the routine to adjust to changing circumstances, such as those illustrated in the above examples.

Routinization vs. ritualization – opposite mechanisms?

A common view is that ritual is an exaggeration and amplification of the routinization of action in normal behavior – a view implicitly supported by clinical criteria for OCD in the *Diagnostic and Statistical Manual IV* [2]. However, one can argue that, in terms of action organization and attention focus, routinization and ritualization are different processes [6] because they focus attention on different levels of mental event-hierarchies. Zacks and colleagues (2001) demonstrated that humans perceive and conceive the world at three hierarchical levels. The basic and most elementary level is that of *gestures*, which comprise 'acts' or movements. A higher level is that of *episodes*, which comprise a set of acts that are relevant to each other in a certain way. The upper level is that of a *script*, a series of episodes that are linked together to a certain task [22-24]. For example, a script of “getting

dressed" includes episodes such as "put on shirt", "put on shoes", etc. Each of these episodes is built of gestures such as "get hold of the shirt", "insert right hand into right sleeve", etc. Zacks and Tversky (2001) suggested that the spontaneous and normal focus and attention are at the middle level of *episodes* [24], which is also supported by the existence of a "basic" level in event-taxonomies [15]. That is, if we need to describe the above script of "getting dressed", we readily describe it by listing the episodes (put on shirt, shoes, etc.), and not by the gestures. In following this parsing concept, Boyer and Lienard (2006) suggest that in ritualized behavior the attentional focus is shifted from episodes to gestures, a feature that accompanies the high degree of cognitive control, and attention to fine-grained aspects of performance, typical of rituals. We suggest here that, in motor routines, attention and focus shift from the spontaneous mid-level of episodes to the broader level of script (Figure 2). That is, in performing a motor routine we attend only to the general script (such as "driving to work", "lighting a cigarette", or "making coffee"), and are not necessarily conscious of which episodes comprise each of these scripts.

In this view, even though routinization and ritualization result in a relatively fixed and rigid performance, the underlying processes are actually diametrical – routinization shifts the focus from episodes to scripts, while ritualization shifts it from episodes to gestures (Figure 2). Routinized behavior is based on automated performance with a low demand for attention and lesser emphasis on proper performance. In contrast, ritualized behavior is executed with high control and attention and includes explicit emphasis on proper performance [6]. Moreover, ritualized action often applies to familiar actions that are performed routinely, seemingly without thinking (e.g. walking or making coffee). In ritualization, such actions turn into difficult tasks (like walking without stepping on the sidewalk lines or making coffee without touching the cup) [6]. In all, therefore, rituals are not a mere amplification of motor routines, as they seem to involve inversed cognitive and attentional processes.

Figure 2

OCD rituals – are they an amplification of motor routines?

The conceptual methodology applied in the present study was previously utilized in the study of motor rituals in obsessive-compulsive disorder (OCD) human patients [26]. In that study, behavior of each OCD patient was compared with a non-OCD control who was instructed to perform the same task that the OCD patient had performed. In comparing OCD with non-OCD behavior, acts that were performed by both the OCD patient and the respective healthy control were considered functional, whereas acts performed by only the OCD patient or by only the control were considered to be non-functional since the other individual could accomplish the same task without performing these acts [26]. The data from that study and the present data are summarized side by side in Fig 3. This comparison comprises three states: normal routines (solid line), the pathologic state of OCD patients (dotted line), and data of non-OCD people instructed to perform a task (dashed line). As shown, OCD rituals comprise the same relative part of functional (sharing index of 1) acts as in routines, perhaps since the OCD patients were also required to accomplish the performed task. However, the pathology in OCD behavior is apparent in the non-functional acts (sharing index <.2) that in OCD rituals are twice as prevalent compared with motor routines. On the other hand, the instructed tasks included a higher incidence of functional (sharing index = 1) acts, and a minimal incidence of non-functional acts. In other words, instructing someone to perform a certain task reduces the non-functional component and augments the functional one. Taken together, these data suggest OCD pathology as involving an inflated performance of non-functional acts. Delineating different patterns in a variety of behavioral events may facilitate the acquisition of means to optimize behavioral performance, as well as highlighting processes in the development of pathologic behavior.

Figure 3

Acknowledgments

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Table 1. Summary of act and sequence dimensions for six different routines, broken down by gender, with statistical comparisons. Significant differences are depicted in bold.

		Routine duration (sec)	No. of acts	Act repertoire	rate of repetition	Mean act duration (sec)
Put on shoes	women	26.8 ± 8.6	22.2 ± 2.8	8.6 ± 1.1	2.6 ± 0.2	1.4 ± 0.6
	men	24.4 ± 8.3	20.0 ± 4.1	8.2 ± 1.6	2.4 ± 0.2	1.3 ± 0.4
Put on a button shirt	women	32.2 ± 11.7	16.2 ± 6.2	7.2 ± 1.9	2.2 ± 0.3	1.4 ± 0.1
	men	32.2 ± 5.4	17.6 ± 2.2	6.4 ± 1.1	2.8 ± 0.6	1.6 ± 0.3
Start a car	women	19.6 ± 2.1	10.8 ± 1.9	9.6 ± 1.5	1.1 ± 0.0	1.3 ± 0. 5
	men	22.6 ± 9.1	12 ± 2.9	10.2 ± 2.2	1.2 ± 0.1	1.4 ± 0.4
Lock a door	women	7.9 ± 1.9	7.4 ± 0.9	5.6 ± 0.5	1.3 ± 0.1	1.1 ± 0.2
	men	7 ± 2.2	7.2 ± 1.3	5.8 ± 0.8	1.2 ± 0.1	0.9 ± 0.2
Light a cigarette	women	11.2 ± 3.1	11.6 ± 2.6	8.8 ± 1.1	1.3 ± 0.2	0.8 ± 0.2
	men	11.2 ± 4.1	11.8 ± 1.3	9.0 ± 1.4	1.3 ± 0.1	0.9 ± 0.2
Make coffee	women	65.2 ± 12.1	40.2 ± 4.3	11.2 ± 1.3	3.6 ± 0.5	1.5 ± 0.3
	men	78.1 ± 12.2	37.4 ± 3.4	10.0 ± 0.7	3.8 ± 0.5	1.6 ± 0.4
Within groups (women vs. men)	$F_{1,5}$	0.9	0.3	0.2	2	0.1
	P	0.348	0.609	0.647	0.166	0.859
Between group (routine)	$F_{1,5}$	115.8	113.5	146.1	84.6	8.5
	P	**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**
Interaction (gender x routine)	$F_{1,5}$	1.1	0.8	0.3	2.7	0.3
	P	0.41	0.528	0.885	0.047	0.902

Table 2. Correlations between different dimensions of acts and sequences. Correlations marked * are significant at $p < 0.05$

	No. of acts	Act repertoire	Rate of repetition	Mean act duration
Routine duration	0.97 *	0.59	0.92 *	0.74
No. of acts		0.60	0.95 *	0.64
Act repertoire			0.35	0.35
Rate of repetition				0.69

Table 3. Shared and individual acts – the example of “lighting a cigarette”.

	Women					Men					
	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	Sharing index
Cigarette											
put in mouth	+	+	+	+	+	+	+	+	+	+	1.00
take out	+	+	+	+	+	+	+	+	+	+	1.00
inhale	+	+	+	+	+	+	+	+	+	+	1.00
take out of mouth	+	+	+	+	+	+	+	+	+	+	1.00
switch hands								+			0.00
Cigarette packet											
take out						+					0.00
open	+	+	+	+	+	+	+	+	+	+	1.00
put on table	+	+	+	+	+	+	+				0.67
put in pocket									+	+	0.11
close	+		+	+	+	+	+	+		+	0.78
throw on chair								+			0.00
Hand											
protect from wind	+	+	+	+	+	+	+	+	+	+	1.00
Lighter											
take out						+			+		0.11
put on table	+	+	+	+	+						0.44
pick up					+						0.00
light cigarette	+	+	+	+	+	+	+	+	+	+	1.00
put in pocket						+	+		+	+	0.33
spin							+				0.00
throw on chair								+			0.00
switch hands			+			+	+	+			0.33
Leg											
lift up	+			+							0.11
cross				+							0.00
Chair											
sit down								+			0.00
move closer				+							0.00
Sunglasses											
put on				+							0.00
take off				+							0.00
Ashtray											
move closer				+							0.00

Figure legends

Figure 1. Relative frequency (Mean ± SE) of acts as a function of sharing index (see Methods for the calculation of sharing index). As shown, frequency was high for sharing indexes of 0 and 1, and low for other index values. Indeed, one-way ANOVA with repeated measures revealed a significant difference among the sharing indexes ($F_{9,50} = 10.86$; $p < 0.01$). A subsequent Tukey test revealed that sharing index 0 and sharing index 1 were significantly different from all other indexes, but not from each other.

Figure 2. Theoretical distinction between routinization (focus is shifted from episodes to the overall script that includes them) and ritualization (focus is shifted from episodes to the gestures they comprise).

Figure 3. Comparison of routines (data of this study) to OCD rituals and commanded tasks [26], in terms of act-frequency as a function of act-sharing. Data were calculated as in Figure 1. As shown, the balanced peaks of shared and non-shared acts in normal routines (solid line) is tipped to increased frequency of non-shared acts in OCD (dotted line), in contrast to tipping toward increased frequency to shared acts in commanded task (dashed line).

Figure 1

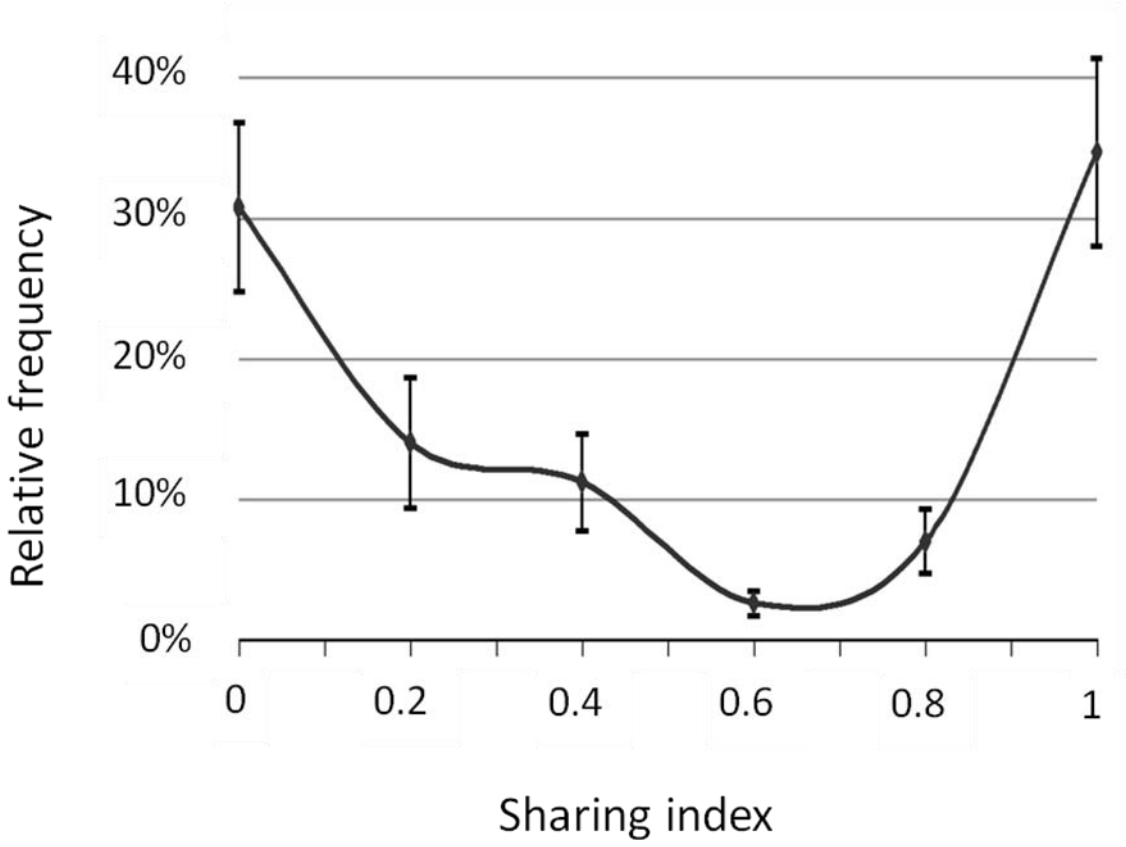


Figure 2

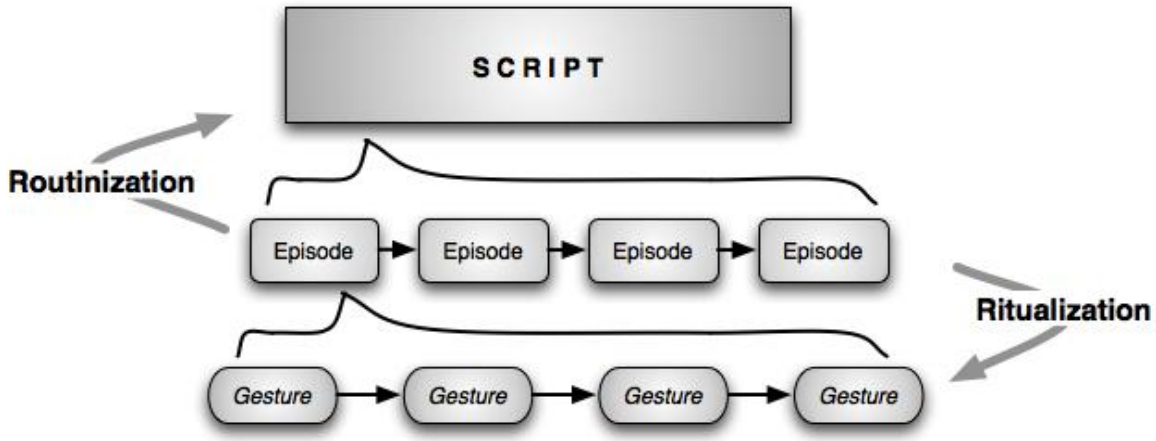
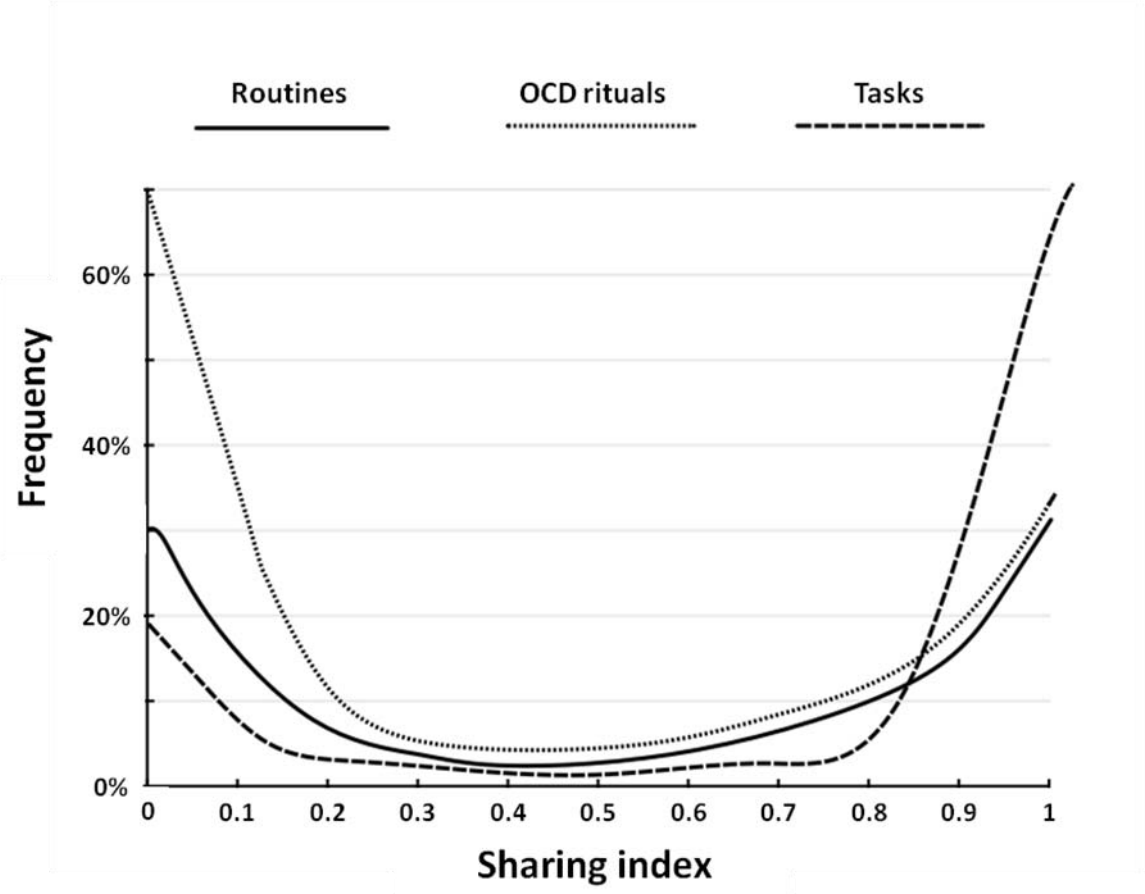


Figure 3


Routines
OCD rituals
Tasks
Frequency
60%
40%
20%
0%
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Sharing index