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Why ritualized behavior? Precaution Systems and action parsing in developmental, pathological and cultural rituals

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Abstract: Ritualized behavior, intuitively recognizable by its stereotypy, rigidity, repetition, and apparent lack of rational motivation, is found in a variety of life conditions, customs, and everyday practices: in cultural rituals, whether religious or non-religious; in many children's complicated routines; in the pathology of obsessive-compulsive disorders (OCD); in normal adults around certain stages of the life-cycle, birthing in particular. Combining evidence from evolutionary anthropology, neuropsychology and neuroimaging, we propose an explanation of ritualized behavior in terms of an evolved Precaution System geared to the detection of and reaction to *inferred* threats to fitness. This system, distinct from fear-systems geared to respond to *manifest* danger, includes a repertoire of clues for potential danger as well as a repertoire of species-typical precautions. In OCD pathology, this system does not supply a negative feedback to the appraisal of potential threats, resulting in doubts about the proper performance of precautions, and repetition of action. Also, anxiety levels focus the attention on low-level gestural units of behavior rather than on the goal-related higher-level units normally used in parsing the action-flow. Normally automatized actions are submitted to cognitive control. This "swamps" working memory, an effect of which is a temporary relief from intrusions but also their long-term strengthening. Normal activation of this Precaution System explains intrusions and ritual behaviors in normal adults. Gradual calibration of the system occurs through childhood rituals. Cultural mimicry of this system's normal input makes cultural rituals attention-grabbing and compelling. A number of empirical predictions follow from this synthetic model.

Keywords: childhood ritual; compulsion; event boundaries; evolutionary psychology; obsessive-compulsive disorder; ritual; thought intrusion

1. Ritualized behavior

In a variety of circumstances, humans[1] produce rituals, intuitively recognizable by their stereotypy, rigidity, repetition, and apparent lack of rational motivation. Behavior of this kind is found in cultural rituals, religious or non-religious; in the complicated routines of many children; in the pathology of obsessive-compulsive disorders; in normal adults around certain stages of the life-cycle, especially during birthing. The common features of these behaviors cry out for explanation.

We build on a variety of prior models to describe a core psychological process that we call *action ritualization* – which is only a part of individual or cultural rituals but a crucial part. The occurrence of ritualization depends on the conjunction of two specialized cognitive systems. One is a motivational system geared to the detection of and reaction to particular *potential* threats to fitness. This "Hazard-Precaution System" includes a repertoire of clues for potential danger as well as a repertoire of species-typical precautions. The other system might be called "Action Parsing." It is concerned with the division of the flow of behavior into meaningful units. In some circumstances, specific interaction between these systems creates ritualized actions. The circumstances are different for individual, pathological, and collective rituals, as we will see. But the core ritualization process explains some of their common properties.

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 (Gluckman 1975). Ethologists use criteria such as repetition and stereotypy (Payne 1998). Clinical psychologists' descriptions of OCD pathology, as in the DSM-IV, mention "ritualistic behaviors" without more precision (American Psychiatric Association 1995).

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Besides, models of the phenomenon are generally limited to one domain of ritual. There is a large clinical literature about children's OCD but little study of normal childhood ritualization, simply because the latter is not pathological, even though it may be difficult to understand one without the other (Evans et al. 1997). Models of OCD do not usually cover normal episodes of obsessiveness and ritualistic compulsion in the life-cycle although these are probably continuous with the pathology (Mataix-Cols et al. 2005). Very few anthropologists have considered the striking similarities between cultural ritualized behavior and individual pathology (Rappaport 1999). A notable exception is Alan Fiske (Dulaney & Fiske 1994; Fiske & Haslam 1997), who re-opened an issue famously framed by Freud a long time ago (Freud 1928).

Following up on Fiske's pioneering work, discussed in section 8.1, as well as neuro-physiological (Szechtman & Woody 2004) and evolutionary (Abed & de Pauw 1998) models, we aim to provide a model of the different domains of occurrence of ritualized behavior. We certainly do not mean to underestimate the obvious differences, but we do think that the common features of ritualized actions require an explanation. We aim to provide an *integrated* model that includes not only a cognitive specification of the behavioral patterns and their elicitation conditions, but also the neural correlates of the behaviors and of their pathological distortion, the developmental patterns involved, and the evolutionary background.

It might seem imprudent to make any general statements about a disparate set that includes pathological and normal manifestations, and individual as well as collective rituals. Note, however, that our aim here is not to account for all these behaviors. Our aim is to account for the psychological salience of a particular feature they share, namely the performance of what we call here "Ritualized Behavior," a precisely defined way of organizing a limited range of actions. In the following sections we outline the diverse domains of ritualized behavior before putting forward an integrated neural-developmental-evolutionary model of ritualization.

2. Diverse domains of ritualization

2.1. Obsessive-compulsive disorder (OCD)

The main features of the pathology of OCD are familiar: intrusive, bothersome thoughts about potential danger, as well as a strong compulsion to engage in stereotyped and repetitive activities with no rational justification. Standard criteria in the DSM-IV include (a) intrusive thoughts that (b) cause distress and (c) are often accompanied by ritualistic behaviors that (d) disturb normal activity and (e) are recognized as irrational by the patient (American Psychiatric Association 1995).

Typical obsessions include contamination and contagion (i.e., fear of catching other people's germs, of ingesting contaminated substances, of passing on diseases to others), possible harm to others (e.g., handling kitchen utensils and wounding people), as well as social ostracism following shameful or aggressive acts (thoughts about assaulting others, shouting obscenities, exhibitionism, etc.). This is often combined with "thought-action fusion" – the assumption that having forebodings of possible misfortunes is tantamount to bringing them about – and an exaggerated feeling of responsibility for others (Salkovskis et al. 2000).

Obsessions are typically accompanied by rituals. Some patients engage in endlessly repeated sequences of washing hands, cleaning tools or utensils (Hodgson & Rachman 1972). Others repeatedly verify that they properly locked their door, rolled up the car window, or turned off the gas stove (Hodgson & Rachman 1977). Still others are engaged in constant counting activities or need to group objects in sets of particular numbers, with specific alignments (Radomsky et al. 2001). Although a categorical division between "checkers," "washers," and "hoarders" has become popular in descriptions of OCD and as a descriptive clinical tool, there seems to be a large overlap in these categories (Khanna et al. 1990). A more accurate description would construe "contamination," "insecurity and doubt," and "excessive precautions" as *dimensions* of the syndrome (Mataix-Cols et al. 2005), with each patient presenting a cluster of symptoms distributed along these dimensions (Calamari et al. 2004). Most patients are aware that their obsessions are unreasonable and their rituals pointless (patients' insight used to be a criterion in the DSM) but they also report that neither is easily controlled (Eisen et al. 1999).

2.2. Children's rituals

Most young children engage in ritualistic behaviors in a limited range of situations and at a particular stage of development, starting at age 2 and peaking in middle childhood. This developmental phase is characterized by perfectionism, preoccupation with just-right ordering of objects, attachment to a favorite object (imbued with a special value), concerns about dirt and cleanliness, preferred household routines, action repeated over and over or a specific number of times, rituals for eating, awareness of minute details of one's home, hoarding, and bedtime rituals. (Obviously, most children in most situations also create disorder, at least relative to what adults expect; insistence on "just so" performance is limited to highly specific contexts.) The themes and the age-range are similar among American and other cultural groups (Zohar & Felz 2001). In many children, rituals are connected to anxiety states with specific targets. Among them is the fear of strangers, as well as the possibility of inflicting harm to self or others, possible contamination, attack by strangers or animals. The tendency to engage

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in rituals is correlated with anxiety or fearful traits (Zohar & Felz 2001). Both fears and rituals typically evolve with development, from "just so" insistence to elaborate rituals (Leonard et al. 1990). Younger children's ritualistic behaviors are related to prepotent fears such as stranger and separation anxieties, whereas the ritualistic behaviors of older ones are related to more specific and contextual fears such as contamination and social hazard (Evans et al. 1999). Some children connect their rituals to supposed effects by magical beliefs in ritual efficacy (Evans et al. 2002), but this is by no means necessary or even general.

Although the facts of childhood ritualization are familiar and impressive, there is no definitive account of the functional basis of such behaviors in young children. This is mostly because OCD pathology is seen as discontinuous with the "normal" routines of childhood, given both the obvious differences in frequency and emotional intensity and the fact that only very few young ritualists become clinically obsessive (Leonard et al. 1990). However, it seems difficult to understand the pathology in the absence of a proper causal model for this highly recurrent, culturally stable part of the normal developmental process (Evans et al. 1997).

2.3. Life-stage-relevant intrusive thoughts

Specific disturbing thoughts occur in many people at particular phases in the lifetime, notably pregnancy, motherhood, and fatherhood. Senseless, intrusive, unacceptable ideas, thoughts, urges, and images about infants are common among healthy parents of newborns, both fathers and mothers (Abramowitz et al. 2003). The content of intrusions is related to specific stages of the life-cycle. While new fathers and post-partum mothers report fears about harming the infant, pregnant women report heightened fears about contamination (Abramowitz et al. 2003). They also develop rituals of washing and cleaning related to these intrusions. A common underlying theme is uncertainty and doubt concerning possible harm to the infant. Three-quarters of the new parents surveyed by Abramowitz et al. reported persistent thoughts about accidents, suffocation, and other possible ways of intentionally harming the infant (Abramowitz et al. 2003). The individuals feel responsible for these intrusive thoughts. Development of specific perinatal anxieties may be part of a "primary parental preoccupation" complex that includes nesting behaviors, repeated checking, thoughts about the infant's perfection, and fantasies about possible threats to its security (Leckman et al. 2004). Rodent models suggest oxytocin as a major modulator of such maternal behaviors (Leckman et al. 2004).

The connection between these non-clinical context-relevant intrusions and OCD is not just a matter of similarity. The onset of OCD in women occurs during pregnancy more than at other life-stages (Maina et al. 2000; Neziroglu et al. 1992). Note that the development of intrusions and early rituals into OCD is quite distinct from the evolution of post-partum depression (Williams & Koran 1997). The former triggers very specific, highly consistent obsessive thoughts as opposed to unfocused or frequently shifting depressive ruminations. OCD onset also results in an urge to act (perform specific rituals) very different from the withdrawal from action observed in post-partum depression (Hagen 2002). Among OCD patients, pregnancy and postpartum result in more severe symptoms (Labad et al. 2005). Activation of the fronto-striatal networks as a result of infant cries is different in new mothers and controls (Lorberbaum et al. 2002), suggesting functional calibration of the circuitry involved in OCD (see section 3.1.).

2.4. Cultural rituals

A great variety of social occasions are identified as "rituals" in the anthropological literature. They range from private ceremonies with few participants, or indeed just one person, to large gatherings, and from single acts to long sequences spread over months or years. The general themes range from worship to protection to aggression. The occasions for ritualized behaviors also vary, either contingencies such as illness or misfortune, life-stages like birth, initiation, and death, or recurrent occasions such as seasonal changes. Finally, the connections between rituals and religious concepts are crucial in some cases (e.g., ancestor worship, Islamic prayer), or only peripheral (e.g., anti-witchcraft divination), or just absent (as in "secular" rituals).

How do we recognize such actions? As Roy Rappaport argued, it seems that we (anthropologists but also lay folk) use a conjunction of specific criteria that a model of ritual should explain (Rappaport 1979). Here is a slightly modified list of features he emphasized:

1. First, actions are divorced from their usual goals. In cultural rituals, one typically washes instruments or body parts that are already clean, one enters rooms to exit them straightaway, one talks to interlocutors that are manifestly absent. Also, many rituals include actions for which there could not possibly be any clear empirical goal, such as passing a chicken from hand to hand in a circle, going round a temple seven times, and so forth.

2. Second, cultural rituals are often presented as compulsory, given a particular situation. People are told that a particular ceremony must be performed. More often than not, there is no explanation of why that ritual should be performed given the circumstances. True, a ritual often has a specific overall purpose (e.g., healing a particular person, keeping witches at bay); but the set of sequences that compose the ritual are not connected to this goal in the same way as sub-actions connect to subgoals in ordinary behavior (Boyer 1994).

3. Third, in many cultural rituals people create an orderly environment that is quite different from the one of everyday interaction. People line up instead of walking, they dance instead of moving, they wear similar clothes or make-up, they build alignments of rocks or logs, they create elaborate color and shape combinations, and so on. Related to this is the recurrent concern with delimiting a particular space (a sacred circle, a *taboo* territory) often visually distinct from the other, unmarked space.

It is important to distinguish "rituals" from ritualization. There may be lots of different reasons why particular kinds of ceremonies are found in human cultures, why they persist, and why they are relatively stable. We discuss these issues elsewhere (Lienard & Boyer, forthcoming). For instance, one may propose plausible evolutionary scenarios for the existence of birth celebrations and of death rituals in most cultural environments. But these

scenarios do not explain why these social occasions all include *ritualized* behavior in the precise sense intended here.

2.5. General features of rituals

Behavior in these different domains displays obvious similarities:

1. *Compulsion.* Given certain circumstances, people feel that it would be dangerous or unsafe or improper not to perform ritualized actions. There is an emotional drive to perform the action, often associated with some anxiety at the thought of not performing it (especially in patients and children) and some relief after performance. Naturally, this varies between domains. Anxiety precedes ritual actions or behavior in many personal and pathological rituals but not always in cultural rituals. Common to all domains, though, is the important fact that compulsion does not require any explanation. People feel that they must perform the ritual, otherwise... [something might happen], but they require no specific representation of what would happen otherwise.

2. *Rigidity, adherence to script.* People feel that they should perform a ritual in the precise way it was performed before. They strive to achieve a performance that matches their representation of past performances and attach negative emotion to any deviation from that remembered pattern. This is familiar in childhood rituals and OCD but also in the "traditionalistic" flavor of most cultural rituals (Bloch 1974). Deviation from the established pattern is intuitively construed as dangerous, although in most cases the participants have or require no explanation of why that is the case.

3. *Goal-demotion.* Rituals generally include action-sequences selected from ordinary goal-directed behavior. But the context in which they are performed, or the manner of performance, results in "goal-demotion," in performance divorced from observable goals. For instance, people tie shoe-laces that were tied already; they touch a specific piece of furniture without trying to move it or use it as support; they wash hands many more times than hygiene would require; and so on.

4. *Internal repetition and redundancy.* Repeated enactments of the same action or gesture, as well as reiterations of the same utterances, are typical of many rituals. A given sequence is executed three or five or ten times. What matters is the exact number. This makes many ritual sequences clearly distinct from everyday action, in which there is either no repetition of identical sequences (e.g., in assembling a musical instrument, one performs a series of unique actions), or each repeated act has a specific outcome (e.g., in weaving), or repetition is cumulative (the egg-whites rise only after a long period of whipping).

5. *A restricted range of themes.* Many rituals seem to focus around such themes as: pollution and purification, danger and protection, the possible danger of intrusion from other people, the use of particular colors or specific numbers, the construction of an ordered environment (Dulaney & Fiske 1994). A ritual space or instruments are described as "pure" or "safe" (or, on the contrary, as the locus of concentrated "pollution") or the point of the ritual is to "purify" people or objects, to "cleanse" mind or body, and so on. In collective rituals, this concern with pollution and cleansing is so prevalent that it has been considered a foundation of religious ritual (Douglas 1982).

Is there a common explanation for these different features of ritualized behavior? Here we will start from pathology and summarize what can be safely concluded from the clinical and neuropsychological evidence. This supports a particular model of *action ritualization* which we will also extend to developmental rituals in children and adults, before proceeding to the distinct case of cultural rituals.

3. Interpretations of compulsive ritualization

3.1. Neuropsychological modeling

OCD has been interpreted as a specific dysfunction of the basal ganglia (Rapoport 1990, 1991). To understand how this would result in the specific symptoms, the impairment should be described in terms of the specific functions of a cortical-striato-pallidal-thalamic circuit (CSPT). This network includes projections from many cortical areas (including medial and orbital frontal cortex) into the striatum (caudate and putamen) and back to the cortex via the substantia nigra and thalamus (Rauch et al. 2001; Saxena et al. 1998). This has been confirmed by neuroimaging studies, as OCD is associated with increased activity of the orbitofrontal cortex (OFC) as well as in the striatum, thalamus, and anterior cingulate cortex (ACC) (Saxena et al. 1998; Saxena et al. 2004). Also, the anatomy of the caudate, putamen, and globus pallidus seems to differ between patients and controls (see, e.g., Giedd et al. 2000). One generally distinguishes between a "direct" and an "indirect" pathway in the CSPT networks (see Fig. 1). The direct pathway links (1) frontal cortices to (2) the striatum, to (3) the globus pallidus (pars interna) and substantia nigra (pars reticulata) to (4) thalamus and (5) cortex. The indirect pathway connects (1) cortex to (2) striatum to (3a) globus pallidus (pars externa) and subthalamic nucleus to (3b) globus pallidus (pars interna) and substantia nigra (pars reticulata) to (4) thalamus to (5) cortex.

The basal ganglia are involved in the formation of habits, motor habits in particular (Rauch et al. 1997). The pattern of projections from the cortex to the striatum suggests that the latter may store summaries or "chunks" of motor behavior. This is confirmed by involvement of the striatum in the learning and production of habitual responses (Graybiel 1998). Striatal networks may act as coordinators of cortical input and orchestrators of motor habits.

What specific dysfunction would result in OCD symptoms? In animal models, modifying dopamine uptake in the striatum results in stereotypic and repetitive behavior (Canales & Graybiel 2000; Szechtman et al. 1998). So an imbalance between various parts of the basal ganglia system or a modification in the dynamics of cortico-striatal pathways are probably involved in the condition. Saxena and colleagues identify the "indirect" pathway as the locus of impairment. In their model, the association of globus pallidus (external) and subthalamic nucleus can be construed as a "basal ganglia control system" that modulates the projections to the thalamus and cortices (Saxena et al. 1998). The indirect pathway consists of inhibitory (GABAergic) projections from the striatum to

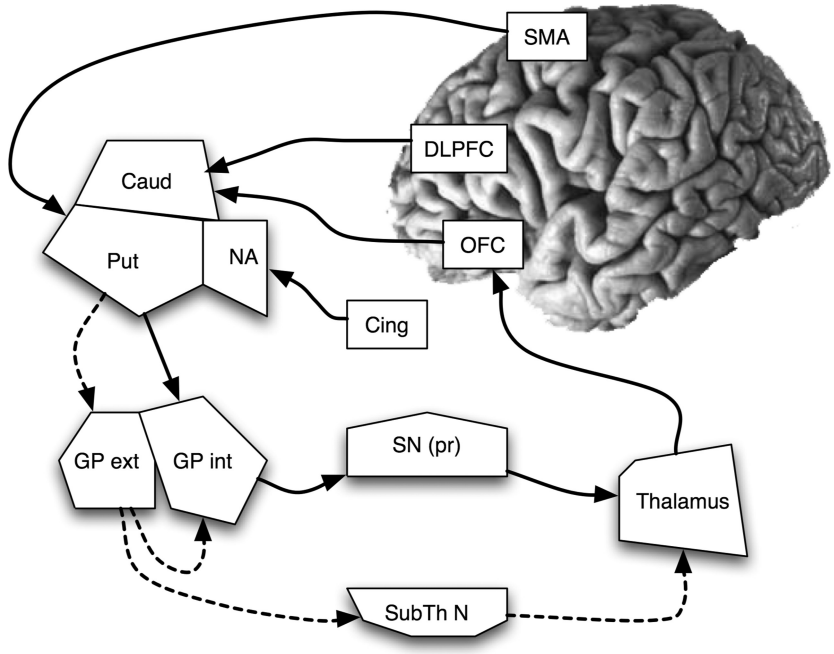

Figure 1 (Boyer & Liénard). A summary of some cortico-striatal pathways relevant to OCD. Continuous line for the "direct" pathway and dotted line for "indirect" pathways (both highly simplified). SMA: Supplementary Motor Area, DLPFC: dorso-lateral prefrontal cortex, OFC: orbito-frontal cortex, Caud: caudate nucleus, Put: Putamen, Cing.: Cingulate Cortex, NA: Nucleus Accumbens, GP: globus pallidus (external and internal), SN(pr): substantia nigra pars reticulata, SubTh Nuc: Subthalamic nuclei.

the thalamus. To the extent that this pathway becomes less tonic, it would fail to inhibit habitual motor responses and result in unmotivated, stereotypic routines (Saxena et al. 1998).

Also important is the regulatory role played by the orbitofrontal cortex (OFC) and the anterior cingulate cortex (ACC). Early neuroimaging studies showed differential activation of these regions in OCD patients in situations of symptom provocation (Adler et al. 2000; Rauch et al. 1994). OFC activation makes sense given its role in the selection, control, and inhibition of behavior as demonstrated both by neuroimaging and by lesions of this area (Happaney et al. 2004; Ogai et al. 2005; Schnider et al. 2005). Anterior cingulate activity is also revealing. Ablation of the area has been used in refractory OCD cases (Kim et al. 2003). ACC hyperactivity is not limited to situations of symptom provocation (Ursu et al. 2003). In an event-related study of error-processing, Fitzgerald and colleagues found increased ACC activity with error-detection in both patients and controls, with significantly higher increases in patients. The amount of ACC activity also correlated with the severity of the patients' compulsive symptoms (Fitzgerald et al. 2005). The anterior cingulate can be described as an error-detection network that activates top-down responses to situations of conflicting information, for example, between expectation and perception in errors, or between discrepant stimuli (Van Veen & Carter 2002).

All this converges to suggest that OCD may stem from a dysfunction of a neural system involved in the production and inhibition of a particular set of habitual or routinized behaviors. The etiology of the dysfunction includes probable genetic factors (Campbell et al. 1999; Zohar et al. 2004) as well as infectious conditions (Giedd et al. 2000; Henry et al. 1999), although evidence for either cause is tentative. The compulsive nature of the actions seems to result from a failure to inhibit strongly motivated routines initiated in the striatum, either because striatal networks over-respond to cortical inputs, or because their inhibitory effect on thalamic networks is diminished, or both, leading to ritualization. This picture is consistent with the clinical and pharmacological evidence (Kaplan & Hollander 2003; Zohar et al. 2004).

3.2. Cognitive models: General or specific?

Cognitive models provide a bridge from neuropsychological findings to the phenomenology of OCD symptoms. A classical cognitive model describes the condition as a disorder of threat-appraisal and cognitive control (Rachman & Shafran 1998; Salkovskis 1985). Patients produce a misguided appraisal of intrusive thoughts, exaggerate the threats present in the environment as well as the extent of their own responsibility for what befalls others, and finally fail to appreciate the measure of safety introduced by normal precautions. In this model, OCD differs from other anxiety conditions (general anxiety disorder, panic) only in that the eliciting stimuli are very specific – a series of intrusive thoughts with recurrent themes (Clark 1999).

Obsessions and compulsions might then result from a general failure to appreciate levels of danger, to evaluate one's responsibility in external events, and to form an appropriate picture of one's situation. For instance, ritualized repetition may stem from the patient's failure to realize that he or she has actually accomplished the action (Pitman 1987). There is indeed evidence (though not conclusive) for general memory problems. OCD patients have the right intuitions in both memory for actions and source monitoring (i.e., whether they

performed as opposed to imagined performing an action) but they report less confidence in their own intuition (Hermans et al. 2003).

However, there is also definite evidence for domain-specific aspects of OCD. For instance, OCD patients are similar to controls in their recall of neutral objects but are markedly better at recalling dangerous items (Tolin et al. 2001). OCD "checkers" are impaired in their recall of own actions but less so in recall of other information (Ecker & Engelkamp 1995). In terms of attention, modified Stroop tasks show that OCD "washers" are more attentive to contamination words than are controls, and OCD patients in general show more interference than controls do from danger-related words (Foa et al. 1993).

3.3. Security-motivation

Most cognitive models of OCD are phrased in domain-general terms. An exception is Abed and de Pauw's evolutionary hypothesis about OCD as a disruption of a specific "psychological immune system" (Abed & de Pauw 1998). The hypothesis starts from the observation that the prevalence of OCD would suggest the tail of a phenotypic distribution rather than harmful mutations. According to Abed and de Pauw, obsessional phenomena are an exaggerated version of thought processes selected because they lead to risk-avoidance behavior (in particular through fear or disgust). Central to the hypothesis is the fact that intrusive thoughts, in patients and normal individuals, consist of detailed scenarios of possible danger, an "Involuntary Risk Scenario Generating System" (Abed & de Pauw 1998).

A similar evolutionary background motivates Szechtman and Woody's interpretation of the condition in terms of a "security-motivation" system (Szechtman & Woody 2004). The model is an attempt to integrate the diverse components of the relevant behaviors (emotion, perception of specific information, typical actions, inhibition or disinhibition of automatic routines) in a *motivational* system functionally specialized in potential danger.

In contrast to general cognitive impairment models, both Abed and de Pauw's and Szechtman and Woody's models provide a parsimonious account for the specificity of OCD intrusions.

The security system is present in all normal human beings and monitors external signals of particular kinds of *potential* danger. The neural circuitry involved in both normal and pathological safety motivation can be broken down in three major functional components with excitatory and inhibitory links. An appraisal system handles information that matches input conditions for environmental cues of potential danger. A security motivation system handles the evaluation of these cues. A set of various evolved security-related programs is engaged, depending on the outcome of this motivation assessment, with specific motor and visceral output (see Fig. 2).

As a result of engaging security-related motor-programs (this may consist in visual inspection of one's environment, cleaning, ordering, etc.), the security motivation system produces a specific experience of things being "just right" which feeds back into the danger appraisal system.

Szechtman and Woody's identification of the neural correlates of these systems extends beyond the cortico-striatal pathways. The appraisal of potential danger involves perceptual and memory information and feeds into both orbital cortex and the cortical-striatal pathways. From there, Szechtman and Woody identify two distinct informational loops. One of them, the affect loop, includes most of the "indirect pathway" structures, producing a specific anxiety. In parallel, a "security-related programs" loop, connects striatum to the globus pallidus (internal) and ventral thalamus to elicit the performance of stored motor routines. Finally, the normal inhibition of these two loops is provided by brainstem structures after performance of the elicited motor routines. The model states that OCD is the result of a *dysfunction in a satiety signal*, plausibly generated in brainstem structures, that connects the performance of security related behaviors as inhibitory feedback to a subsystem that generates and sustains security motivation.

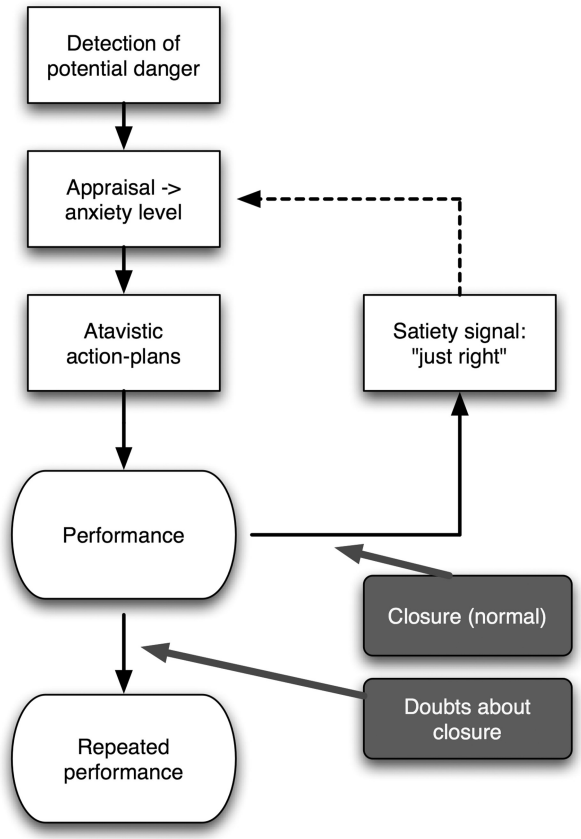

Figure 2 (Boyer & Liénard). An interpretation of Szechtman and Woody's (2004) model. Rectangles correspond to distinct systems activated, rounded boxes to behavioural results and call-outs to aspects of the processing. Danger clues are evaluated and action-plans selected, resulting in a "just right feeling" that sends negative feedback to danger appraisal. This loop is absent or impaired in patients, leading to doubts about performance, which themselves result in repetition and rigid action-plans.

3.4. Outstanding questions

In our view, while current models of compulsion have great descriptive and explanatory value, they still provide an incomplete account of various aspects of the obsessive and compulsive spectrum, especially if we include normal as well as pathological manifestations of ritual dispositions.

A more complete model should account for the following aspects of ritualized behavior:

1. *Why these specific themes?* The thoughts patients and others report are clearly not random conceptual associations. They center on a few threats that are particularly disturbing. Even this is much too broad a description. People have intrusive thoughts about causing accidents involving their kin, but not complete strangers; they fear contamination more than bone fracture or inflammation; they fear that they may have left the back door open or the oven on, not that their car will be stolen or the fridge will break down.

2. *Why these specific actions?* Compulsions seem to focus on a narrow set of possible actions. This is clear for contamination compulsions which result in repeated washing and cleaning. The same applies to checking behaviors, limited to visual cues. Not all actions seem likely to become compulsive.

3. *Why combine the actions in that way?* Many compulsive rituals organize action in a very specific way. For instance, there are many negative rules in compulsions (avoid treading on the lines on the pavement). Also, there are specific rules about the number of iterations (touch this chair three times) or about the order of actions (tie the right shoe before the left one).

4. *Why does ritual provide relief?* Most clinicians agree on a temporary lowering of anxiety levels after the performance of rituals. The question points to one possible explanation for the compulsive character of the behavior. Could it be that patients intuitively reproduce behaviors that reduce anxiety? But then, what is it about such organization of action that could reduce anxiety?

5. *Why does ritual eventually strengthen obsessions?* This too is a feature often noted by clinicians (see, e.g., Salkovskis 1985). Although rituals provide some relief, this is only temporary and the intrusive thoughts quickly come back. Indeed, it would seem that the more rituals one performs, the more focused and bothersome are the intrusive thoughts.

4. Ritualized action: The core process

What follows is a list of the different points of the model which will be explained in the following sections. In our view, ritualization in young children, in normal adults at particular life-stages, and in patients comprises a series of processes in which specific information is acquired or retrieved and specific behavioral plans are engaged:

1. Security-motivation systems are engaged. This may be because of potential danger cues in the environment (described below), information imparted by other people, self-generated thoughts, or intrusions. In any case, these thoughts focus on cues for *potential* hazards chosen in a small set that we call the Potential Hazard Repertoire.

2. Safety motivation triggers an arousal state in which non-action is intuitively considered dangerous (something *must* be done) although there need be no clear representation of why that is the case.

   2a. This state triggers a non-deliberate, non-controlled search for action-sequences that appear intuitively appropriate. Some cues make some actions seem apposite although the subject generally has no explanation for the intuition (or may only have *ex post facto* rationalizations). These actions are selected from what we call an Evolutionary Precaution Repertoire.

   2b. The arousal triggers a special attentional state that focuses on low-level properties of own actions. The action-flow is parsed in smaller units than is usually the case.

   2c. The arousal state may bias the appraisal system in such a way that "just right" or "closure" experience is delayed. This triggers doubts about actual or proper performance and reiteration of action-plans.

3. Performance of the actions with attention to low-level parsing [see 2b above] may impose a heavy load on working memory-systems, with two consequences:

   3a. The intrusive themes are temporarily pushed away from conscious access, resulting in a short-lived reduction in anxiety level.

   3b. The intrusive themes are monitored by automatic, not controlled processes, which should result in higher salience (and renewed intrusion) after performance.

These different steps are summarized in Figure 3. In what follows we explain the processes engaged in more detail and provide arguments for their presence in most domains of ritualization. An important point to emphasize is that we do not identify any particular component of the overall process as being exclusively pathological. In our view, most reactions to inferred threats engage all these processes. Whether or not a given action triggers doubt about proper performance, leading to rigid repetition, that is, *ritualization* of these reactions, may be a matter of degree.

5. Why these particular obsessions and compulsions?

5.1. Logic of our evolutionary approach

Intrusions and compulsions are bothersome and time-consuming. Not only do they confer no particular adaptive advantage, they seem to be clearly maladaptive in diverting attention and memory resources from valuable goals. However, note that OCD and other disorders of the frontostriatal circuitry (Tourette's syndrome, ADHD, and schizophrenia) all have some genetic basis, as may be suspected from their prevalence (Bradshaw & Sheppard 2000) and is tentatively confirmed by gene-loci studies (Arnold et al. 2004; Grados et al. 2003).

To the extent that a specific kind of motivation is involved in the pathology of ritualization (perhaps also in its normal occurrence), it makes sense to wonder why and how humans are endowed with this special focus on particular kinds of hazards. In particular, are such systems the outcome of the evolutionary history of the species? In this case *ultimate* explanations would help us make sense of the pathology (Nesse 1998), a strategy used in physiology (Nesse & Williams 1996), psychiatry (Baron-Cohen 1997; Cosmides & Tooby 1999; Stevens & Price 2000) and neuropsychology (Duchaine et al. 2001; Gazzaniga & Miller 2000), and, as mentioned earlier, already outlined in some studies of OCD (Abed & de Pauw 1998).

Providing an evolutionary model requires the following steps: (1) Identify the relevant fitness-related problem; (2) identify the knowledge base and computational rules that would be minimally required to solve that problem

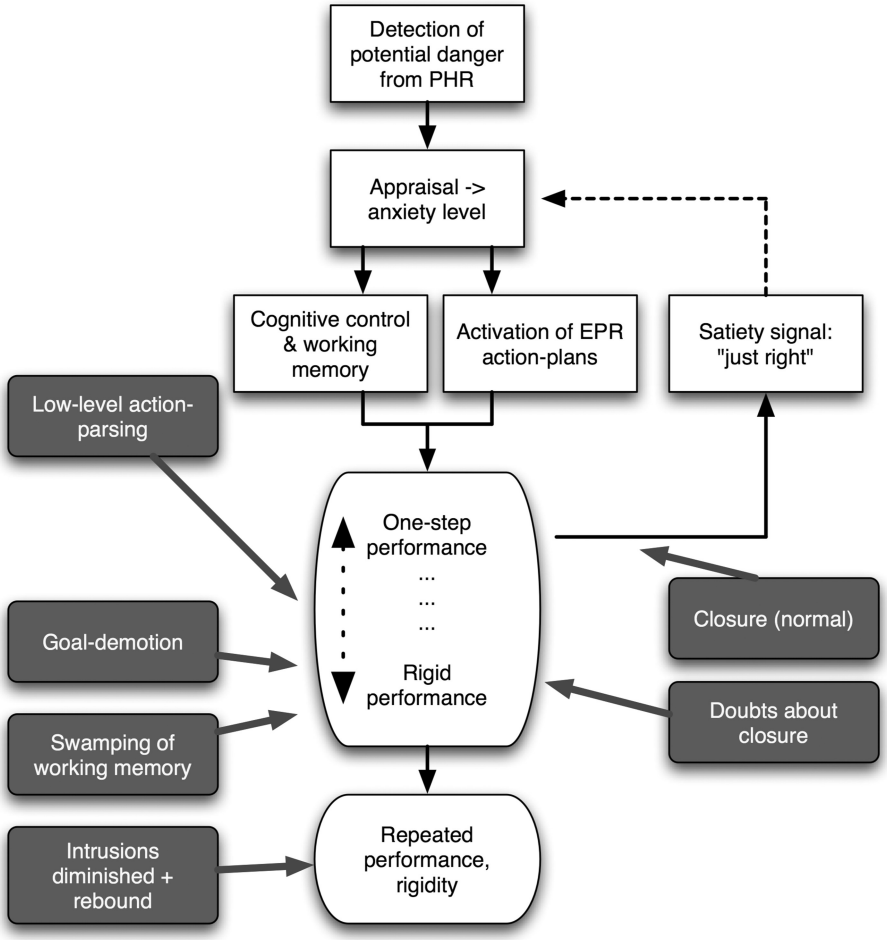

Figure 3 (Boyer & Liénard). Summary of our Potential Hazard and Precaution model. Boxes denote specific processes with corresponding neural systems. Rounded box describes performance. Dark call-outs describe some of their typical properties. Clues for danger must suggest hazards from the Potential Hazard Repertoire. Appraisal of the clues if modulated by anxiety, leading to activation of plans from Evolutionary Precaution Repertoire and action-monitoring systems. At the normal end of the spectrum, performance triggers satiety feelings with a negative feedback to danger appraisal systems. At the pathological end of the spectrum, doubts about proper performance lead to repetition and a positive feedback to danger appraisal.

in ancestral environments; and (3) provide experimental evidence for the actual operation of a mental system that meets this computational specification. Once this is accomplished, such a model may allow us to delineate possible pathogenic scenarios, causally deeper than the vague clusters identified in DSM-IV (Murphy & Stich 2000).

There are some indications that this approach may be appropriate for anxiety disorders and OCD in particular. First, negative emotions like anxiety or persistent low mood should not be considered as dysfunctional. They may consist in evolved warning systems whose negative rewards steer organisms away from fitness-reducing situations (Nesse 1998). Second, the specific thoughts and actions that compose the symptoms may be linked to evolutionary concerns (Leckman 2003; Mataix-Cols et al. 2005). Third, some of the conditions associated with fronto-striatal impairment may actually result in adaptive phenotypes (Bradshaw & Sheppard 2000).

5.2. Two types of fitness-threats

We know enough of early primate and early human living conditions to identify broad categories of highly salient danger in our evolutionary past: reproductive risk (e.g., for females, mating with un-nurturing or low-fitness males; for males, cuckoldry or choosing unhealthy females); predation (failing to detect or deter predators); contamination from pathogens (bacteria, viruses, toxins); resource scarcity (e.g., failing to anticipate seasonal changes); social harm (e.g., ostracism, but also reduced cooperation).

From an evolutionary standpoint, we should expect (1) that such recurrent hazards, not more recent ones, would be the target of specific emotions, and (2) that different kinds of hazard require different decision rules. On the first point, it is clear that specific emotions target hazards of great evolutionary ancestry rather than more recent ones, even though the latter may be much more dangerous. Our danger-avoidance systems do not seem to rely on an unprejudiced tabulation of which features of the environment effectively predict harm or misfortune. If this were the case, we would observe in modern conditions many cases of anxieties, fear, or even phobic aversions to electricity, cars, and cigarettes, which cause vastly more deaths than do spiders and rats. But we observe the opposite. Second, it seems that different kinds of fitness-threats do activate different inferential

rules. Specific principles inform the gender-specific perception of particular mates as more or less of a waste of reproductive potential (Buss 1989). Predator-prey interaction is governed by early-developed intuitions that do not apply to other interactions (Barrett 1999). Recurrent features of disgust reactions suggest a pathogen-minimizing system that adapts to local conditions (Fessler et al. 2003; Rozin et al. 1993) or to particular individual circumstances such as pregnancy (Fessler & Navarrete 2003a; Profet 1993). Problems of resource scarcity are handled by specific foraging strategies (Krebs & Inman 1994) which can override explicit reasoning (Rode et al. 1999). Finally, a host of "social intelligence" principles support the monitoring of social interaction, from the establishment of friendships and coalitions (Harcourt & de Waal 1992; Kurzban et al. 2001; Tooby & Cosmides 1996), to dominance (Sidanius & Pratto 1999) and punishment (Boyd & Richerson 1992; Kurzban & Leary 2001).

At this point we must introduce an important distinction between two types of fitness-threatening situations. First, there are cases of *manifest* threats, cases in which the organism receives signals about the presence of the source of danger: for example, a predator or enemy attack, or seeing one's infant in danger. Situations of this type are handled by specialized and context-specific fear-mechanisms in humans as in other primates (LeDoux 2003; Maren & Quirk 2004) and result in aggression, freezing, or flight routines (Blair 2001; Payne 1998). Second, there are *inferred* threats, when the potential danger is probable given certain clues in the environment. For instance, the strange taste of a particular dish may be evidence of rotting; tracks may betray the recent passage of a dangerous predator; a particular person's attitude may indicate that they will not cooperate. Such circumstances typically engage what Abed and de Pauw called an "Involuntary Risk Scenario Generation." Naturally, the distinction is a rough one (many situations involve threats for which there are direct and indirect clues). It is also, obviously, species-specific since some situations are a threat to some organisms but not others.

5.3. Potential danger as a specific domain

It may seem odd to hypothesize a domain-specific system whose activation is triggered by such disparate potential inputs as a footprint, a disgusting odor, or the fact that one's infant is out of sight for a moment. How specific is the system if it can encompass such physically different stimuli? But this objection assumes that domain-specific inference systems are tied to a physically specified range of stimuli, which is true for some perceptual systems (e.g., 3D vision) but certainly not for most higher-level functional systems. A human mind can parse linguistic input in just the same way on the basis of auditory, visual, or tactile information. Neuro-cognitive systems specialized in assessing the value of potential mates use information from conversations, from comparison of visual information to some ideal template, from observed interactions between the potential mate and other people, and so forth. Indeed, it would be surprising (and maladaptive) if a particular kind of physical input always triggered a unique inference-system. A man is a man is a man, but a father, a brother, an attacker, and a potential mate should activate different mental systems.

So the autonomy or specificity of a domain-specific system can be inferred, not from focus on a physically specific range of cues, but from specific processing principles, a specific kind of output, a specific learning logic, and – in some cases – a specific pattern of impairment. These are criteria that seem present in the case of the Hazard-Precaution system.

There is indeed some behavioral evidence that humans have specific inference rules for information relative to precautions. Fiddick and colleagues have demonstrated that when considering precautionary rules (e.g., "if you take oranges on board you will not get scurvy"), subjects pass logical tests for verification of rule-violation that they fail in other contexts (Fiddick et al. 2000). This is a replication, in another domain, of the performance on rule-verification in the Wason selection task observed when the rules allude to social contracts, however unfamiliar, as opposed to other deontic domains, however familiar (Cosmides 1989; Fiddick et al. 2000). Although these findings concern explicit judgment more than intuition, they suggest that potential hazard management might require cognitive processing that is quite different from other inferential tasks.

5.4. The limited range of obsessions and compulsions

To explain the recurrent features of both intrusions and compulsions, our model stipulates two kinds of databases, called Potential Hazard Repertoire and Precaution Repertoire respectively. Intrusions and compulsions have to do with a specific, narrow range of hazards, which, in our view, are best explained as recurrent threats to fitness in ancestral environments.

One reason for defending this hypothesis is that the actions combined in ritual sequences are generally (i) species-specific and (ii) precaution-related. Ritualists do not generally design entirely novel behavioral sequences from scratch. Rather, they combine familiar elements of actions (e.g., washing, cleansing, checking) into novel sequences. This is also manifest in animal models of the condition. The ritualistic behaviors triggered in rats treated with quinpirole (a dopamine agonist) are species-specific, consisting in checking with return to a home-base, similar to those of controls, but stylized, redundant, and time-consuming (Szechtman et al. 1998). Second, these actions are generally relevant ones as a protection against various kinds of fitness-threatening situations (Rapoport & Fiske 1998). A review of the different dimensions of OCD obsessions but also adult normal intrusions and children's anxieties should illustrate the point.

5.4.1. Contamination. Thoughts about contamination and contagion are too specific to be interpreted as the outcome of a general lowering of the anxiety threshold. They tend to center on invisible agents such as toxins, viruses, and microbes – of obvious evolutionary import. Besides, people's anxious thoughts about contamination focus on modes of contact (touching with the hand, kissing, licking, having sex, sharing food, breathing next to a particular source) that are actually used by pathogen vectors. In patients, the compulsions associated with these thoughts are not arbitrary either. They center on measures such as washing and cleansing, protecting oneself from intrusive material by staying at a distance,

avoiding contact, suspending breathing. In ancestral environments, before the discovery of asepsis, these procedures would indeed constitute the only measures to reduce or control contamination.

There is behavioral and cross-cultural evidence that a concern with possible contamination triggers specialized inferential circuitry in humans. For instance, Fessler and colleagues have documented the disproportionate representation of meat among the foods that are "good to taboo" in many cultures. They connect this to the specific challenges of meat consumption caused by protozoa and other pathogens (Fessler & Navarrete 2003b). In the same way, meat seems to be the chief target of early-pregnancy aversions, a period of dangerous immunodepression (Fessler 2002). More generally, many sources of disgust are also sources of contamination: decaying corpses but also rotting substances, faeces, spit, and so on.

5.4.2. Symmetry and order in one's environment. Many children and adults are concerned with creating an orderly environment. Children align toys in a particular order, ritual participants need to create elaborately ordered displays, and the same is true of many OCD "checkers." These behaviors are often construed, especially in the domain of children's rituals, as the expression of a need for reassurance; as the urge to create a recognizable and therefore reassuring environment.

However, this "therefore" is question-begging. What is reassuring about a predictable environment? True, predictability implies a reduction in computational load, but that cannot be the reason, as children and ritualists in general devote great amounts of time and cognitive resources creating their orderly world. So there might be other aspects of order and symmetry that motivate cognitive investment. In our view, ordered environments combine two properties that may explain this motivation.

First, alignments and symmetry are such that they make other agents' intrusions clearly visible. Anecdotal (but massive) evidence suggests that children but also various sub-clinical obsessive personality-types get quite upset when "intruders" such as parents or cleaners disrupt their sequences and alignments. We speculate that the point of the ordering may be precisely to detect such disruptions. Or rather, that the behavior may be a stored action-plan that would have this function in other environments. This is indeed the one explanation of some animals' "tidying up" routines as an anti-predator strategy (Curio 1993). So the creation of a non-trivial order that is not immediately detectable by intruders may be a powerful motivation in such compulsions. Note that childhood rituals center on the *home* environment and in particular on children's own *personal* space (usually their bedroom).

Second, the specific use of symmetry and conceptual order (alternating colors, corresponding shapes) is diagnostic of uniquely human dispositions to alter the environment. Bowerbirds may be among the few exceptions – and seem to resort to similar ways of making a display salient: pure colors, symmetry, and so on. Indeed, people readily detect such specific alterations – which has been used for millennia as a way of advertising human presence. Cairns are improbable pilings of rocks that no species other than human beings would build. Broken twigs, straight paths, and color markings serve as landmarks for the same reason. What makes this possible is the combination of sophisticated symmetry and pattern-detection capacities in humans (Bornstein & Krinsky 1985; Bornstein & Stiles-Davis 1984; Fisher et al. 1981) and sophisticated tool-making capacities (Wynn 1993). This is particularly relevant to children's construction of ordered environments, which may consist of a period of systematic training in the construction of such signals of human presence.

These are bound to remain speculative as there is, to our knowledge, no systematic research on the cognitive and emotional processes involved in ordered displays, particularly in children's strong motivation to produce such environments.

5.4.3. Social offence. Some of the intrusive thoughts of obsessive people center on possible acts that would offend or harm other people, resulting in social exclusion. These fears also represent, in our view, a domain of evolutionary hazard. Given human dependence on conspecifics for all aspects of survival, it is not surprising to find that possible social strife is seen as extremely dangerous. Life in complex societies makes this dependence diffuse and impersonal. By contrast, in ancestral environments people depended on known members of the group. Conflict in such groups threatens each member's access to resources, cooperation, and information (Tooby & DeVore 1987). In this domain too, it seems that the precautionary measures taken by obsessives are in fact rather appropriate. For instance, one of the features of OCD patients (especially checkers) is a tendency to monitor actions, in particular the minutiae of one's own behavior, well beyond the "normal" limits. Another common feature is that people choose to avoid social contact lest they insult or assault others, which again is intuitively appropriate as a precautionary device.

5.4.4. Harm to offspring. Intrusive thoughts reported by adults often focus on possible harm to one's own offspring, accompanied by fears of handling tools and utensils in a dangerous way, smothering or dropping the infant, as well as forgetting about the baby and losing it (particularly in stores and other public places). Again, the danger is one of obvious evolutionary significance, as tools and weapons are part of our ancestral past. Also, shifting attention away from one's infant is risky but unavoidable in humans who need to attend to such tasks as foraging or processing food. Again, the compulsive precautions (hyper vigilance, neglect towards other people and social interactions, etc.) would seem appropriate given these hazards.

5.5. The Precaution System associates domain-specific repertoires

Specific reactions to inferred threats suggest a functional system that we called the Precaution System, whose specific input consists in inferences to non-manifest threat and whose output is selective activation of particular precautions. At both ends of its operation, the postulated system is highly specific. The Precaution System does not respond to all or most *actually significant* signals of potential danger, but to a limited repertoire of cues. As we said above, humans seem to infer fitness threats, with a specific anxiogenic response, from wounds or rotting carcasses, but not from tobacco smoke or electricity.

The range of action-plans activated is also restricted to a few possible precautions (washing, avoiding contact, etc.) that may or may not be most appropriate given changing circumstances. Note that this model does not account for some sub-varieties of OCD symptomatology. Hoarding, for instance, does not seem to result in ritualized behavior in the precise sense described here. This may be because the underlying processes are different from other OCD dimensions, as is suggested by neuroimaging studies (Calamari et al. 2004; Saxena et al. 2004). In our model, the specificity of cues and responses maps a set of highly recurrent threats in human evolutionary history.

6. Why the complicated action?

6.1. Ordinary action-parsing

The ritualization process imposes particular constraints on the performance and sequencing of action. This is why the features of ritual should be considered in the context of action representation in general. Human beings attend to each other's behavior and react to it, which means that they must "parse" other people's and their own behavior in meaningful units (Newtson 1973). The experimental study of such parsing mechanisms provides a background against which we can understand specific features of ritual.

People identify actions as belonging to particular categories (e.g., putting on one's socks) but also as part of larger sequences (putting on one's socks as part of getting dressed). This "partonomic" structure is general to action sequences in normal contexts. Small units are parts of larger units and the boundaries between large units tend to coincide with a boundary at a lower level. Zacks and colleagues distinguish between three levels of representation: that of simple *gestures* (sequences of a few seconds), that of *behavioral episodes* (an order of longer magnitude, actions like "getting dressed"), and that of a *script* (series that can span a much longer time, e.g., "eating out," "giving a talk") (Zacks & Tversky 2001; Zacks et al. 2001b).

In the absence of specific instructions to the contrary, people spontaneously describe and recall behavior in terms of middle-level behavioral units (Zacks & Tversky 2001; Zacks et al. 2001b), that could be called a "basic level" for event-taxonomies (Rifkin 1985). Indeed, people can generate far more categories of events at that middle-level than either super- or subordinates (Morris & Murphy 1990). Mid-level breakpoints also correspond to specific neural activity (Speer et al. 2003; Zacks et al. 2001a). It is certainly not a coincidence that this is also the level of description at which people typically ascribe *goals* to behavior. While gestures do not readily reveal intention, and scenes include many different intentions, behavioral episodes typically constitute the realization of a particular goal. Action-parsing develops early in infants and seems to focus on the intentional unit level from that early stage (Baldwin & Baird 1999; Baldwin et al. 2001).

6.2. Goal-demotion in ritualized action

These studies converge to suggest that spontaneous parsing focuses on middle-level action-units connected to specific goals. It is very difficult for normal humans *not* to parse action at that level. Indeed, an excessive focus on a low-level, gestural description of behavior, with the attendant imprecision about goals, is characteristic of frontal lobe or schizophrenic patients (Janata & Grafton 2003; Zalla et al. 2003).

Now this focus on low-level gesture analysis of the action-flow is precisely what happens in cultural and individual rituals. People's attention is typically drawn to the details of performance, the particular direction of a gesture, the specific number of times an action should be performed, and so on. Conversely, the description of ritual action in terms of goals is either not available or in any case irrelevant.

This is what we call "goal-demotion." Although there may be a goal for the overall ritual script, there are no obvious sub-goals for its components. In typical patients' rituals or in developmental rituals, there may be an explicit goal. For instance, producing a particular alignment of twigs in a particular order is supposed to ward off intruders; or a sequence of familiar actions, for example, tying one's shoes in a very specific way, will prevent accidents. But the contribution of each part of the script is *not* connected to particular sub-goals. For some ritual actions it is impossible for the actor to imagine what contribution they would make as they reverse the results achieved through previous actions (e.g., piling up objects and carefully putting them back in a line before piling them up again). More generally, the actions are considered an indispensable part of the script although the subject has no representation of why he or she should be included in it. This contrasts with the standard parsing of action-flow, where the units identified at all levels of partonomic division correspond to specific goals. Indeed, in a typical example of routinized efficient practice, that of blacksmithing techniques, the correspondance between action-units and goals serves to mobilize different units of knowledge as they become relevant to the sub-task at hand (Keller & Keller 1996). This is emphatically not the case in ritualized behavior, the performance of which seems to be a "tunnel" in which each action only points to the following one in the prescribed sequence (Bloch 1974).

6.3. Swamping of working memory

There is very little study of the attentional effects of the focus on low-level features of action, combined with high control and hypersensitivity to possible mistakes, during performance of personal rituals. Our model suggests a specific, temporary effect on working memory which would explain some effects of rituals. Working memory is a specific memory system that holds information for a short time and allows updates and transformations of that information (Baddeley 2000). In typical working memory tasks subjects are asked to repeat a sequence of letters in the right order, repeat in inverse order, repeat the sequence formed by letters while ignoring digits provided in between, or specify which was the third letter before last in a series that ends unexpectedly. In all such tasks, the subject must consider a certain set of information units or chunks at the same time in order to perform the required operations (Baddeley 2000).

In our view, one of the effects of prescribed, rigidly compulsory action-sequences is a momentary overloading or "swamping" of working memory, especially if the action

sequences are represented at the fine-grain parsing level. This is very much what happens to some patients whose spontaneous action-parsing remains at this same low level of description. As Zalla puts it in her description of frontal lobe patients, "the weakening of the causal connections between the component actions leads to the decomposition and the fragmentation of the action representation. [. . .] The increased amount of fragmented information rapidly overloads subjects' working memory capacity" (Zalla et al. 2004). A similar point can be made about fragmentation of action in OCD compulsions (Ursu et al. 2003).

Many ritual prescriptions resemble the tasks designed by cognitive psychologists in the study of working memory. They require focused attention on a set of different stimuli and their arrangement. For instance, a requirement to turn round a ritual pole three times clockwise without ever looking down imposes executive control of two tasks at the same time. Also, the frequent combination of a positive prescription ("do *x*. . .") and a negative one (". . .while avoiding doing *y*") would seem to engage working memory and executive control in a way that is not usually present in everyday action flow.

6.4. Core ritualization is the opposite of routinization

In the model proposed here, ritualized acts are very different from other routines. However often an individual may perform a ritualized action, it does not seem to become automatic. On the contrary, it remains constrained by high-level cognitive control. Ritualized actions as described here require high cognitive control because the rules often apply to familiar actions (e.g., walking, talking, preparing food) and turn them into more difficult tasks (e.g., walking *without* treading on the line). This clashes with a commonsense notion that rituals only include actions that one performs "routinely" or "without thinking." Indeed, it is essential to our model that the component of rituals that we called Ritualized Behavior cannot be automatic.

7. Implications of the model: Individual ritual

7.1. Intrusions as context-sensitive adaptive algorithms

A surprising conclusion from the very few systematic studies of intrusions and mild compulsions in the normal population is that thoughts about potential dangers (contamination, social harm) and some compulsive reactions are not confined to the clinical population. Most normal people seem to experience the same kind of intrusive thoughts as patients do, and to some degree generate the same ritualized action-plans to avoid such dangers (Abramowitz et al. 2003; Rachman & de Silva 1978). The crucial difference, then, is not in the contents of the thoughts but in their appraisal (Salkovskis 1985).

The evidence available is insufficient to address the fundamental questions of the distribution, themes, intensity, and effects of intrusions in the normal population. Our model implies that intrusions are generally not dysfunctional. They are the outcome of systems geared to protecting the organism against potential dangers by over-interpreting specific inputs, which would suggest this prediction:

[P1] The position of an individual along fitness-related life-cycle dimensions (young vs. old, male vs. female, nulliparous vs. multiparous, high vs. low status) should predict the frequency, intensity and contents of intrusive thoughts.

So far, we only know that contagion and risk intrusions become highly salient during the perinatal period (Abramowitz et al. 2003; Leckman et al. 2004). This may also be true of other stages in the life-cycle, such as puberty, menarche, and the death of relatives. There is simply no general, population-sample study of thought-intrusions and their correlates. Sampling bias is particularly likely in this domain. Perinatal intrusions get noticed only because pregnancy is a period of higher medical monitoring.

7.2. Spontaneous optimization and relief

Why the strange rules and prescriptions in compulsive action? Also, why should such performances induce temporary relief? Many patients explicitly associate their rituals with specific obsessions, stating that performing the ritual is one way of inhibiting or repressing the unwanted thoughts (Salkovskis 1985). Clinicians' observations and patients' reports converge in suggesting that the relief from unbearable anxiety, though temporary, is palpable. But there is nothing in current cognitive models to explain the fact.

In our view these two questions are related, and the common answer lies in the effects of ritualization on cognitive control and working memory. We suggested earlier that the performance of rituals, accompanied by numerous, specific, attention-demanding prescriptions, has the effect of "swamping" working memory. We propose that such rituals constitute spontaneous and moderately efficient forms of *thought-suppression.* The difficulties of thought suppression in everyday life (trying not to recall unpleasant experiences or not to mull over possible future misfortunes) are familiar to everyone. Dan Wegner and colleagues have studied the phenomenon in controlled environments and demonstrated the complex control processes at work in such attempts (Wegner & Erskine 2003; Wegner & Schneider 2003). One interesting feature of these experimental studies is that only a few techniques are available to effectively "push away" unwanted thoughts. They include focusing on emotional information of greater intensity than the target thoughts, or focusing attention on intrinsically difficult tasks like mathematical problems. These are difficult precisely because they recruit working memory to a greater extent than most everyday tasks and cannot be accomplished automatically.

Obviously, compulsive rituals are in many ways different from the phenomena observed in such studies. First, Wegner's subjects generally have no intrinsic motivation to avoid the suppressed thoughts, other than compliance with the experimenter's instructions. By contrast, OCD patients are strongly motivated. Second, the intrusions in patients are far stronger (more difficult to push away from consciousness) than a simple neutral theme suggested by an experimenter. Third, patients have a history of thought-intrusion and thought-avoidance, whereas experimental subjects are genuine beginners in the domain.

Notwithstanding these differences, we think the studies on thought-suppression are important to suggest a possible mechanism for the elaboration and rigidity of ritual prescriptions. In our view, patients with complicated compulsions have spontaneously attained an optimal point in the kind of activity that is so demanding in cognitive control that intrusive thoughts can be, at least for a while, pushed away from consciousness.

This "trick" exploits certain features of the action-parsing systems reviewed (see sect. 6.1). Given that action-parsing processes are engaged when *any* behavior is witnessed or produced, there are not many tricks that could force attention to focus on the low-level description of action. Among these features is repetition, which results in goal-demotion. Another such gimmick, obviously, is to borrow a sequence from ordinary scripts and perform it in a context that makes goal-ascription impossible: for example, wash objects without using water, pretend to trace an imaginary line, and so on. What results from these "tricks" is what we called "goal-demotion" above. Actions are represented without attaching a goal to each behavioral unit, as would be the case in non-ritual contexts.

This has several implications for the organization of compulsive rituals:

[P2] Compulsive actions should be such that they mobilize working memory and require high degree of cognitive control.

We have suggested that this is precisely what complicated prescriptions achieve, in particular when they result in control of usually automatic actions, such as choosing which shoe to tie first, or whether to push the doorbell button with this or that finger.

[P3] Compulsive rituals may be the outcome of a trial-and-error process.

This means that patients more or less deliberately (usually not) try various behaviors with various prescriptive rules until they reach an optimum, that is, the maximal occupation of working memory that is compatible with the intrinsic limits of memory itself. This would carry another consequence:

[P4] The symptoms should become unstable if the actions become routinized.

Working memory is effectively swamped when usually automatic actions are submitted to cognitive control. But even demanding tasks (e.g., tying one's shoes in a particular order that changes with the time of the day) might become partly automatic with time. One would predict that this would result in diminished efficacy and the spontaneous search for different prescriptions, or for more complex sequences. Naturally, this dynamic model does not imply that patients are at any point aware of the effect of prescriptive rules on memory. They may simply come to associate slightly more controlled action to slightly diminished intrusion, which would be enough gradually to lead to the baroque complications of individual rituals. We do not have much comparative clinical evidence concerning the particular contents of obsessive-compulsive rituals, that is, the number of actions, their precise description, their prescribed order, and so on, as opposed to general descriptions such as "washing" or "checking." Nor do we have much in terms of longitudinal studies of ritual elaboration or progression; which is why these remain speculative predictions from the model.

7.3. Ironic outcomes

Studying normal subjects instructed *not* to think about a particular item, Wegner showed that thought suppression typically results in a "rebound" – in higher salience of the unwanted thoughts (Wegner & Schneider 2003). This, in Wegner's model, is caused by the combination of two distinct processes engaged in thought suppression. While an explicit process directs and monitors the suppression, implicit processes are engaged that detect material associated with the target item (Wegner & Erskine 2003). Here again, we do not wish to read too much in the parallel between an experimental paradigm and a long-lasting behavior pattern. However, an ironic outcome would seem to follow from the working-memory swamping scenario:

[P5] The precise intrusions that rituals can tone down should become more frequent or more difficult to resist as rituals are frequently practiced.

Although it has not been studied in precise quantitative terms, this ironic rebound does seem characteristic of compulsive rituals (Rachman & de Silva 1978). The patients who perform more rituals are typically more anxious, and also more bothered by their intrusive thoughts. In other words, the long-term effects of ritual performance are the opposite of its short-term results. Indeed, this may be why an effective cognitive and behavioral therapy for OCD, in particular exposure and reaction prevention (ERP), requires that the patient evoke the dangerous thoughts but restrain the compulsive response (Rachman et al. 1971).

7.4. Developmental calibration

Our model implies specific claims about the Hazard-Precaution system in children, suggesting that early childhood is a period of *calibration* of the system. Many cognitive systems require calibration, that is, a change in parameters as a function of specific information picked up in the child's environment (Bjorklund & Pellegrini 2002). A salient example is the development of food-preferences in young children, with a period of unlimited tolerance followed by "parameter-setting" when young children reject anything that does not taste familiar (Birch 1990). Another domain would be predator-prey relations, in which common assumptions are gradually refined in view of local circumstances (Barrett 2005).

We can make a similar point about the Potential Hazard Repertoire. As we said, the system should handle indirect clues and produce inferences about the potential presence of dangerous substances, predators, and conspecifics. But it immediately appears that the number of possible clues is multiplied by the fact that (a) any one of these dangerous situations could be detected using a large number of possible clues and (b) the situations themselves must have changed a great deal, and changed frequently, during human evolution. Indeed, modern humans have adapted to variable conditions of subsistence in primary forests, grasslands, and dry savannas. They also had to adapt to seasonal changes. Most important, cultural evolution led to rapid cultural change, or "life in the fast lane" (Boyd & Richerson 1995). Ecological and cultural change means that old predators are gone but new ones are present; that noxious substances are not found in

the same plants or animals; and that social interaction is handled in significantly different ways.

In this way the security system is a *learning system*, that appears in infants as a disposition to pick up particular kinds of locally relevant information from the natural and social environment, and changes its parameters as a function of that information. This would explain not just why children perform ritualistic behaviors, but also why the phenomenon appears and subsides at particular stages of development and why its typical manifestations evolve from prepotent fears for which there is clear preparedness, to more complex inferred threats like social harm. The system is designed to address a specific question: How to create a secure environment and to provide a series of contextually relevant solutions like washing, cleaning, checking, or modifying one's interaction with other agents? This implies particular directions for development in the kinds of thoughts and compulsions found in childhood. If the system is in calibration during that period, we should observe the following:

[P6] Anxiogenic thoughts should become gradually more specific with development.

[P7] Compulsive reaction should become more specific with development.

In terms of anxiety, a fear of vaguely defined predators animals should become a fear of particular animals, a fear of strangers should become a fear of particular strangers, and so forth, as the system picks up information from the environment. This applies to compulsions, too. At an early stage, all recipes should be equiprobable. At a later stage, children should acquire locally relevant associations between a particular potential danger and a particular recipe. This also predicts differences in the rituals of older children from different groups. To the extent that different cultural groups live in different conditions, different kinds of dangers would be relevant and different clues significant:

[P8] Fears and compulsions should become more culturally specific as children get older.

We already have some fragmentary evidence that developmental trends in children's fears support these predictions. Fantasies and intrusive thoughts change with development, as mentioned earlier (Evans et al. 1999; Leonard et al. 1990).

7.5. Cultural similarities and differences in pathological ritual

Our model assumes that there is a Precaution system focused on certain kinds of potential danger. We also suggested that this system undergoes calibration during childhood, given that clues about potential danger change with changing environments. This would imply specific predictions about cross-cultural variations in the condition:

[P9] Anxieties and fears that result in compulsion belong to the narrow range of ancestral potential dangers: contamination, intrusion, social offence, and resource-depletion.

[P10] We should observe important cultural differences in the relative prevalence of symptom clusters (or "subtypes").

There is very scant comparative anthropological evidence for anxieties or fears, although it seems to suggest something of this kind. In industrialized countries, the notion of electricity and cars as massive killers is virtually absent from the repertoire of phobic and obsessive patients. Also, the few studies of OCD patients in non-Western environments report the familiar obsessive themes of social offence, contagion, and potential danger (Abdel-Khalek & Lester 1998; Arrindell et al. 2002; Barker-Collo 2003; Bertschy & Ahyi 1991; Sasson et al. 1997) and the prevalence of OCD *as a general category* is the same in different places (Weissman et al. 1994).

Cultural differences too are suggestive, although there are to date very few (reliable) comparative studies of the condition and most of them only bear on clinical populations (so we have no evidence of what intrusive thoughts are common or exceptional in the population at large). For instance, a study from Bali documents a culture-specific tweaking of the general OCD themes. The patient needs to identify all passers-by in terms of genealogy and status, and reports obsessions about spirits and witches (Lemelson 2003). Both are culturally specific variants of the social harm and social exposure obsessions, as hierarchy and status are fundamental to social interaction in Balinese society and social strife is expressed through witchcraft accusations (Barth, 1993). In Muslim countries, by contrast, many patients report concerns about pollution and contamination strongly influenced by religious prescriptions on hygiene and purity of thought (Al-Issa 2000; Mahgoub & Abdel-Hafeiz 1991; Okasha et al. 1994). A sample of Bahrain patients showed that the fear of blasphemy was prevalent (about 40% of cases), which may be a local expression of the fear of social harm and potential exclusion (Shooka et al. 1998).

This would suggest that an important calibrating factor is the range of cultural messages emphasizing potential danger. In particular, further epidemiological studies of the various dimensions of OCD (contagion, social offence, checking) may be correlated to the intensity of precautionary messages available in the environment of development. While Islam includes many descriptions of possibly impure actions or thoughts, Western children are bombarded with insistent warnings about invisible germs. Whether this results in significantly different normal and pathological intrusions is simply not documented yet.

8. Implications of the model: Cultural ritual as derivative

So far, we have not mentioned one of the most salient and socially important manifestations of ritualized behaviors, namely, collective, culturally sanctioned rituals. We consider that the model presented so far can help us understand why rituals are widespread the world over and why they are compelling – an argument summarized here and presented elsewhere in more ethnographic detail (Liénard & Boyer 2006).

8.1. A capacity for ritual?

We start from the work of Fiske and colleagues. Comparing hundreds of ritual sequences with clinical descriptions of OCD cases, they showed that the same themes recur over and over again in both domains (Dulaney & Fiske 1994; Fiske & Haslam 1997). OCD-typical features that also enter into rituals include specific (lucky or unlucky)

numbers, use of special colors, repetition of actions, measures to prevent harm, ordering and symmetry, stylized verbal expressions, washing, concern with contagion, and so forth (Fiske & Haslam 1997).

Fiske and colleagues speculate that there may be a human capacity to perform cultural rituals, that is distorted or hyperactive in pathological individual ritual (Fiske & Haslam 1997). In Fiske's model, rituals are used to channel individual anxiogenic thoughts and make them bearable by providing a broader cultural context in which they can be shared and make better sense. Fiske and Haslam did not pursue the psychological and cultural implications of this hypothesis. It would provide a simple and elegant way of explaining the similarities in themes and actions between pathological and cultural ritual. Moreover, it would do so by connecting both to evolved, species-specific anxiogenic situations.

However, we consider that cultural rituals may be better explained in a different way, as partly parasitic on the Hazard-detection and Precaution systems described above. Our main reason for preferring this account is that it is more parsimonious. There is no empirical evidence that humans do have a *specific* capacity for ritual. There are no evolutionary grounds to consider that such a specific capacity would be adaptive (see our discussion of rituals as possible adaptation in section 9.1.) So this is a costly hypothesis. By contrast, we have seen that there is solid evidence for systems specialized in responses to potential hazard. So if the disposition to perform cultural rituals is a by-product of these systems, we do not need to posit additional mechanisms.

8.2. The cultural selection background

The first assumption in our treatment is that cultural rituals, like other forms of cultural behaviors, should be treated as the outcome of cultural selection (Boyd & Richerson 1985; Durham 1991; Sperber 1994). Representations that we call "cultural" occur with roughly the same content in other minds among people of a particular group. Indefinitely many factors (local or universal, psychological as well as physical) can in principle contribute to the spread of a particular mental representation. One type of factor of great interest to us is the set of general human dispositions that make certain representations, once they are expressed or conveyed by some people, particularly attention-grabbing or memorable or compelling, leading to their cultural transmission (Sperber 1985).

We observe that people seem compelled to perform particular ceremonies at particular junctures, and also that they seem compelled to perform them in (what they judge to be) the prescribed way. This is what we need to explain. Now, one way to explain this would be to posit that there must be a particular *urge* to perform such ceremonies, or that they may fulfill particular needs of the human mind or of human groups. However, there may be another kind of explanation, based on the fact that people who receive information about particular performances already have sets of mental systems designed to respond to particular classes of stimuli. The question becomes: What mental systems would be activated, such that performing *this* ceremony in *these* circumstances would seem compelling?

8.3. Cultural information, mimicry, and cognitive capture

Cognitive systems can be functionally described in terms of their particular *input format*, their *operating principles*, and their *output*. The input formats of cognitive systems are, in some cases, well known. For instance, the auditory stream provides information about pitch and location, which is then routed to different systems (Kaas et al. 1999; Romanski et al. 1999). The pitch information is divided into linguistic input and non-linguistic input, transmitted to different parts of the auditory cortex (Liegeois-Chauvel et al. 1999). At each step, the transfer from one system to the other depends on the signals' format. This extends to higher cognitive systems.

The range of stimuli or internally generated information that meets the input format of a system is its *domain*. Now it is important to distinguish between an *evolutionary* or *proper* domain of stimuli and an *actual* domain (Sperber 1996). The proper domain includes those objects or situations that played a causal role in giving the particular system a selective advantage. The actual domain includes all objects or situations that trigger activation of the system. In most evolved cognitive systems, the actual domain is larger than the proper domain, giving rise to false alarms. The frog snaps at any small objects whizzing by in its visual field, not just to actual edible insects.

Any system of this kind is vulnerable to *capture* and *mimicry*. The terms describe situations in which the system reacts to an input that matches its input format, is part of its actual domain, yet is not among the classes of stimuli that the system was designed to process, its proper domain. We reserve the term "mimicry" for the situations in which a particular behavior or physical trait in an organism gains adaptive value by entering the actual domain of another organism's cognitive system. This is what happens in familiar cases, like that of Viceroy butterflies adopting the genuine poison-warning garb of Monarchs without having to manufacture the poison.

A different situation is what we call "cognitive capture." Consider a familiar example. Most visual art in humans (from tattooing to painting to architecture) seems strongly biased towards vertically symmetrical displays, while other symmetries are less salient. Vertical symmetry detection capacity appears in infancy (Bornstein & Krinsky 1985; Fisher et al. 1981), influences pattern recognition in childhood (Bornstein & Stiles-Davis 1984; Mendelson & Lee 1981), and has evolved for purposes other than the appreciation of aesthetic displays, most probably for detecting facing predators and healthy mates (Thornhill 1998). Music too is a good example, as it "hijacks" certain parts of the auditory cortex and provides auditory super-stimuli (Jerison 2000). Narratives about imagined persons can be, as we say, "captivating" because they capture our capacities for mind-reading and the explanation of behavior.

This is not mimicry since in the cases mentioned here the organism's Type I error does not benefit another organism. The important point about cognitive capture is that a great deal of human culture is acquired and transmitted because of this inevitable propensity of cognitive systems to "fire" beyond their proper functional range. Most items of "culture" in the sense of group-specific sets of norms and concepts depend for their transmission on cognitive capture of this kind (Sperber 1996).

8.4. Core ritualization in cultural rituals

To understand the cognitive effects of collective rituals, we must describe the kinds of information available to the participants. At first sight, it would seem that most people who participate in most rituals do not have much information at all. People do not generally hold a "theory" of their own rituals – this is what makes ethnography indispensable and difficult.

However, this is not to say that people participate in a ritual on the basis of mere imitation, peering at their cultural elders and simply performing similar gestures. This would be implausible, given that very little human cultural transmission actually involves such mindless imitation (Sperber 2000). In this particular case, some behavior activates some mental templates in the mind of observers, and triggers non-random inferences about what is accomplished by the behavior. This, we contend, may be sufficient to explain the cultural success of Ritualized Behavior.

To make comparisons simpler, we follow in our description the outline of action ritualization processes described earlier. The individual reaction to a particular cultural ritual can be functionally described as consisting in the following elements:

1. People receive specific information about the ritual:
   a. They are told that a ritual should be performed and are led to infer that non-performance is a dangerous option. For instance, one is told that because of a particular event (someone's illness, a death or a birth, the change of seasons, a war with another group, possible damnation), it is necessary to go through a particular ritual sequence.
   b. People also receive information and produce inferences about the kind of danger against which the ritual is supposed to protect the group, for example, "pollution" by invisible substances, attacks by invisible predators like witches or spirits, threat of disease, possible famine, social strife, and so on. These themes substantially overlap with the Potential Hazard Repertoire.
2. This triggers a (dampened) activation of Hazard-Precaution system.
3. People are instructed to participate in the ritual in particular ways. That is, people are generally not allowed to just add to their ritual whatever action they think fit. They are enjoined, more or less explicitly, to follow a particular script. Information about the script has the following properties:
   a. Action descriptions include themes that mimic some of the typical outputs of the Hazard-Precaution system: actions such as cleansing, washing, checking.
   b. Descriptions of prior conditions, particular taboos, substances to avoid, et cetera, reinforce activation of security motivation system.
   c. There is great emphasis on the details of each action, inducing low-level parsing of the action flow during performance, especially because of negative prescriptions.
   d. Description induces goal-demotion, by insisting on repetition, redundancy, apparently pointless acts, and so forth.
4. Performance enacted in these conditions temporarily swamps working memory because of the attentional demands of the tasks.
5. Performance ironically strengthens the salience of particular themes associated with gestures or situations to avoid during ritual.

These various elements and their putative causal relations are outlined in Figure 4. In the next sections we present some evidence for these various claims and for the psychological and cultural effects of the processes.

8.5. Cognitive capture in cultural rituals

Our model suggests that ritualized actions are culturally successful to the extent that they activate information-processing and motivation systems made manifest in other domains of ritualization. In this sense, cultural rituals result in *cognitive capture* of the systems described so far, and this is why they can seem attention-demanding and compelling to participants.

Many features of collective rituals activate the Hazard-Precaution system by including cues for potential dangers of the Evolutionary Potential Hazard Repertoire. First, occasions for ritual often allude to clues of possible danger that overlap with the Potential Hazard Repertoire: for example, threats to fitness such as famine or illness, invisible germs or miasma, dangerous invisible pollution present in newborn infants, dead bodies and menstruating women (Bloch & Parry 1982; Metcalf & Huntington 1991). Second, details of prescribed performance also include many security-related motifs. As we said previously, many collective rituals include such operations as washing and cleaning, checking and re-checking that a particular state of affairs really obtains, as well as creating a symmetrical or otherwise orderly environment (Dulaney & Fiske 1994; Fiske & Haslam 1997), so we will not comment on this any further.

In our model, precaution systems are activated to the extent that particular themes (e.g., "this village must be purified") and prescribed actions (e.g., "wash hands three times in this particular river") trigger activation of evolved Precaution systems. This, however, does not entail that the ritual as a whole should be explicitly and exclusively about these themes. Indeed, there are many ceremonies in which prescribed behavior is only weakly related to these themes, while other themes (e.g., procreation, social exchange, hierarchy) are at the forefront of people's attention. Our claim is only that the *ritualization* itself is derived from the operation of Precaution and action-parsing systems.

8.6. Ceremonies, ritualized action, and routinization

This model, in our view, provides at least elements towards an explanation of why ceremonies that include ritualized actions are found in most human groups and are generally stable within traditions. The model also has some implications that make it diverge from received anthropological usage and common intuitions about ritual.

Ritualized actions are not "rituals." Ritualized actions as described here are only a subset of what people actually do in what are called "rituals." For instance, a ceremony may include a typical example of what we described earlier, such as, a prescription to turn around a cow three times clockwise while avoiding to stare above the horizon and making sure to touch the cow with one's thumb only.

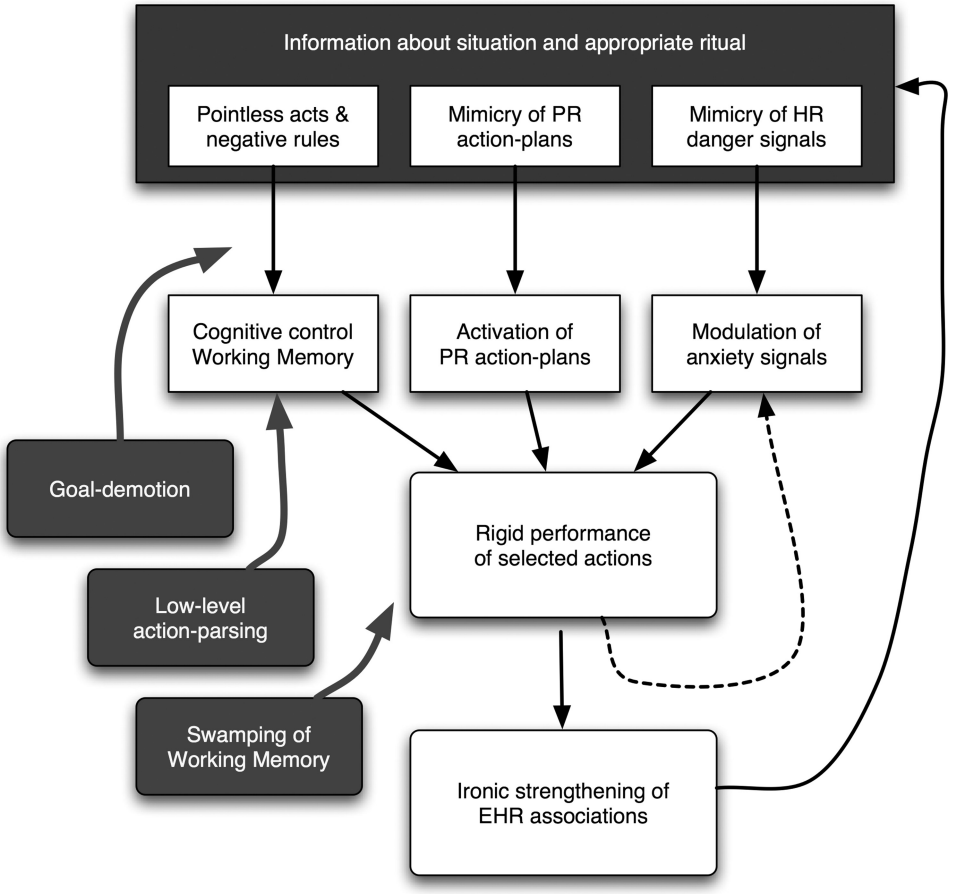

Figure 4 (Boyer & Liénard). A simplified model of action ritualization in cultural rituals. Boxes identity different functional systems in the same way as in Figure 3. Participants in rituals are provided with two kinds of information, (a) statements about potential danger and (b) scripted recipes for ritual action, that activate the security-motivation systems. Rules for ritual performance result in both goal-demotion and low-level action-parsing with the resulting swamping of working memory. These processes result in highly attention-demanding and compelling performance of rigidly scripted actions. This in turn makes the associations more salient, which should make subsequent messages about ritual more intuitively compelling.

But the circumambulation of the cow may be an element of a larger ceremony that also includes singing, dancing, feasting, and all sorts of other behaviors that are not precisely scripted in the sense described here. In other words, ritualized behaviors are certainly not the whole of "rituals."

Ritualization is not routinization. The model has the slightly counter-intuitive implication, that ritualized action is described as quite different from routinized behavior, indeed as its opposite. In most ceremonies we expect to find an alternation between phases of ritualized action (high control, attentional focus, explicit emphasis on proper performance) and routinized action (possible automaticity, low attentional demands, lesser emphasis on proper performance).

Cultural ritual is not individual ritual writ large. We said that cultural ritualized actions are "derivative" and it is important to stress that they are a by-product of the Precaution systems and the action-parsing systems, *not* of individual ritualized behavior. Given the similarities between individual and cultural forms of ritual, it is of course tempting to take one as a scaled version of the other, as Freud suggested (Freud 1928). But this is clearly misguided. First, to maintain the parallel, cultural rituals would need to be behaviors that social groups initiate because they perceive certain potential dangers. But groups as a whole do not literally behave or perceive, only their members do. Also, cultural rituals differ from individual ones in the way the information about compelling action is acquired – from other agents and from personal intuition, respectively. Most importantly, what compels performance is entirely different in the two situations. While individual ritualists (especially patients) may feel great anxiety at the prospect of not going through the ritual sequence, participants in a cultural ritual are likely to participate (among other reasons) to the extent that the particular sequence meets a minimal threshold of relevance. The idea of "scaling" would also predict all sorts of interesting phenomena that are simply not observed; for example, that people who become more religious would tend to become more obsessive, or that OCD patients would tend to be more religious than controls, that children during early childhood should be more interested in religious ritual than at other stages of development, and so on. Although there are connections between certain forms of religious practice and obsessionality (Fallon et al. 1990; Hermesh et al. 2003), they fail to support these general conjectures.

9. Conclusions

9.1. Ritualization and cognitive adaptations

Our models of individual and cultural ritualization take as a starting point a specific connection between obsessive pathology and security motivation (Mataix-Cols et al. 2005; Szechtman & Woody 2004) but also a more general set of assumptions about the adaptive character of specialized neuro-cognitive function (Cosmides & Tooby 1999; Duchaine et al. 2001). We have assumed that the Hazard-Precaution system was the outcome of selective pressure for gradually finer-grained inferential detection of and appropriate response to recurrent hazards in ancestral environments. This naturally leads to the question, whether action-ritualization might constitute a cognitive adaptation, in the same way as other domain-specific capacities do (Cosmides & Tooby 1994). The question should be more specific and bear on either individual or cultural rituals, since the cognitive processes involved are so different.

Let us consider cultural rituals first. In the anthropological literature, there are various hypothetical models of the ways in which participation in collective ceremonial may have conferred adaptive advantage to individuals (Burkert 1996; Knight et al. 1998; Rappaport 1999; Sosis 2000; Watanabe & Smuts 1999). This stems from a long anthropological tradition of construing ritual as crucial to social organization and cohesion (Durkheim 1947; Hocart & Needham 1970; Smith 1889). We discuss the various hypotheses in more detail elsewhere (Liénard & Boyer 2006). Suffice it to say that these different models may well explain a disposition to participate in coordinated social action, but not why these common endeavors should include scripted, goal-demoted, redundant scripting of familiar actions.

The question of individual ritualization is more complex. In our model, the activation of the Precaution system normally results in performance of appropriate actions from the Precaution Repertoire – and this, in most circumstances, should produce enough of a closure or satiety experience (Szechtman & Woody 2004) to preclude reiteration. However, the closure experience probably is the outcome of continuous changes in the relevant circuitry, leading to various degrees of repetitiveness and anxiety about proper performance. So, in our model, it is not the ritualized behavior but the Precaution system itself that constitutes a cognitive-motivational adaptation. It has the hallmarks of such adaptations, such as a specific class of inputs, a specific mode of operation, a particular series of fitness-enhancing consequences, a non-trivial functional design – and, in this particular case, a specific neural implementation as well as specific impairment.

9.2. Phylogeny: Rituals and displays

What is the connection between human and other animal "ritual"? We use scare quotes here, as the term is stretched to encompass highly disparate forms of behaviors (Gluckman 1975). Nevertheless, one should comment on the obvious similarities between human rituals and various forms of animal communication, notably in the context of agonistic and sexual displays where stylized behavior, repetition, and redundancy are clearly present. Is this evidence for the deep phylogenetic ancestry of ritual? In our view, this question suffers from several ambiguities:

First, although we may sometimes follow a "same effects, same causes" rule of thumb, this is rather misguided if it leads us to confuse observable behaviors with the neuro-cognitive systems that support them (Povinelli et al. 2000). Indeed, even in the limited domain of human rituals, apparently similar behaviors (in patients and in cultural ritual participants) actually stem from very different cognitive processes. This should *a fortiori* be expected when comparing widely different species.

Second, the question downplays the extent to which certain features of behavior are constrained. Consider OCD patients for instance. They are not motivated by a positive urge to ritualize. Rather, ritualized behavior happens to constitute an optimal response to the anxiety produced by cognitive impairment. Other forms of behavior would not seem appropriate given the anxious concerns; they would not produce temporary relief. So the redundancy, et cetera, in this case stems from the properties of action-parsing and precaution systems in humans. Now consider animal displays. They are strongly constrained too, in this case by the logic of signaling processes. For instance, signals must be clear and distinct enough to preclude ambiguities, which typically results in redundancy (Rowe 1999). The evolution of attentive receivers requires that signals maintain a relatively high level of accuracy (Bradbury & Vehrencamp 2000; Silk et al. 2000) and that the content of the signals be directly related to the fitness dimensions they advertise (Zahavi & Zahavi 1997). In other words, in both human rituals and animal displays, features like stylization, redundancy, and repetition are the outcome of external constraints, but these seem to be different in the two cases.

This would support the tentative conclusion that the presence of "ritual" in both cases is a case of behavioral analogy rather than the index of similar capacity and processes. (Obviously, this is not to deny that humans like other animals do engage in stereotypical displays, in situations of courtship or aggression). This is tentative in the sense that we do not know much about the phylogenetic history of ritualization (in the precise sense used here) in the hominin line. The evidence so far simply does not support the notion of a direct evolutionary homology.

9.3. Epilogue

It is a cognitive and evolutionary puzzle that humans perform rituals, given the waste of time and resources involved. We aimed to solve the puzzle by piecing together the evidence from neuroimaging, neuropsychology, clinical psychology, developmental studies, and evolutionary anthropology. Ritualization may be seen as an occasional by-product of specific precaution systems and action-parsing capacities in humans.

This explanation however compels us to discard the common intuition that there is a natural kind of phenomena called "rituals." If valid, our model does not explain "rituals" but a highly specific form of behavior that is found in many of them and occurs *for different reasons* in the behavior of most normal children and obsessive patients, on the one hand, and in the context of collective rituals, on the other.

Discarding misleading categories of behavior (like "ritual" – but there are many others) may well be the inevitable consequence and benefit of proposing *integrated* explanations. Our model is an attempt to bring together neural systems, evolutionary background, behavioral manifestations, and developmental trajectory to the understanding of action-ritualization. We consider this indispensable. True, much work remains to be done to understand the phenomenon. For instance, the cognition of children's ritual is still largely unexplored; the connections between ritual performance and anxiety relief in patients need a proper neurophysiological study; the persuasive power of cultural rituals is not properly explained. But we are confident that all these and other puzzles will be solved by the kind of "general behavioral science" that transcends fields and discipline boundaries.

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Open Peer Commentary

Why ritual works: A rejection of the by-product hypothesis

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Abstract: We argue that ritual is not a by-product as Boyer & Lienard (B&L) claim, but rather an evolved adaptation for social communication that facilitates non-agonistic social interactions among non-kin. We review the neurophysiological effects of ritual and propose neural structures and networks beyond the cortical-striato-pallidal-thalamic circuit (CSPT) likely to be implicated in ritual. The adaptationist approach to ritual offers a more parsimonious model for understanding these effects as well as the findings B&L present.

Why humans engage in "irrational," costly rituals is a perplexing evolutionary question. Boyer & Lienard's (B&L's) attempt to answer this question through the integration of evolutionary, neuropsychological, and neuroimaging evidence is an important first step in understanding both the proximate and causal mechanisms of ritual. Their inclusion of childhood, life cycle, and pathological rituals focuses attention on significant developmental, ecological, and population elements of ritual heretofore ignored. Moreover, their consideration of underlying neurophysiological components offers insights into specific neural pathways implicated in ritual behaviors. These elements are significant advances in the evolutionary study of ritual. Unfortunately, the model developed from this promising foundation fails to fulfill the potential of their approach. Most significantly, the authors' conclusion that "ritualization may be seen as an occasional by-product of specific precaution systems and action-parsing capacities in humans" (target article, sect. 9.3) does not adequately explain the data presented throughout their discussion or advance our understanding of why ritual occurs so ubiquitously and frequently across species. We argue that a more compelling approach views ritual as behavior evolved for social communication that optimizes appraisal and learning, and facilitates non-agonistic social interactions among non-kin.

Laboratory experiments have shown that the core elements of ritual, that is, formality, pattern, sequence, and repetition, heighten and focus attention, promote associational learning, and enhance long-term memory (Rowe 1999). As noted by B&L, ritualized behaviors are neither routine, nor automatic, but instead require "high cognitive control." B&L argue that such control results in the "swamping" of working memory which permits the temporary suppression of intrusive thoughts. They claim, however, that ritual performed on a long-term basis has the "ironic outcome" (sect. 7.3) of actually strengthening such thoughts. In contrast, we view this effect of ritual to be a functional adaptation rather than an "ironic outcome." Neuroimaging studies have shown that tasks of sustained attention or vigilance increase activation of right hemisphere prefrontal and superior parietal cortices (Pardo et al. 1991). Increased right hemisphere activation has several important consequences: it promotes social-emotional information processing (Tranel et al. 2002); it forefronts negative appraisal systems (Cacioppo et al. 2002); and, it elicits holistic, gestalt thinking. Recent research has also shown that the right posterior association cortex is particularly important in the processing of new information, as well as in anticipating consequences and determining emergency reactions (Schutz 2005). Ritual's ability to engage these various right hemispheric functions, and its promotion of associational learning and strengthening of long-term memory would be particularly important in relation to complex social decisions involving unrelated and potentially dangerous conspecifics. It is precisely under such circumstances that ritual occurs in humans and nonhumans alike. In addition to right hemispheric dominance effects, the core elements of ritual are also likely to activate neural structures and pathways specific to the brain's vigilance and reward systems.

B&L review neuroimaging evidence regarding the corticostriatal circuits implicated in obsessive-compulsive disorder (OCD) ritualization. Although they propose a specialized "Precaution/Hazard" brain module, their discussion of neurophysiological pathways stops short of incorporating mesolimbic and corticolimbic vigilance and reward networks associated with the cortical-striato-pallidal-thalamic circuit (CSPT) (Cardinal et al. 2002; Dehaene & Changeux 2000). These pathways encompass limbic structures, such as the amygdala, which are critical for evaluating stimuli in relation to both physical and social threat (Adolphs 2002; Dolan 2000). They also include structures fundamental to the brain's reward system, such as the nucleus accumbens. While the amygdala has been shown to be critical for social judgments of trust (Adolphs 2002; Morris et al. 1998), recent neuroimaging studies show that the nucleus accumbens and other reward system structures are activated during episodes of mutual cooperation (Rilling et al. 2002). Both the amygdala and the nucleus accumbens are critical components in motivational pathways for approach/avoidance (Cardinal et al. 2002; Dehaene & Changeux 2000). These structures also provide evaluative input to the orbitofrontal cortex that is critical for both social judgment and effective personal decision-making (Dehaene & Changeux 2000; Schoenbaum et al. 2003). The dopaminergic corticostriatal associational networks that encompass orbitofrontal, limbic, and basal ganglia structures undergo a developmental shift during adolescence (Spear 2000). As we have discussed elsewhere (Alcorta & Sosis 2005), these pathways constitute likely neural networks for learning and emotionally valencing both the signals and symbols of ritual. These pathways encompass the neurophysiological counterpart of the "Precaution/Hazard" brain module proposed by B&L. In sharp contrast

to their model, however, we view ritual as an evolved adaptation that activates these pathways, rather than as a dysfunctional by-product of their operation. We propose that ritual activation of the cortico-limbic-striatal networks kicks socio-emotional appraisal and learning processes into high gear and initiates right hemispheric processing of the complex cost/benefit calculations associated with approach/avoidance decisions that lie at the heart of non-agonistic social interaction between unrelated conspecifics.

If the capacity for ritual is an evolved adaptation, then individual genetic propensities for ritual should display variation throughout a population. B&L note that just such variation has been proposed as an explanation of OCD. Ritual also exhibits considerable ontogenetic and socioecological malleability, as well (Alcorta & Sosis, forthcoming). The continuum of simple to complex behaviors found in both human and nonhuman ritual clearly includes a broad range of both "fixed" and "learned" elements. Within many species, such as songbirds (Marler 1999) and baboons (Watanabe & Smuts 1999), learning is both a necessary and developmentally sensitive component of ritual. As noted by B&L, and as we have discussed elsewhere, this appears to be true of human ritual, as well (Alcorta 2006). Although the capacity and the propensity for learning such behaviors is genetically encoded in each individual, the activation and development of the neural pathways specific to such behaviors requires that learning occur through social transmission. Such learning may be optimally accomplished during particular "experience expectant" developmental periods (Greenough 1986). This model of ritual predicts that ritualized behaviors will vary across the population, will occur predominantly in relation to social concerns, and will display a range of intensity and expression in response to differing individual, developmental, life cycle, and ecological factors. These predictions are borne out by the human data presented by B&L and by ethological research (Ball 1999; Marler 1999; Rogers & Kaplan 2000; Wingfield et al. 1999).

A robust evolutionary theory of ritual requires that we consider both human and nonhuman data, and that we shed false individual/cultural dichotomies, as well. Unlike the by-product theory of ritual, a theory of ritual as an evolved adaptation for social signaling and communication provides a parsimonious and integrated explanation of all the relevant data across disciplines and across species. Testing hypotheses derived from this theory can move us forward in understanding both the proximate and ultimate causes of ritual.

Compulsions and cultural rituals: The need for a drive-motivational framework

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Abstract: Instinct theory parsimoniously clarifies the relationships between emotions, such as fear and anxiety, and perceptions, thoughts, and actions. Its acceptance allows more elegant insights into riddles of obsessions and compulsions. Their relationship to anxiety and dysexecutive function needs to be explained, as does their characteristic egodystonia, while avoiding the pitfalls of cognitivist, empiricist, and teleological thinking.

> *Left to itself, reason is like a … wonderful system of wheels within wheels, without a motor to make them go round. The motive power that makes them do so stems from instinctive behaviour mechanisms much older than reason and not directly accessible to rational self-observation. … These deep strata of the human personality are, in their dynamics, not essentially different form the instincts of animals, but on their basis human culture has erected all the enormous superstructure of social norms and rites whose function is so closely analogous to that of phylogenetic ritualization.*
>
> — Konrad Lorenz (1963/2002, p. 240)

McDougall (1924), who regarded instincts as the "prime movers of all human activity," discerned that the operation of each instinct "is accompanied by its own peculiar quality of experience which may be called a primary emotion" (p. 128). Fear is the "characteristic emotional accompaniment" of the "instinct of escape," which enacts, first, "a running to shelter" and, second, "a lying hid when the shelter has been attained" (pp. 150–51). For gregarious species, shelter may be represented by "the mass of the congregated herd." A loud noise "is perhaps the most nearly universal key" to the "gates of fear," another being "the sudden move of a large object" (p. 152). The impulse of the *gregarious instinct* is to approach conspecifics. Uneasiness and restlessness, and a craving to be back in the company of others, afflict the individual on his absence from the group (McDougall 1924). The likely emotional accompaniment of the *gregarious instinct* – anxiety – may be similar to that of the *instinct of escape*, suggesting the two instincts are evolutionarily related.

Situations or objects are perceived because "they are specific excitants of these instincts" (McDougall 1924, p. 273). An object *recognised* or *thought about* "evokes in [the subject] an impulse to effect some change"; conative experience in proportion to the strength of the underlying instinct – as the "felt impulse to action," – is integral to all our "sense-impressions" (p. 265). Thus, certain cues evoke fears of contamination, which lead to washing or cleaning rituals. Other cues evoke concerns about intrusion by others, leading to checking rituals, but anxiety indeed forms an important context for *compulsive* actions. Perception of threats and ideas about possible threats may represent *displacements* – unconscious attempts to convert overwhelming anxiety into concrete forms of fear that allow specific responses in form of specific rituals. The subject's attention to potential threats may be heightened inasmuch as his anxiety cannot be resolved through secure interpersonal relatedness (Heidegger's [1927/1962] notion of "fleeing anxiety"). Compulsive actions, then, may relieve a specific fear – the immediate motivational impetus behind these actions – but they would not substantially alter the background of anxiety. "Goal-demotion" (see target article) of normal fear responses and their repetition would be due to the fact that the ultimate motivational force – existential anxiety – is not addressed.

Although "patients who perform more rituals are typically more anxious," this does not mean that anxiety is one of "the long-term effects of ritual performance" (target article, sect. 7.3). If anxiety does increase in the course of obsessive-compulsive disorder (OCD) then this may be due to social debilitation. Conversely, helping the patient in therapy to develop secure interpersonal relatedness addresses his anxiety and can reduce obsessions and compulsions (Gabbard 1990). The key difference between *normal* "ritualized action-plans to avoid […] dangers" (sect. 7.1, para. 1) and pathological compulsions may not lie in "appraisal" of dangers but in the presence or absence of background anxiety. Specific fears can be abreacted under most circumstances, but anxiety often cannot – because secure social relatedness may be beyond reach for the individual, particularly if *impulsivity* is a confounding problem.

Much of social behaviour is determined from a drive-motivational perspective by successive impulses of "aggression, fear, protection-seeking and renewed aggressiveness" (Lorenz 1963/2002, p. 55). In *phylogenesis*, ritualisation creates new instinctive motor patterns by welding together conflicting impulses (Lorenz 1963/2002). The display of such behaviours often acquires signal function in social situations. *Submissive gestures* are ritualised behaviour patterns that elicit in members of the same species an active inhibition against aggression. Norms of social behaviour developed by *cultural ritualisation* started to play an important part in human society "when invention of tools was beginning

to upset the equilibrium of phylogenetically evolved patterns of social behaviour" (p. 249). Social manners represent "culturally ritualised exaggerations of submissive gestures most of which probably have their roots in phylogenetically ritualised motor patterns conveying the same meaning" (p. 77).

Illness or misfortune may provide occasions for complex cultural rituals indeed, but it makes sense to insist that their function – like that of social manners – is to foster *social cohesion* in complex societies. What makes collective rituals attention-grabbing and compelling is not their presumed ability to "activate the Hazard-Precaution system by including cues for potential danger" (sect. 8.5, para. 2); instead, their compelling nature and stability within traditions may stem from their role as a socially acceptable outlet for instinctive intraspecific aggression and culturally appropriate medium for negotiation of rank order. Participation in cultural rituals – and adherence to social norms in general – is not compulsive, but compulsory – that is, demanded by the group – insofar as it deflects instinctive intraspecific aggression from the group and signals submission and conformity. Deviation from norms and rituals is *dangerous* indeed because it leads to social rejection; and it is in this sense that fear plays a role.

Boyer & Lienard's (B&L's) suggestion that their attempt to "explain a disposition to participate in coordinated social action" stands out from other such attempts in that they resolved "why these common endeavors should include scripted, goal-demoted, redundant scripting of familiar actions" (sect. 9.1, para. 2), attests to today's ignorance of Lorenz's work. In contrast to Lorenz, B&L dispute that "obvious similarities between human rituals and various forms of animal communication, notably in the context of agonistic and sexual displays" could be seen as "evidence for the deep phylogenetic ancestry of ritual" (sect. 9.2, para. 1). Their model *demands* that apparently similar behaviours "actually stem from very different cognitive processes," – suggesting, for instance, that *in animals* "signals must be clear and distinct enough to preclude ambiguities." However, human cultural rituals too have a signal function: they signal social assertion or submission in aggressively motivated competition within the group for ranking positions and resources.

Obsessive and compulsive phenomena are not just exaggerated versions of risk avoidance behaviour, as B&L maintain. Compulsions and obsessions are characteristically *egodystonic*; they are accompanied by inner resistance reflecting a conflict between drives. This is usually between an urge to escape a specific hazard and fear of aggression. Expectations of punishment, which relate to patients' preserved insight into the abnormality and social unacceptability of their compulsions – psychoanalytically conceptualised as fear of the superego – are the source of much of their suffering. Obsessive thoughts about harming or offending others indeed elicit fears of social ostracism, representing a conflict between the individual's aggressive drive and his fear of becoming the target of others' aggression.

Rather than linking obsessive-compulsive disorder (OCD) to "a *dysfunction in a satiety signal*, plausibly generated in brainstem structures" (sect. 3.3, para. 4; emphasis in the original), we should emphasise the motivational instability between conflicting drives, ultimately between existential anxiety urging human relatedness (transformed into a specific fear) and the fear of aggression. As B&L recognise, "conflict in groups threatens each member's access to resources," so that the motivational conflict derives its immediacy precisely from the "human dependence on conspecifics for all aspects of survival" (sect. 5.4.3). These conflicts would be expected to activate the anterior cingulate gyrus in patients with OCD, consistent with findings by Fitzgerald et al. (2005), bearing in mind that the anterior cingulate cortex is more likely a structure representing basic motivational/emotional states, including fear and anxiety (Behrendt 2005; Ploghaus et al. 2003), rather than an "error-detection network" (Winterer et al. 2002). What may be of greater pathophysiological relevance is the association of OCD with prefrontal lobe/basal ganglia pathology, given that compulsiveness is clinically related to *impulsivity* – part of the dysexecutive syndrome.

What else is driving ritualized behavior, besides the "Hazard-Precaution system"? Developmental, psychopathological, and ethnological considerations

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Abstract: The target article presents arguments for a motivational system dedicated exclusively to the detection of, and reaction to, particular threats to fitness, the so-called "Hazard-Precaution System," which, according to the authors, drives ritualized behavior. We approach the issue of a motivational system from three perspectives – developmental, psychopathological, and ethnological.

The goal of an integrated model of ritualized behavior, put forward by Boyer & Lienard (B&L) in the target article, is both ambitious and laudable. Yet the search for commonalities might sometimes overlook differences between partly or superficially similar phenomena. Like the authors, we approach from three perspectives – developmental, psychopathological, and ethnological – a key aspect in this search: the issue of a motivational system dedicated exclusively to the detection of, and reaction to, particular threats to fitness, the so-called Hazard-Precaution system, driving ritualized behavior.

From a developmental perspective, one of the major claims by B&L draws our attention: that ritualized behavior cannot be routine-like or automatic, but rather, requires high-order cognitive control. The distinction between routines and rituals *per se* is conceptually a worthy one. However, there is a corollary claim that rituals involve an explicit emphasis of the agent on his or her own proper performance of actions – and, at the clinical end, that rituals even involve a patient's recognition of his own irrationality. But this *self-reflection* or *autonoetic consciousness* (Tulving & Markowitsch 1998) involves a degree of *metacognition* which is not easily present in the cognitive system of 2 to 4 years old children.

The positing of such self-consciousness is even more problematic with regard to what is the most flourishing period of compulsive behavior in normal children, that is, age 2 to 4 years (see Evans et al. 1997). Evans and Gray (2000) have suggested that younger mental age groups (MA) (2–5 years) exhibit a greater number of ritualistic behaviors than do older ones. Yet, far from functioning maturely, some "basic ingredients" of self-reflection are barely emergent during the same age interval: ingredients such as, self-concept (Howe & Courage 1993; Povinelli et al. 1996), understanding mental representations (Perner & Ruffman 1995), and episodic thinking about the personal past (Nelson 1993; Welch-Ross 1995) and future (Atance & O'Neill 2005). Therefore, it might be worthwhile to further explore the very construct of ritualization as proposed by B&L, in relation to early childhood compulsive behaviors.

In exploring the early beginnings of ritual behaviors, a closer look at child development suggests a possible link with knowledge structures, for example, scripts and narratives, rather than with fear management.

Script theory (Schank & Abelson 1977) assumes that people have generic knowledge structures that reflect an understanding of the temporal and causal sequences of actions. For early

childhood, scripts are considered basic building blocks of cognition (Nelson 1986, 1996). Children easily establish these forms of knowledge representation when encountering repeated events (Bauer & Mandler 1990). Already at ages 1 to 2 years, children can retain and reproduce causal, temporal, and goal-directed structures of events (Bauer et al. 1998). Scripts become increasingly abstract or schematized with experience (Fivush & Slackman 1986). However, Farrar and Goodman (1992) indicate that younger children (aged 4 versus 7) are more schema-dependent when encoding an event.

Higher prevalence of ritualistic behavior, synchronized with the prevalence of script knowledge structures, may signal a child's need for cognitive mastery of the environment (see also Piaget 1952). Computational economy, rather than the notion of reaction to inferred threats to fitness, could better explain such a rich cognitive and behavioral canonical repertoire.

Shifting now to child psychopathology, one particular case unexplored by the target article is that of autistic spectrum disorders. Here again, rituals, as cornerstone psychopathological features, are performed without any clear connection to threat avoidance. "Need for sameness," restrictive interests, and repetitive behaviors are classical autistic symptoms (Kanner 1943). But autistic rituals are performed out of the realm of consciousness. And more basic brain mechanisms involved in change detection seem to function atypically in this case: people with autism have some difficulty in involuntary attention switching when processing unexpected infrequent stimuli (Gomot et al. 2006). Behavioral, ritualistic "avoidance of change" would then be a secondary dysfunction, an adaptive behavior aimed at keeping the environment as predictable as required by such an atypical neural/cognitive system.

The ethnological approach distinguishes coercion within tradition from compulsion within individual threat-responding ritual behavior.

In order to locate the segment of tradition we are addressing, we need to temporarily set aside the questions of origins of orally transmitted cultural facts. These are hardly reducible – in both shape and content – to sharply and easily recognizable items such as rituals, customs, and narratives. Therefore, we may safely hypothesize that their incidence at a given moment in time, for a certain community, represents far more than the sole transmission from a previous segment of time, subdued to rigidity within tradition; a snare of relations that makes both ceremonials (individually or collectively performed) and narratives (individually and collectively produced) be strongly a matter of active creativity, just as they continue to be a matter of "adherence to script" (see target article, sect. 2.5). Field results we were able to collect from within what we call Romanian folkloric culture of today, vividly show a continuum among folkloric genres of enacted tradition-transmitted knowledge (Benga 2005): to quote but one example, the complex choreutic therapy performed by the ritual dance of *Căluş* is explicitly linked to abundant local narrated mythology about the specific trance-like disease called *luatul din iele*, and about the mythic culprits – a category of fairies. Yet, new forms of coercion have lately replaced the old motivations, in the form of competition for stage virtuosity on the occasion of socialist-time flavored festivals. The ethnologist is himself compelled to treat these with just as much seriousness as he does treat the confessions of old peasants – because what he witnesses today is precisely one of several forms of survival of the old ceremonial/ritual dancing: in other words, a genuine form of cultural transmission.

This is why we favor, as much more fertile, the concept of "salient memories" in analyzing the transmission of tradition (Boyer 1990, pp. 8–20), over the somehow restrictive, although method fueling, framework that delineates religious behavior in cognitive terms (Boyer 1993, pp. 4–18; cf. target article, sects. 8.2, 8.3). For, whatever learning process our brains might be prepared for, that fact alone shall not provide a religion to the bearer (Boyer 2001a, p. 13) – which brings us nicely back to the subtle relation between the "what" and the "how" of transmission, be it, successively, more orally, or more ritually, salient.

Ritualized behavior in animals and humans: Time, space, and attention

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Abstract: A study of the organization of obsessive-compulsive disorder (OCD) rituals in time and space illuminates a postulated mechanism on shifting focus in action parsing, from mid-ranged actions to finer movements (gestures). Performance of OCD rituals also involves high concentration rather than the automated, less attended performance of rituals in normal and stereotyped behaviors in animals and humans.

The target article suggests that two systems may account for the occurrence of ritualized behavior. One system is of "inferred threats to fitness," the second is of "action-parsing." Manifestation of movement parsing is overt and the actions that comprise rituals are visible and measurable by virtue of animal behavior studies that have scrutinized ritualized behavior, developing conceptual frameworks and analytic tools that are also applicable in studying ritualized behavior in patients with obsessive-compulsive disorder (OCD). Indeed, recent utilization of such an approach in studying OCD rituals (Eilam et al. 2006) revealed facets that coincide with the question raised by Boyer & Lienard (B&L). Specifically, the outstanding question is not only as posed in the target article, "*why* ritualized behavior," but also *where* and *how* does ritualistic behavior occur. "Where" refers to the typical coupling between rituals and specific locations or objects; "how" refers to the high concentration involved in compulsive performance.

In the target article, action parsing is described at three levels that correspond to those offered by Zacks and colleagues (Zacks & Tversky 2001; Zacks et al. 2001b) as: (1) simple gestures; (2) behavioral episodes; and (3) script. B&L hypothesize 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, this is precisely what was revealed when tools derived from studying the quinpirole-treated rat model of OCD (Ben-Pazi et al. 2001; Szechtman et al. 1998) were applied in studying rituals in OCD patients (Eilam et al. 2006). Parsing categories became obvious when described in the context of the location or object at which they were performed, especially since OCD rituals carry a remarkable spatial component with a strong affinity between compulsion and specific location or object (Eilam et al. 2006). 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 can then be scored by notating the movements at each location/object. This is illustrated in Table 1, describing the OCD ritual of car-locking.

First, the patient's ritual was divided into two distinct domains in which it was executed: acts performed inside the car (Table 1), and those performed outside the car (not shown here). Then, the locations at which the patient displayed acts were identified as the ignition key, light switch, and so on (top rows in Table 1). Finally, the set of acts in each of these locations was scored in terms of a verbal description of the acts. The resulting description shown in the table provides the sequence of acts, highlighting the repetitive performance in the OCD patient compared with a control individual who was asked to execute the same action (bottom of Table 1). The entire sequence of the control individual took 11 seconds, compared with 63 seconds taken by the OCD patient. The excessive duration of the OCD ritual was thus generated by the repetitive manner of the compulsive

Table 1. *Car-locking ritual in OCD patient (A) and control individual (B)*

LOCATION/OBJECT				
Ignition key	Light switch	Steering wheel	Gear stick	Other actions
A. Ocd Patient				
Switch engine off				
Take out the key	{Switch on and off} × 3			
Insert the key				
Switch on and off		Hold it	Lock it	
			{Move it forth and back} × 4	
			Press it down	
			{Move it forth and back} × 2	
		Rotate left	Press it down	
			{Move it forth and back} × 2	Collect handbag
		Rotate right		
Switch on and off				
Take out the key		Rotate right		
		Rotate left		
	Switch on and off		Move it forth and back	
			Press it down	Get out of the car
Total acts:				
6	*4*	*5*	*13*	*2*
B. Control Individual				
Switch engine off				
Take out the key			Lock it	Get out of the car
Total acts:				
2	*0*	*0*	*1*	*1*

ritual, which becomes apparent when the number of acts (=gestures) is summed for each location, resulting in 30 acts $(6 + 4 + 5 + 13 + 2)$ for the OCD patient, compared with four acts $(2 + 0 + 0 + 1 + 1)$ for the control individual who performed the same task of car-locking (=script). Moreover, a comparison of acts (gestures) at the various locations (episodes) in 14 OCD rituals revealed that there were 1–3 locations at which acts were repeated significantly more than any of the control movements, resulting in the repetitive manner of OCD rituals (= many repetitions of the same few movements). Thus, as suggested in the target article, OCD rituals consist of excessive focus on simple gestures (movements). Our current data (Eilam et al. 2006) add to this a spatiotemporal component: gestures are coupled with specific locations, and gesture repetition accounts for the extended ritual duration.

A central contention of the target article relates to the high concentration involved in displaying ritualized behavior. Indeed, the vigor, precision, and high concentration of OCD patients when displaying their rituals is striking to a bystander. B&L suggest that a swamp of working memory and an urge for precise performance account for the high concentration, resulting in the ironic outcome of higher anxiety in patients with more rituals. Our study adds to this the finding that high concentration is the discriminator of compulsive rituals from other rituals in animal and human behavior (Serruya & Eilam 1996). Repetitive, stereotyped, or well-practiced performance in animals and humans has been suggested as a mechanism for minimizing the involvement of information-processing systems that are required for motor performance, enabling the direction of attention elsewhere (Fentress 1976). For example, when driving along an unfamiliar road we are required to concentrate more compared with driving along a familiar road, where we are more relaxed and may direct attention elsewhere. In animals, familiar paths enable directing attention to other aspects of the environment, such as the presence of potential predators (Serruya & Eilam 1996). Thus, unlike compulsive rituals, other rituals involve lowered attention.

Nonetheless, the link between attention and performing rituals is bidirectional and rituals may be constructed in order to concentrate and avoid goal-demotion, as, for example, the intensive religious rituals that enhance concentration during rigorous prayer, or sportsmen rituals that facilitate concentration in performance and disassociation from spectators. In all, although some of B&L's contentions, such as the "threat to fitness" may remain hypothetical in being hard to assess or quantify, the data collected during our observations on OCD patients strongly support several of B&L's measurable hypotheses.

Contextual features of problem-solving and social learning give rise to spurious associations, the raw materials for the evolution of rituals

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Abstract: If rituals persist in part because of their memory-taxing attributes, from whence do they arise? I suggest that magical practices form the core of rituals, and that many such practices derive from learned pseudo-causal associations. Spurious associations are likely to be acquired during problem-solving under conditions of ambiguity and danger, and are often a consequence of imitative social learning.

Boyer & Lienard's (B&L's) model describes the underpinnings of a Sperberian attractor (Sperber 1996, Ch. 5) in the cultural

evolution of rituals: the model generates the prediction that practices that produce the appropriate load on working memory are more likely to be maintained and spread, as they have an addictive component to them, temporarily ameliorating, but ultimately exacerbating, panhuman concerns. While this usefully explains why many rituals share core features, it does not address how rituals arise. To complement the authors' model, I therefore summarize here (with no claim to originality) some possibilities in regard to the latter, based on the premise that magical practices lie at the root of rituals, and spurious associations lie at the root of magical practices.

The relationship between actions and consequences is often difficult to discern. Consequences may be delayed, making the effects of actions unclear, or actions may be efficacious only in the presence of an undetectable mediator, such as microbes, that is sometimes absent. Ambiguity regarding the relationship between actions and consequences opens the door to learning spurious associations – people will often erroneously conclude that a given action produces a given consequence (cf. Bruner & Revusky 1961). This is particularly likely when no readily discernable avenues for influencing events exist – when the solution to a problem is not obvious, people will expand the scope of prior actions with which they compare a given outcome (cf. Gmelch 1978). Furthermore, both the acquisition of spurious associations and their stability over time will be enhanced when the goal involves avoiding substantial harm, as this simultaneously increases the benefits of searching for possibly efficacious actions and the costs of systematically putting such actions to the test.

Readers will recognize here elements of Malinowski's (1948) "theory of the gap"; paralleling aspects of B&L's model, Malinowski argued that magic arises as an attempt to assuage anxiety in situations of uncertainty and danger. Disaggregating the uncertainty of a situation and the anxiety generated by a situation, Felson and Gmelch (1979) found that both uncertainty and anxiety increase the use of magic, and that these effects are independent; that is, the anxiety attending a situation is a product of the stakes at issue, not of uncertainty. These findings are consistent with the factors postulated above – uncertainty is equivalent to ambiguity as to the most effective course of action, while anxiety reflects the goal of avoiding substantial harm. Note, however, that whereas Malinowski, like B&L, focuses on the anxiety-reducing function of the performance of magical rituals, I seek to highlight the contextual determinants of the acquisition of spurious associations – although the performance of magical rituals may indeed serve intrapsychic goals, uncertainty and danger lead to problem-solving strategies likely to generate spurious associations regardless of their affective consequences.

B&L stress that, to properly tax memory, rituals must involve multiple components, to be carried out with precision. Although spurious associations can be simple (e.g., a lucky rabbit's foot), such associations will often achieve the complexity demanded by B&L's model. All actions are potentially multiplex, as even simple motions can be broken down into many constituent movements. Because the causal contribution of any given facet of a multiplex action (a) is difficult to discern, and (b) can only be determined by process-of-elimination experimentation that is frequently avoided due to cost, actors will often attempt to reproduce an apparently efficacious action in its entirety. In turn, attempts to maintain complete fidelity in subsequent iterations lead to memory-taxing recipes of minutely specified behavior.

Spurious associations will often be produced by social learning. Imitating successful individuals can be an effective problem-solving strategy. Whenever it is difficult to identify which aspects of a successful individual's behavior led to her success, learners benefit from maximal fidelity of imitation, with the result that many irrelevant behaviors are incorporated into the action sequence (Richerson & Boyd 2004). The situation is complicated by the fact that, in the absence of explicit pedagogy (something frequently missing in small-scale societies; Fiske, n.d.), even if the target of imitation understands which actions are actually efficacious, this distinction is easily lost during the process of imitation. Hence, the version of the action practiced by the learner will often become more complex than that practiced by the target. Iterated over multiple generations, the number of spurious associations incorporated into an action sequence can grow large. As the behavior becomes more complex, it necessarily also becomes harder to learn, whereupon mastery of the behavior can become an index of the intimacy of the learner's relationship with the prestigious target (see Henrich & Gil-White 2001). Because similarity to the target then generates prestige-by-proxy, a new goal – prestige acquisition – is introduced; because this goal is independent of the original pragmatic objective, its introduction further decreases the likelihood that spurious associations will be ferreted out and discarded.

The authors note that both completeness and sequentiality are heavily emphasized in ritual behavior. Both are also often features of complex behaviors that are efficacious, hence actors may adopt a quasi-ritualistic approach as a practical strategy – many rock climbers, for example, always follow the same sequence in donning their equipment. Observation suggests that such actions often become imbued with some of the psychology of rituals, as faithful reiteration of the specified actions leads to a reduction in anxiety, whereas interruptions or modifications enhance anxiety (cf. Gmelch 1978). This likely augments the concretization of a particular form of behavior – although equally effective alternative methods may exist, their negative affective entailments preclude their utilization. Although such behavior constitutes only a nascent ritual (since the actions are goal-directed and effective), when combined with social learning, this kernel may become increasingly ritual-like.

Pragmatic features of problem-solving and social learning thus make it likely that individuals will often acquire spurious associations. This result is particularly likely among persons having low evidential criteria (Brugger & Graves 1997) (probably including most children), making some individuals more vulnerable to the acquisition of spurious associations than others. Associations that are sufficiently complex and sequential as to overload working memory constitute the raw materials out of which rituals are born; these, in turn, are refined by cultural evolution.

The rituals of explanation

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Abstract: Boyer & Lienard's (B&L's) explanation of ritualized behavior is plausible because it fits so well with elementary facts about evolution of plasticity in our behavioral repertoire. Its scope, however, may be broader than its authors explicitly admit. Science itself may be illuminated as ritual behavior. Science, like other rituals, can sustain both healthy and pathological forms.

One ritual of scientific explanation is to begin with a grand theory that later is qualified (sometimes to within an inch of its life) to yield a modest proposal. As Boyer & Lienard's (B&L's) title announces, they propose to explain "Ritualized Behavior" – and this is very exciting, Newtonian, one might say, in its scope. Just as Newton's physics explained terrestrial and celestial motions in one theory, so B&L propose to explain the full spectrum of ritual, from non-pathological forms like religion to unhealthy forms like obsessive-compulsive disorder (OCD). This heady promise propels readers through the article, where we observe the

ritual death by a thousand cuts of the grand theory. It can only come as a disappointment to discover B&L saying, "*Ritualized actions are not 'rituals'*" and "*Cultural ritual is not individual ritual writ large*" (sect. 8.6; B&L's italics): this is no doubt true, but what, then, are we to make of their earlier explanation of religious rituals and cultural ceremonies? And when they urge us to "discard the common intuition that there is a natural kind of phenomenon called 'rituals'" (sect. 9.3), we might wonder what it is, then, that they take themselves to be explaining. B&L's answer is that theirs is merely a modest proposal to explain only the *urge* (sect. 8.2, para. 2) of individuals towards ritual, not its social organization.

This is in no way to say that this is a bad theory. In fact, I think it is a very good theory, one that illuminates ritual in an interesting way: OCD is a behavioral analogue of an auto-immune disease, a quite useful protective mechanism that has gone awry; religion is a harmless, if idle, capture of the same precautionary mechanism during its "calibration" (or recalibration). What this good science leaves out is itself – or so I will argue. Science, too, is, (at least in part) a ritual.

The plausibility of B&L's theory derives not so much from successful tests of it as from elementary facts about evolution. For example, complex multi-cellular organisms evolved from relatively simple single-celled organisms. The behavior of the simplest organisms is ritualized in the sense defined by B&L (see target article, Abstract): a single cell, for instance, has receptors on its surface which swing into action automatically, transferring materials into the cell stereotypically, rigidly, repetitively, and mechanically (without rational motivation). By contrast, the food-seeking, predator-avoiding, competitor-besting behavior of complex organisms is creative, plastic, original, and rational. The evolutionary strategy of *Homo sapiens* has been to free behavior from totalitarian genetic control so that individuals can adapt within their own lifetimes to the conditions that obtain, rather than waiting for the creeping, tectonically slow, genetic adaptation of behavior. Intelligence and learning permit a more rapid form of natural selection, namely selection for adapt*ability* of behavioral repertoire.

So, what really demands explanation is how human behavior overcame ritualization, rather than how it remains in some ways ritualized. And yet, despite the fact that that their explanatory goal goes in precisely the opposite direction, it is B&L's presuppositions about the process of overcoming ritual that makes their explanation of ritualized behavior plausible. History teaches us that it is the unexpected explanatory dividends of a theory that convince us it is true, not the specific phenomenon it was cooked up to explain in the first place. This is the case with B&L's model. It assumes that our ancestors' Precaution System was a healthy evolutionary product with two components, a Potential Hazard Repertoire (sensory mechanisms that enabled the recognition of specific hazards) and an Evolutionary Precaution Repertoire (motor mechanisms that enabled defensive behavior). Though some of the resulting mechanisms are genetically hardwired (like more primitive creatures we automatically scratch what itches and spit out what tastes foul), some also permit "calibration" (sect. 7.4) or learning. Rituals arise during this learning process, specifically when the hazard repertoire is queued by an implicit hazard (one not consciously recognized as a hazard) even when the precaution repertoire contains nothing to adequately deal with it. This B&L denote, cleverly and plausibly, as an instance of *capture*. Capture is the Achilles' heel of our Precaution System. Because "any system of this kind is vulnerable to *capture*" (sect. 8.3), we hardly need be surprised by the ubiquity of religion or by the existence of OCD. Thus, the explanatory dividends begin to roll in.

Indeed, I would argue that the scope of this explanation is even broader than B&L claim. Given that learned responses to implicit hazards are included, science itself (or at least the scientific urge) is explained. Scientific method is our ritualized response to the implicit hazard of ignorance.

In religion there is at least the possibility that ritualized behavior may silence the queuing mechanism: through a religious ritual one might, for instance, expiate one's guilt before God (implicit hazard). But implicit hazards, being not consciously present (by definition?), may persist despite the ritual. The implicit queuing of the OCD sufferer's uncleanliness detection system might persist despite hand washing – permitting temporary relief only when attending to the washing itself (goal demotion, sects. 6.2–6.4): a formula for obsession if ever there was one, and a lovely explanation of OCD. Bravo! But note well that nothing prevents such pathology in religion: adherents who cannot shake off the implicit hazard of guilt may tirelessly repeat religious rituals to get momentary relief.

Running through B&L's account is an implicit (even unconscious?) distinction between the pathological and the healthy. Is it because the explanation of religious ritual as pathology is so implicitly hazardous that B&L ritually back away, protesting that there is more to cultural ritual than ritual behavior "writ large"? They point out that religion involves social organization – but isn't that an accidental difference? How hard is it to imagine an OCD religion based on the ideal of cleanliness and prescribing obsessive rituals to fend off the relentless uncleanliness of this world?

Darwin, too, hesitated to offend religious sensibilities. No wonder B&L don't even mention a more dangerous idea: science, too, is a ritual. Note well that it is at least capable of sustaining pathology – we needn't mention the arms race or eugenics to see that this is so. Scientific ritual may also be healthy, just as the normal ritual of washing before meals is healthy, only science defends us not from uncleanliness, but from ignorance – and this is a very good thing.

Multicultural religious and spiritual rituals: Meaning and praxis

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Abstract: This commentary argues against the theory that cultural ritual behavior is meaningless or that ritual action is solely a by-product of fear-based precautionary and action-parsing systems. Humans demonstrate the ability to spontaneously change their use of proximate intentions and attribute ultimate intentions to ritual actions that are not dependent upon fear or physical and emotional/mental dysfunction.

Boyer & Lienard (B&L) theorize that ritual is not rationally based, and is an attempt to attain relief from anxiety-based cognitive intrusions. They base their theory on a premise, stemming from obsessive pathology etiology, security motivation theories, and neuro-cognitive adaptive functions, that ritualized actions emerged from an evolutionary fear-based system that acts to protect the human from inferred threats to fitness. They propose that ritual actions are a by-product of precaution and action-parsing systems.

The authors' stance is reminiscent of Freud's widely accepted idea (Strachey 1976) that adherence to a Western religious practice is a neurotic excursion as "wishing thinking," in that individuals feel the need: for protection from untamed nature, to reconcile with the privations of social life, and to fulfill longing for the lost father figure. Philosophically, these assumptions surface from the earlier biomedical and current psychobiomedical model in which the "interiors of the human" (e.g., perception, beliefs) are now recognized as having at least a semi-causal role in health. However, neither model allows for the possibility of Cartesian duality, which has been rejected by Western science for some time. Nonetheless, duality is central to most religious and/or spiritual rituals.

This raises an ethical issue regarding the arbitrary imposition of Western ideology upon non-Western belief systems and practice, in addition to the likely misunderstanding of the non-Western religious and/or spiritual practice. This imposition also restricts a delineation of the meaning and teleology of the rituals employed. Thus, the understanding of ritual becomes constrained by the attempt to reduce ritual to neurological events originating from a built-in "self-protection" system. It severely limits a comprehension of multicultural rituals that typically involve varied aspects of duality.

Understandably, the neurological mechanisms that allow for ritual behaviors are very important in the clarification of a body-mind interaction, and the potential for the human to self-heal among other benefits. However, the fact that the neurological mechanisms may exist does not explain *why* they emerged, or their role in how individuals perceive awe or agency, whether or not during ritual. In fact, it is reasonable to argue that ritual behavior could not occur if the neurological mechanisms were absent.

The assumption that ritual stems from a fear-based multifunctional neurological system is limiting. It is more plausible to argue that both fear and pleasure (e.g., joy, awe) are likely motivators in the occurrence of ritual. Although it is important to understand ritual independent of esoteric foundations, the understanding of specific ritual teleology that incorporates some concept of duality is equally important in the delineation of a body-mind-spirit (e.g., agency) interaction, especially when both ritual practice and beliefs are involved in examining health outcomes (Hageman 2002, 2005).

In support of the idea that ritual reduces anxiety, ritual is frequently employed when physical and emotional/mental health issues impact self-identity, the relationship to others, and the relationship to the transcendent (May 1991, p. 9–12). In ritual and ritual-like activities, *liminal* experiences engage the sympathetic and parasympathetic subsystems that alternatively arouse or quiet subcortical neural processing and hormonal involvement (Hogue 2006, p. 231), which may result in emotional engagement as well.

As an alternative to an "inferred threat-based" theory, it may be argued that neural mechanisms provide a "container" in which emotional memories can be encoded, retrieved, rehearsed, and re-encoded for spiritual formation and transformation (Hogue 2006, p. 231). D'Aquili and Newberg (1999, p. 112–16) provide support to this idea in that neural changes produce a self-reported lack of self-boundaries in the brains of experienced meditators. R. J. Davidson and colleagues (J. M. Davidson 1976; R. J. Davidson 2000, 2004; Davidson et al. 2003) offer support by showing that brain neuroplasicity and affective style may be significantly affected by meditation. All of these supportive arguments suggest that individual or group ritual and religious experiences, such as mystical states (D'Aquili & Newberg 1993), may result in similar experiences. Moreover, gesture, movement, posture, and state of arousal have a "bottom-up" effect on participants' experiences in which movement and gesture make use of the somatic subcortical experiences that deepen the experience of self (Hogue 2006, p. 237). However, affect or awe is not always fear-based.

Although ritual lacks a precise definition (Bell 1997, pp. xi, 253), ritual activities do have meaning and contribute to the continuity and the transformation of the personal and of communities (Hogue 2006, p. 230). It appears that less frequently performed rituals may require higher levels of pageantry in order to encode the details and significance of specific rituals. Participation in ritual strengthens their reliability, whereas the narrative construction of specific rituals unfolding over repeated instances serves to establish the extent of a ritual's meaningful impact. Others have suggested that the impact of specific rituals is largely determined by the initial heightened alertness during the ritual and the subsequent on-going vindication of the experience (e.g., cognitive alarm hypothesis proposed by McCauley & Lawson 2002, p. 78).

It is quite apparent that humans have the ability to spontaneously change their use of proximate intentions and attribute ultimate intentions to ritual actions that are not dependent upon physical or emotional/mental dysfunction. Rituals appear to act with intention to organize and orient individuals to act on the lived-in world (Handelman 1998; Sørensen 2005). In this regard, social factors may explain the form and content of ritual action. Evolutionary or neurological theories (e.g., precaution systems, mirror neurons) may explain how emotion and specific actions interplay in dysfunctional repetitive behavior, or in experiencing benefits while observing or participating in ritual. Cognitive theories may elucidate the concept of agency in religious ritual. These theories only partially demarcate why ritual emerged, and why it is a consistent phenomenon in normal human behavior.

In conclusion, a theory of ritual, as noted by Gerholm (1988, p. 197), should explain the effects of ritual, how ritual works in its own terms in ways that may not be recognized by indigenous theory (i.e., the embedded deeper beliefs of a particular culture's traditional practice of "being-in-the-world" that is defined during a specific time of the culture's history, which includes the esoteric explanations for how the ritual works), and illuminate the production of ritual effects in unknown and unanticipated ways. A theory of ritual behavior predicated upon the assumption that rituals lack meaning (e.g., Staal 1979) and a neurological explanation of inferred threat does not fully explicate normal ritual behavior.

What is the relevance of Boyer & Lienard's model for psychosocial treatments?

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Abstract: Boyer & Lienard's (B&L's) model of obsessive-compulsive disorder (OCD) rituals does not completely conform to our clinical experience with patients, and the clinical implications of their model is not described by the authors. We discuss potential differences of opinion regarding both the nature of OCD and the mechanisms involved in the maintenance of symptoms, and how emotional processing theories can account for treatment effects.

The authors present an interesting attempt to account for ritualized behaviors across a series of domains, including obsessive-compulsive disorder (OCD), from evolutionary, neurophysiological, cognitive, and anthropological perspectives. We are clinical researchers and experimental psychopathologists who focus on the nature and treatment of anxiety disorders including OCD. This viewpoint is one of the most underdeveloped features of the model presented by Boyer & Lienard (B&L), evidenced by the devotion of a single sentence to the issue of treatment (sect. 7.3). In their attempt to understand repetitive behaviors as disparate as children's ritualized actions, cultural rituals, and OCD, the authors contend that certain aspects of all rituals are similar enough to merit a common explanation. By contrast, as diagnosticians, clinicians, and psychopathologists our goal is to understand these behaviors in order to help patients eliminate them and improve functioning and quality of life. Specifically, we are interested in the question, "How do compulsions *differ* from apparently similar behaviors?" One of the basic distinctions between OCD rituals and cultural rituals are in the functions served by the behaviors, and therefore in the goals one has in affecting them. Compulsions are triggered by obsessions, maintain anxiety, and need to be reduced in order to improve quality of life. Cultural rituals, by contrast, are often

adaptive behaviors promoted within society, assisting communal coherence.

Overall, there are some issues raised by B&L that do not reflect our knowledge of OCD. In fact, the psychosocial treatment of choice for OCD includes exposure and response prevention, which was derived from cognitive and behavioral theories that do not describe the necessary features of B&L's model (Franklin & Foa 2002).

Many of our differences of opinion lie in their characterization of the features of OCD. Although many fears (OCD obsessions being no exception) have a level of preparedness (Seligman 1971), it seems that the OCD can take on modern concepts as well as capturing evolutionarily based threats. For example, fears of sin and damnation, as well as rituals such as checking stoves, light switches, appliances are common issues in OCD (Foa et al. 1995). In addition, the concept of *inferred* danger characterizes most anxiety disorders, whereas rituals are more exclusive to OCD. Thus, it is not clear from the model why individuals with other anxiety disorders do not typically engage in rituals. Furthermore, other cognitive characteristics, such as thought-action fusion and hyper-responsibility, may be more unique to OCD (Rachman 1993) than other anxiety disorders, but the model does not clearly account for such important features.

Rituals are not always conducted in a repeated, systematically rigid fashion. While caricatures of patients with OCD portray individuals engaging in explicit, repeated behaviors, the clinical picture is much more complex. Individuals with OCD often have varied responses to adapt to a situation. Thus, individuals who typically use tissues as a barrier to avoid contamination when opening doors may instead allow others to open the door or use a sleeve as a barrier when a tissue is not available. Alternatively, they may seek reassurance from others, mentally review reasons why they are not contaminated, or decide to delay their ritual while taking measures to limit further spread of the contaminant along with keeping track of which body parts or personal items will later need to be cleaned. Patients can be extremely creative in working to obtain relief from anxiety through subtle reassurance seeking or other means. Our clinical experience is that patients with OCD are in fact quite flexible with their utilization of rituals, and elimination of all of the potential responses is a key to treatment.

The idea that rituals necessitate action parsing, goal demotion, and swamping of working memory also does not reflect our clinical experience. Contrary to B&L's suggestion, patients are often unaware of some of their rituals precisely because they have become so habitual. Ritual monitoring is the first stage of treatment, and many patients state that the process of recording their rituals makes them more aware of the rituals in which they are engaged. For example, a recent patient whose rituals involved repeatedly saying "I am sorry" reported being quite surprised by the high frequency with which she was offering unnecessary apologies. Patients also frequently report engaging in rituals prior to being aware that they are doing them. Furthermore, many OCD patients appear to be quite clear about their goals and do not lose sight of those goals as they begin to ritualize. Indeed, they frequently view their rituals as direct attempts to achieve their goals. Even when action parsing occurs, the ultimate goal of removing danger usually remains very much at the forefront of their thoughts.

We contend that overt rituals are best understood as a part of a larger class of avoidance behaviors seen in OCD, along with mental rituals, overt avoidance, and other emotion regulation strategies such as thought suppression. All of these behaviors and mental manipulations promote immediate relief of anxiety but serve to maintain fear and obsessions over the long run (Franklin & Foa 2002). The psychosocial treatment of choice for OCD is the combination of exposure situations and thoughts that elicit obsession-related anxiety and response prevention of the various avoidance behaviors, both of which are important components to treatment (cf. Foa et al. 1980). However, B&L omit the importance of exposure for treatment, and the mechanisms through which exposure is thought to work (Foa et al. 2006). Our view is that OCD, and other anxiety disorders, reflect the operation of a fear network which consists of pathological associations between neutral stimuli and representations of danger along with physiological, cognitive, and behavioral responses associated with fear (e.g., avoidance behaviors). Psychological treatment requires activation of the fear network and exposure to disconfirming information. In vivo exposure and imaginal exposure activate the fear network and the nonoccurrence of feared consequences provides the disconfirming information. Rituals serve to reduce that activation through the inaccurate belief that the danger has been removed or eliminated, thereby maintaining anxiety. For example, a patient touching a doorknob without washing leads to learning that they did not get a disease and that relief occurred without ritualizing. The model offered by B&L seems to miss the importance of obsessions and the functional nature of compulsions in describing OCD. Consideration of the rich database on the psychological treatment of OCD serves to inform and constrain theories of OCD.

Ritualized behavior in sport

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Abstract: We consider evidence for ritualized behavior in the sporting domain, noting that such behavior appears commonplace both before a competitive encounter and as part of pre-performance routines. The specific times when ritualized behaviors are displayed support the supposition that they provide temporary relief from pre-competition anxiety and act as thought suppressors in the moments preceding skill execution.

One domain in which a colorful raft of ritualized behaviors can be seen is sport. Superstitious behaviors are extremely common (Neil 1982) and many can be characterized as stereotyped, rigid, repetitive rituals, lacking in rational motivation. Performers may feel compelled to "gear up" in a particular order, to tie and retie their bootlaces, or to perform the same pattern of behavior each time they run onto the field of play.

Boyer & Lienard (B&L) explicitly contrast ritualized behavior with commonsense notions of rituals as actions that are performed routinely or without thinking. Ritualized behaviors are "recognizable by their stereotypy, rigidity, repetition, and apparent lack of rational motivation" (target article, sect. 1, para. 1), whereas routine actions are performed without thinking but with motivation. A defining feature of ritualized acts is that they do not seem to become automatic and remain subject to high-level cognitive control. B&L further note that ritualized acts in obsessive-compulsive disorder may swamp working memory and appear to result in a temporary reprieve from what may be extremely debilitating state anxiety.

In sport, the outcome of a competitive event – and with it the achievement of a status for which the performer will typically have invested many years and many thousands of hours of practice – often comes down to executing a skill successfully at a given moment. The resulting pressure leads many performers to "choke," or perform well below the level of which they are capable. There is considerable evidence that skill failure results from performers focusing on low-level units of behavior and, in particular, from attempting to exert conscious control over actions that normally "run off" automatically. Much evidence for this conscious processing hypothesis (Liao & Masters 2002; Masters 1992; Maxwell et al. 2003) has emanated from skills in

which the performer has time to think prior to executing the skill (e.g., golf putting), but there is also evidence from reactive skills, such as baseball batting (Gray 2004). It may even be the case that conscious processing of one's movements, described by Masters et al. (1993) as "reinvestment," is potentially a mode of ritualistic intrusive thought that, hypothetically, may eventually mutate to become obsessive compulsive. Golfers with type II "yips," for example, are highly compulsive and analytical (Smith et al. 2003), and "what should be an automatic unified movement, becomes a complicated problem of consciously coordinating many separate movements" (Cochran & Stubbs 1968, p. 135).

One of the predictions generated by B&L's account is that ritualized behavior may be functional insofar as the temporary swamping of working memory prevents performers from "reinvesting" conscious control (Masters et al. 1993), as well as resulting in a temporary reduction in anxiety. Ritualized behaviors should be evident in abundance in the period immediately preceding a competitive encounter, as performers attempt to gain control of their emotions. They should also be present as "moderately efficient forms of *thought-suppression*" (target article, sect. 7.2, para. 2; emphasis in original) in the moments immediately before skill execution, particularly in self-paced skills. Consistent with these predictions, many performers do appear to engage in ritualistic behaviors before a competitive event (Neil 1982) and often include ritualistic elements in pre-performance routines (Foster et al. 2005).

There are also many examples of performers displaying ritualized behavior during breaks in competition. In tennis, Raphael Nadal takes great care to position and align his fluid replacement bottles at each change of ends, after drinking from both. Another top player, Justine Henin-Hardenne, reputedly avoids stepping on the lines on the court between points. While behavioral aspects of pre-performance routines, such as their timing, appear to be controlled at a sub-conscious level (Jackson 2003), performers often include conscious elements that may suppress conscious control processes. For example, Foster et al. (2005) showed, in a study of superstitious behavior in basketball free-throws, that some of the behaviors players felt compelled to perform included tapping their head three times before shooting, and touching their heels alternately before each throw.

As well as displaying the characteristics of compulsion and rigidity, other activities also appear consistent with the concept of goal demotion. A golfer clearly needs to grip the club correctly but when the player ritually re-grips the club a set number of times, the behavior becomes divorced from the observable goal. Indeed, this type of behavior sometimes appears similar to that of obsessive-compulsive "checkers." Golfers may be aware that re-gripping the club over and over is unnecessary but feel they have little control over their behavior. Similarly, while it would appear eminently sensible to look at the golf ball when preparing to putt, focusing intently on each letter of the manufacturer's name is not a necessity, though it may well be an effective way to suppress anxiety provoking or performance disruptive thoughts. Indeed, B&L suggest that patients may intuitively produce behaviors that reduce anxiety, and Neil (1982) has argued that superstitious behavior provides a means by which performers can cope with the stress of competition under pressure.

Although much of the evidence is anecdotal, there appear to be many examples of ritualized behavior in sport that are consistent with B&L's account. Sporting competition heightens anxiety, and skill failure often results from attempting to consciously control actions. Pre-competition ritualized behaviors may provide temporary relief from heightened anxiety while ritualized elements of pre-performance routines may help prevent the performer from "reinvesting" conscious control of the skill itself, a process that is implicated in "choking" or skill failure under pressure.

Spectrum of child psychiatric disorders and ritualized behavior: Where is the link?

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Abstract: There is a spectrum of child psychiatric and neurological disorders, in all of which a comorbidity with obsessive-compulsive disorder and ritualized behavior is very common. Therefore, they may appear as a basis for the rituals in children that cross into adolescence and adulthood. Resolving the nature of these disorders may help us to better understand "Why ritualized behavior?"

The model proposed by Boyer & Lienard (B&L) is essential in several respects. First, in that it takes into consideration an extended data base by engaging diverse domains of ritualization. Combining evidence from different fields of science, B&L suggest that a unitary "evolved Precaution System" is responsible for ritualized behavior, in particular in obsessive-compulsive disorder (OCD). Second, the authors' efforts to conceptualize and model the neural basis of ritualized behavior should be appreciated; their model can certainly enhance the understanding of this aspect of human behavior in both normal and pathological conditions.

What deserves particular attention from fundamental and clinical points of view, and may require further refinement, are the neural mechanisms responsible for the evolved Precaution System suggested by B&L. As emphasized by the authors, OCD is likely to underlie the pathophysiological mechanisms leading to deficits of that system in both children and adults. In this regard, it is of special interest that there is a spectrum of child psychiatric and neurological disorders such as attention deficit/hyperactivity disorder (ADHD), tic disorder (TD) and/or Tourette syndrome (TS), oppositional-defiant disorder (ODD), pervasive developmental disorder (PDD), nocturnal enuresis, learning disability, separation anxiety, and depression, in all of which co-morbidity with OCD is very common (Banaschewski et al. 2003; Becker et al. 2003; Biederman & Faraone 2005; Biederman et al. 1992; Geller 2006; Geller et al. 2004; Hounie et al. 2004; Leckman 2002; Leckman et al. 1997; Lewin et al. 2005; Masi et al. 2004; Nestadt et al. 2001; Peterson et al. 2001; Rothenberger & Banaschewski 2006; Rothenberger et al. 2000; Swanson et al. 1998; Yuen et al. 2005). Ritualized behavior is also frequently observed in girls with anorexia and abulia neurosa (Kaye et al. 2004; Sodersten & Bergh 2006; Yohanan et al. 2006).

Therefore, a broad continuum of child psychiatric disorders appears associated with rituals that may further cross into adolescence and adulthood. However, although still under research, the neurochemical and neurophysiological mechanisms of particular disorders are recognized to differ substantially. Various studies have provided converging evidence that the neuronal substrate underpinning ADHD is the dopamine deficit in the meso-limbic and meso-cortical circuits, with the norepinephrine system also being involved (Biederman & Faraone 2005; Castellanos & Tannock 2002; Sagvolden et al. 2005; Swanson et al. 1998). In contrast, tic disorder (TD, TS) is supposed to originate from an enhanced dopaminergic neurotransmission and a hypersensibility of dopamine receptors in the striatum (Leckman 2002; Leckman et al. 1997). Motor system excitability also differs in these two disorders (ADHD and TD). The application of transcranial magnetic stimulation has revealed a reduced intracortical inhibition in children with ADHD (Moll et al. 2000), whereas a deficient inhibition of sensorimotor cortico-subcortical circuits is found in children with TD (Zieman et al. 1997). In this line, although not definitely known, dissimilar pathophysiological mechanisms seem to be activated in ODD, PDD, nocturnal enuresis, learning disability, anorexia nervosa, and separation anxiety, all combined with ritualized behavior. In addition, a serotoninergic deficit has been shown

in depression (Charney et al. 1981; Levinson 2005; Walitza et al. 2002) and selective serotoninergic reuptake blockers are generally recommended for the therapy of OCD and ritualized behavior (Blier et al. 2006; Pediatric OCD Treatment Team, 2004).

Taken together, such results imply that the mechanisms of the ritualized behavior can be linked with or facilitated (or even triggered) by very different neural pathogenic sources, meaning that these mechanisms may be more complex than B&L suppose. Hence, there are two major open questions. First, what are the neuropathological mechanisms of the ritualized behavior that may be common in all these child psychiatric entities; and second, whether and to what extent a genetic polymorphism plays a role (Castellanos & Tannock 2002; Leckman 2002; Rothenberger & Banaschewski 2006).

B&L further propose that cognition plays a role in ritualized behavior. In this respect, it is very important to note that the role for sleep in learning and memory is generally recognized. Hence, it would be of great interest to discuss the possible role of sleep in ritualized behavior. It is generally accepted that stage 2 of non-rapid eye movement (non-REM) sleep is associated with declarative memory consolidation, whereas REM sleep is supposed to play a role in procedural memory (Gais et al. 2006; Hobson 2005; Stickgold 2005; Stickgold & Walker 2005). This issue raises at least two questions: (1) whether ritualized behavior occurs in relation to sleep, and, if so, (2) which sleep stage consolidates it. Consequently, sleep research in children, adolescents, and adults who have OCD and/or ritualized behavior merits attention.

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How far will an account of ritualized behavior go in explaining cultural rituals?

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Abstract: The theory of ritualized behavior should offer insight about cultural rituals. Considering ritualized behaviors' scripted actions and both the frequent absence of anxiety and the routinization of many cultural rituals, questions remain about how much and what precisely gets explained. Among religious rituals, ritualized behaviors arise more strikingly in special agent rituals, but that might be because they usually include novices.

The dogma that ritual will submit to a unified theoretical treatment has burdened cultural anthropology for decades. Attending to the psychological foundations of cultural rituals, Boyer & Lienard (B&L) join myself and Lawson (Lawson & McCauley 1990; McCauley & Lawson 2002) in questioning that presumption. B&L maintain that rituals do not constitute a natural kind but that individuals' "ritualized behaviors" are elements in many (individual and collective) cultural rituals, which other behaviors of individuals – including the rituals of obsessive-compulsives, of children, and of normal adults at pivotal points in their lives – exhibit as well. All such manifestations of ritualized behavior enlist dispositions of the human mind to (1) attend to potential hazards that were characteristic of ancestral environments, and (2) undertake associated precautions in response. B&L develop Boyer's (2001b) contention that cultural rituals persist because they exploit these mental dispositions. Successful cultural rituals approximate a sufficient number of cues associated with items in the "Potential Hazard Repertoire" well enough to activate, if not engage, the programs connected with corresponding items in the "Hazard-Precaution Repertoire." They "cognitively capture" domain specific processing principles that elicit a narrow range of comparatively regularized motor (and affective) outputs such as hand washing.

B&L grant that ritualized behaviors are "not the whole of [cultural] 'rituals'" (sect. 8.6, para. 2). They also reject the view that differences between cultural rituals and other points on the spectrum of ritualized behavior that they envision are simply ones of degree, as they spurn the Freudian notion that cultural rituals are a "scaled" up version of individuals' ritualized behaviors. Still, they hold that their proposal should explain (a) why cultural rituals are widespread and compelling, (b) why they so often incorporate particular themes, and (c) "why these common endeavors should include scripted, goal-demoted, redundant scripting of familiar actions" (sect. 9.1, para. 2). Questions remain, however, concerning just how much and what precisely about cultural rituals B&L's account of ritualized behavior explains. Following are some considerations that may pertain to sorting those questions out.

B&L argue that cultural rituals seem compelling to participants because they cognitively capture the machinery of the potential-hazard detection and precaution systems. At least sometimes, though, the compulsion to perform cultural rituals that play on these themes is tepid at best, and the prospect of facing the consequences of failing to perform them provokes little, if any, anxiety. The opening ceremonies of the Olympic Games, the lighting of the torch, the athletes' recitation of the Olympic oath, and the head-of-state's public declaration of the Games' beginning, no doubt create considerable excitement and inspiration; but few would feel much anxiety about the ensuing two weeks of competition if these events were rained out, or many athletes were too distracted with taking pictures of the events to take the oath, or the head-of-state's inebriation led to an unrecognizable declaration. Why, as B&L concede, is the compulsion accompanying cultural rituals, which co-opt the forms of ritualized behavior, often so thin, and how do they manage to dispel the anxiety that should result concerning the possibility of non-performance?

B&L discuss both logical and psychological aspects of goal-demotion in cultural rituals. Patterns of actions such as reversals and repetitions undermine those actions' instrumental coherence, whereas a focus on low level parsing of ritual actions results in participants' inattention to either sub-goals or overall goals (at least in the course of carrying out the actions in question). This occasions two comments. First, the duration of any inattention to goals differs considerably from one ritual and one context to the next. On B&L's theory, ritualized behavior includes comparatively rigid adherance to a *script*. For example, in the aforementioned item (c), they *twice* describe these actions in terms of scripts, and scripts are typically characterized in terms of *goals*. Among the non-literate mountain Ok of New Guinea (Barth 1987), the script and its goal – not just what people happen to remember – determine what matters enough to get included in the "remembered pattern."

Second, B&L contend that goal-demotion prevents ritualized behaviors from becoming automatic or routinized and insist that this feature is "essential" to their account of the role of ritualized behaviors in cultural rituals. Perhaps so, but that does not discredit the commonsense view that cultural rituals *often* involve mindless routine. Addressing this matter, B&L speak of cultural rituals as "ceremonies," which alternate between non-automatic ritualized behaviors and routinized, automatic actions. The proportion and prominence that B&L's ritualized behaviors enjoy, at least in religious rituals, can vary vastly. The frequency with which the Pomio Kivung repeat all of their rituals has guaranteed that those rituals have become thoroughly routinized even for the least involved participants (Whitehouse 1995). Participants find these familiar rituals so boring that they sometimes fall asleep during their performance. Even in religious ritual systems that include key rituals in which ritualized

behaviors have a more salient role, at least some priests, in contrast to ritual novices, give every evidence of proceeding through utterly familiar routines automatically. Ritualized behaviors seem to arise more strikingly, if not more regularly, in what Lawson and I (see McCauley & Lawson 2002) have dubbed "special agent rituals," that is, religious rituals in which agents with counter-intuitive properties (or their ritually designated representatives) do things to participants that bring about permanent changes in those participants' religious and ritual statuses.

The crucial point is that these are rituals that participants typically undergo *only once* in their lifetimes, so *all* of the patients of these rituals are novices. (The most obvious but by no means sole illustrations are the classic rites of passage.) Since these novices may be comparatively unfamiliar with these rites or the rites may simply be so elaborate, in many cases (e.g., bar mitzvahs) they go through preparations for these ceremonies that can readily result in actions that display the characteristic earmarks of ritualized behaviors including goal-demotion and swamped working memory. Moreover, the publicity of these rituals and the representations religious systems deploy seem to foreclose on any pathologies analogous to OCD. The gods seemed to have mastered the trick of allaying the concomitant anxieties, since what the gods do, they need do only once.

Ritual pathology and the nature of ritual culture

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Abstract: Boyer & Lienard's (B&L's) biological model of ritual achieves a rather straightforward account of features shared by ritual pathology and the idiosyncratic rituals of children; but complexities accrue in extending it to human ritual culture generally. My commentary suggests that the ritual cultural traditions of animals such as songbirds share structural features, handicap-based origin, as well as the enabling neural mechanism of vocal learning with human ritual culture.

Boyer & Lienard (B&L) draw a number of convincing parallels between the phenomenology of ritual pathology and the idiosyncratic rituals developed by young children without apparent pathology. The family resemblance between the two domains is a strong point of their perspective, and supports the reality of the hazard-precaution system they outline for us. But what of the delightful handclapping and similar rituals of children at play? These complex, scripted, stereotypic, repetitive, and interactive play rituals can be found in diverse cultures around the world, but go unmentioned by B&L (Opie & Opie [1960] provide a striking sample from England). The ambience of merriment and camaraderie that sustains play rituals lies far from the negative emotions on which B&L's model turns. Moreover, sequences in play rituals are not idiosyncratic but are shared by the local or regional playground culture – though they differ across regions and cultures. The actions these sequences involve need in no way echo precautionary measures (e.g., mutual touching of hands without a hint of "washing"); they are not usually invented by participants but are acquired by a learning process involving coaching by peers and deliberate practice in conformity with a local *prototype*, which, like other cultural traditions, shows continuity as well as change across generations; and they typically feature vocal activity in the form of chanting, rhyming, singing, or recitation. In all these respects the play rituals of children are perfect miniatures of the normal human cultural rituals which cause B&L so much difficulty in the concluding sections of their article.

The reason for the difficulties, I suggest, is that normal human cultural ritual has a source other than the one suggested by B&L. The key to its identification is the very "waste of time and resources" that makes it so tempting to assimilate cultural ritual to ritual pathology, but which in the light of modern behavioral biology hints at another source. The point of the elaborateness, conspicuousness, and persistent repetition (often with variations) of animal ritual displays (which may require lengthy learning and practice for proficiency, as in birdsong) is the very waste of resources such attributes entail. This makes them "costly" and qualifies them as fitness indicators on the simple principle that whoever can sustain such waste on a regular basis commands resources over and above those required for merely "getting by," and thus is worth taking seriously. Contrary to B&L (sect. 9.2), these signals are never *directly* related to the fitness dimension they advertise. They function as *proxies* or *substitutes* for direct tests of fitness according to the handicap principle (Zahavi & Zahavi 1997). The length to which such indirectness can go is demonstrated by the awkwardly named "nutritional stress hypothesis," according to which the size of a songbird's repertoire, via brain size in turn dependent on early parental care becomes an indicator of fitness reflected in reproductive success of the adult singer (see Hasselquist et al. 1996; Nowicki et al. 2002).

The handicap principle helps us understand the "goal-demotion" which features so prominently in B&L's account of ritual, but remains unexplained there. Genuine cultural traditions among nonhuman animals (Fragaszy & Perry 2003) come in two kinds: instrumental culture and ritual culture (Merker 2005). The behaviors transmitted by an instrumental tradition pay their way by being usefully arranged to accomplish an invariant practical outcome (food washing, termite extraction, and nettle stripping traditions are primate examples). Context-attuned performance flexibility is the hallmark of instrumental behavior, whereas literal duplication of the actual details performed by an observational model is likely to impede rather than promote instrumental success.

Literal duplication, however, lies at the very heart of ritual. The need to *remember* and *reproduce* essentially arbitrary details on an obligatory basis burdens behavior with a handicap, and the ability to sustain that burden is proof of capacity, and hence tends to *impress*. Formally, ritual is identifiable by the fact that a hypothetical pattern substitution – such as a sequence reversal or inversion – does not on those grounds alone allow one to conclude that the altered sequence in principle is any less fit for its ritual purpose *qua* ritual than the canonical version, yet performing the altered version counts as ritual error (Merker 2005). The pattern substitution may even be canonical in a different subpopulation of the same species (say, of songbirds), thus proving its ritual adequacy. Ritual adheres to correct *form*, while the achievement of an instrumental outcome – assuming there is one – counts for little if ritual form is violated. Hence the goal-demotion, even goal-independence (in instrumental terms), that is intrinsic to ritual.

There is reason to believe that humans by nature are carriers of ritual culture in the sense just defined. We, in contrast to chimpanzees – indeed, alone among all the primates (Janik & Slater 1997; Snowdon & Elowson 1992) but like many songbirds and the humpback whale – are in possession of a neural mechanism that allows us to duplicate with our voice that which we have heard with our ears. Most mammals, who excel at learning in other respects, are incapable of doing so (see review by Janik & Slater 1997); yet we humans do so with every song we know how to sing and with every word we know how to pronounce. Through the duplicative logic of this mechanism – technically termed vocal learning, and supported by a "conformal motive" intrinsic to it (Merker 2005) – we are equipped with a natural facility for forms of imitative learning that faithfully duplicate their model to result in the lasting acquisition of formally patterned behaviors as integral parts of cultural traditions with ritual characteristics. It is the "watershed adaptation" of vocal learning (Nottebohm 1976), I suggest, that holds the key to what makes us – and not chimpanzees – a ritual species.

Such a perspective helps us understand why ritual form marks human culture not only in domains touched by precautionary concerns, but in well nigh every area of human pursuit. Many a prayer ritual certainly is directed at warding off potential threat, while others are directed at the acquisition of positive benefits such as wealth beyond the necessities of life (i.e., unassimilable to a scarcity context). Innumerable human rituals, moreover, have a frankly *celebratory* nature (naming rites, birthday ceremonies, and harvest rites – typically performed *after* rather than before the harvest – are cases in point). Hope and affirmation thus join fear in the emotional ambience of cultural ritual. Note also that a statistical skew in the thematic distribution of cultural rituals in a precautionary direction is easily accounted for by the general psychological asymmetry adhering to loss versus gain in human judgments, an asymmetry by no means confined to ritual circumstances (Kahneman & Tversky 2000). Much more could be said about the matters touched upon here (the interested reader may consult Merker [2005] and Merker [in press] for additional detail), but I conclude by thanking the authors for providing the occasion for these reflections through their interesting and timely article.

Useful distraction: Ritualized behavior as an opportunity for recalibration

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Abstract: Responding to potential hazards is likely to require precaution-related recalibration, the extensive integration of complex variables related to inferred risk and fitness. By swamping working memory with goal-demoted actions and focusing recalibration on the inferred threat, ritualized behaviors may serve to increase the efficacy of precaution-related recalibration. This benefit may be an important mechanism maintaining non-pathological ritualized behavior.

In addition to the specific actions described in the Potential Hazard and Precaution model, responding to potential hazards is also likely to require the activation of specific cognitive pathways for the timely, effective processing of complex, hazard-related information and the updating of fitness-related variables, that is, precaution-specific recalibration (Cosmides & Tooby 2000). The swamping of working memory that occurs during ritualized behavior may have the additional advantage of effectively serving to free-up higher-level cognitive processes that are responsible for integrating and interpreting complex information (Dijksterhuis et al. 2006). Although working memory is necessary for making effective decisions, its role in decision-making is not absolute (Bechara 2004). Thus, the goal-demoted actions characteristic of ritualized behavior may represent useful distractions that create a cognitive environment where higher-level cognitive routines may be effectively freed from the yoke of working memory, facilitating more effective integration and processing of disparate forms of information.

By this view, ritualized behaviors have two consequences for information processing: (1) ritualized behaviors focus background processing explicitly on the inferred threat from the Potential Hazard Repertoire, and (2) ritualized behaviors swamp working memory, serving to further increase the effectiveness of precaution-related background processing. As a result, an intrusion or compulsion that arises because of inferred threats from the Potential Hazard Repertoire is also beneficial for promoting recalibration. This predicts that, in addition to being triggered by an inferred threat, ritualized behaviors might be engaged once an information threshold is reached whereby further computational effectiveness requires extensive recalibration. This information can take any form related to fitness – it could be information that modifies the likelihood of successful mate acquisition, changes the nature of a social contract, provides opportunities for resource acquisition, and so on.

As a result, regardless of the original context in which ritualized behavior arose, it may serve the additional purpose of improving the processing of complex information and subsequently reinforcing ritualized behavior. For example, compulsive cleaning may have arisen primarily to restore symmetry and reduce contamination, but it may also have the benefit of providing a time when recalibration occurs. Thus, when faced with situations requiring recalibration (e.g., failure to get a promotion that you were sure you were going to get), some individuals engage in ritualistic cleaning, regardless of whether or not their home is actually dirty. Similarly, ritualized behavior promoting symmetry in one's environment, such as stacking and re-stacking poker chips while in a heated game, may be useful as a way to access cognitive routines for assessing complex probabilities relating to whether or not to call an opponent's bet.

Ritualized behavior is often associated with particular stages in life or specific circumstances (e.g., during stressful events, risky situations) when more efficient precaution-related background processing may be particularly advantageous. For example, ritualized behavior is often pronounced during early childhood and pregnancy, stages that are associated with an onslaught of diverse, fitness-related information and the need to make important choices. As development occurs and ritualized behavior becomes more culturally specific, the same ritualized behavior once enacted in response to a cue from the Potential Hazard Repertoire may be enacted in response to a situation that requires extensive recalibration. As the usefulness of situation-specific recalibration increases due to age or social circumstance, ritualized behaviors may be entirely motivated by the need for recalibration. For example, elderly individuals may exhibit greater ritualized behavior because they are more susceptible to inferred threats (e.g., less likely to escape a predator or survive a pathogen). However, such individuals might also exhibit more frequent ritualized behavior because age-related changes in social status, ability to acquire resources, or cognitive ability may require more frequent extensive recalibration.

Although the authors suggest that early cultural rituals may have parasitized ritualized actions, it is possible that the changes in background processing promoted by ritualized behaviors also promoted their use in cultural rituals. This may be the case because a tremendous amount of information is available during cultural rituals which often has direct bearing on an individual's social status, resource acquisition, and reproductive opportunities (Rappaport 1971). Assimilating and interpreting this information may require intensive recalibration, and may serve as an additional explanation for why goal-demoted, redundant behaviors are employed in cultural rituals. During the performance of a cultural ritual, the use of these strictly ritualized behaviors is typically interspersed with goal-oriented, non-ritualized components (e.g., a display performed by some members of the group while others observe). Thus, cultural rituals contain periods of explicit information gathering interspersed with periods of focused, fitness-related background processing, mediated by the use of ritualized behaviors.

Recalibration may also play a role in the pathology of obsessive-compulsive disorder (OCD) as outlined in Boyer & Lienard's (B&L's) model. In the authors' model, OCD may occur when ritualized behaviors are triggered, but doubt exists that the selected action from the Evolutionary Precaution Repertoire was properly executed. This situation creates a positive feedback loop that encourages continued intrusions and compulsions characteristic of OCD. However, if elevated background processing were part of the system, closure of the system might also occur once recalibration was sufficient (e.g., the poker player stops stacking and re-stacking his chips, not because they are finally in order, but because recalibration has finished).

As such, in some OCD patients, an impairment in some component of recalibration may cause closure to be less frequent.

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Does meditation swamp working memory?

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Abstract: Religionists often presuppose that "mysticism" aims at somehow emptying the mind. In the light of evidence, however, meditation seems rather to consist of ritualized action without an explicit emphasis on subjective experience. Boyer & Lienard's (B&L's) theory of ritualized action as "swamping" working memory thus might help explain the effects of meditation without postulating experiential goals the "mystics" obviously do not have.

Rituals of meditation exemplify cultural rituals such as the ones Boyer & Lienard's (B&L's) hypothesis is meant to explain. They are of particular interest here because in religious studies meditation is a paradigmatic example of an activity that aims at emptying the mind (see Almond 1982; Andresen & Forman 2000; Tart 1969).

Scholars of meditation and mysticism are roughly divided into two camps. "Perennialists" (see Huxley 1946/1959) argue that meditation aims at a "mystical" experience that is everywhere the same, irrespective of culture and tradition (Forman 1990; 1993; Stace 1960). "Constructivists" argue that all experience is culturally constructed and that there thus is no pure experience, apart from its conceptualization (Gimello 1983; Katz 1983; 1985; Proudfoot 1985).

Many authors also make a distinction between introvertive and extrovertive "mysticism." The basic idea is that one can strive for an experience of unity either by focusing attention on some external object, or by "diving inwards" as it were (Almond 1982; Q1 Pahnke & Richards 1969; Stace 1960). Robert Forman (1990, 1993) argues that the "pure consciousness" that Stace regards as the outcome of the introvertive way, is a state in which one is conscious, although one's consciousness is not directed towards any object and thus does not have any content.

In the light of neuroscience, it is more probable that what is known as "pure consciousness event" is an *un*conscious but wakeful state (Pyysiäinen 2001, p. 114). One cannot, however, use contemporary practices as "transparent windows to the past" in trying to find or reconstruct a timeless "mystical" experience (Sharf 1995, p. 235). Sharf has amply shown that the widespread idea of Eastern religions as laying a heavy emphasis on subjective, "mystical" experience is an unfounded Western projection (Sharf 1995; 1998).

Whether it is Theravada Buddhism, Tantrism, or Zen, historical and ethnographic reports clearly show that the emphasis is nearly always on rigid ritual practice and faithful repetition of the doctrine, not on any "altered states of consciousness" (Sharf Q1 1995; 1998). As Robert Buswell (1992, p. 219) observes, the "testimony of Korean [Zen] monastic community [. . .] suggests that a disciplined life, not the transformative experience of enlightenment" is the most important element in this form of religion. Stephan Beyer (1973) argues likewise that in the Tibetan Tantric rites he had observed, the visualization of deities always took place in a ritual context, while rhythmically reciting a text; this made visualization so difficult that even high-ranking incarnate lamas admitted that they really could not master it.

In Theravada Buddhism, the so-called *mārga*-texts ("path texts"), regarded as meditation manuals, function "more as sacred talismans than as practical guides" (Sharf 1995, p. 241). Prior to the 19th century "Protestant Buddhism," which was a counter-reaction to colonialism and Christian missionary efforts, meditation mostly meant the recitation of Pali texts pertaining to meditation. Even today, most monks consider nirvana to be unattainable and rarely engage in meditation (Sharf 1995, pp. 241–42; 1998, pp. 105–106; see also Bond 1988; Gombrich 1988).

Also, in Zen monasteries the monks are primarily interested in ceremonial repertoires and mastering vast collection of *kôans*. Even the Japanese terms for "experience," *keiken* and *taiken*, were actually coined at the end of the 19th century to translate the German *Erlebnis* and the English "experience." Words such as *satori* do not originally refer to "enlightenment" as an unmediated experience, but rather, to the full comprehension of the Buddhist doctrines. Physical discipline and ritual competence are emphasized at the cost of inner experience (Sharf 1995, pp. 247–49). It is the faithful transmission of bodies of doctrine or of ritual practice that is important. The texts that speak of meditative experience are not first-person reports but rather elaborations of doctrinal ideals. Buddhist monks are explicitly forbidden from vaunting their spiritual accomplishments in public (Sharf 1995, p. 236).

We may thus conclude that in the Buddhist traditions meditation is a heavily ritualized practice. An explicit emphasis on some kind of transformative subjective experience as the ultimate goal of this activity is a modern Western idea having its roots in the Protestant ideal of lived experience at the heart of true religion (Proudfoot 1985). Sharf, however, says nothing of the effects that this practice might have on individuals without their knowing.

B&L's hypothesis, for its part, is based precisely on the assumption that ritualized behavior cannot be explained with reference to persons' explicit motives. First, rituals have effects of which the people concerned are not conscious; second, rituals cannot be explained by their effects alone. Rituals involve familiar actions (walking, etc.) that have been turned into difficult tasks requiring such cognitive control which "swamps" working memory.

It seems that the *kôan* rituals of Zen might work precisely this way. A novice is given a paradoxical problem to be solved, such as the question "what is the sound of one hand clapping." After pondering the question in meditation, the novice meets with the master and tries to provide a solution. There is no correct solution, however; the whole point seems rather to be in that one keeps going with the ritual process. At some point, the master may accept some solution as the correct one, but the "correctness" seems to be based on the master wishing to terminate the process rather than on anything in the details of the solution itself (see the classic collections of *kôans*, *Hekiganroku* 1961; *Mumonkan* 1966; cf. Buswell 1992, pp. 59, 150–58).

Thus, B&L's theory might help explain some of the psychological effects of rituals of meditation, without that we need to ascribe to people motives and goals they obviously do not have. Speculative interpretations can be replaced by an empirical explanatory strategy to explore whether religious rituals actually do swamp working memory.

One important implication for the study of religion is the effect such swamping might have for persons' attitude towards the doctrines in question. Sharf (1995, p. 236) points out that the prohibition to vaunt one's spiritual accomplishments has enabled Buddhists to attribute spiritual experiences to past masters without a need to find living masters claiming to have attained to these experiences. Whitehouse (2004, pp. 67–68) argues in the same vein that a frequent public rehearsal of religious teachings ensures that persons will not try to provide novel and

unorthodox interpretations of the doctrine. Whereas Whitehouse presupposes that such blocking of "spontaneous exegetical reflection" takes place through a heavy routinization, B&L argue exactly the opposite: it is precisely the non-routine nature of rituals that does the swamping of working memory. Whether this leads to a blocking of unauthorized doctrinal innovation, is yet another empirical question that deserves to be explored.

Habit formation in Tourette Syndrome with associated obsessive-compulsive behavior: At the crossroads of neurobiological modelling

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Abstract: Tourette Syndrome (TS) and Obsessive-Compulsive Disorder (OCD) are highly associated and often it is difficult to differentiate their symptomatology. In TS, habit forming neuronal systems may form habits of their own – sometimes similar to ritualized behavior. However, whereas in OCD merely the "affect-loop" is touched, in TS the "sensorimotor-loop" plays the major role, although some overlap can be seen in the clinical spectrum between TS and OCD. The latter is mainly related to the "just-right" phenomenon which shows a clear developmental course. An analogous behavioral model for TS and OCD with reference to "just-right" is suggested.

Tourette Syndrome (TS) is frequently associated with, and is pathophysiologically closely related to, obsessive-compulsive behavior/disorder (OCB/OCD; Roessner et al. 2005). TS, with its covert drumbeat of sensorimotor urges and its overt motor and vocal tics (which may give relief from the urges with the consequence of a "just-right" feeling), reveals that in this disorder habit forming systems may form habits of their own (Leckman & Riddle 2000; Leckman et al. 2006) – sometimes similar to ritualized behavior.

Habits are assembled routines that link sensory cues (either external or internal) with motor actions. Although no direct causal link between TS/OCD and habits has been established, there exists some evidence that patients with TS have impaired habit learning. This is probably because of their striatal deficit, which is based on a decreased inhibitory influence of the fast spiking neurons (FSNs) over matrisomal cells (MSs). This could allow the cortical sensorimotor inputs to more easily activate MSs, eliciting the premonitory urges experienced by individuals with TS (Banaschewski et al. 2003; Leckman et al. 2006). It is also suggested that FSNs are instrumental in orchestrating the oscillatory activity of the MSs in the dorsal lateral striatum. This seems to be related to normally occurring rhythmic oscillatory activity within basal ganglia circuits, which plays a key role in the emergence and performance of regular voluntary actions and habits. Further, these oscillations appear to be linked with oscillations from cortical regions (e.g., prefrontal, mesiofrontal) during the repetitive performance of learned behaviors and tic suppression (overview in Leckman et al. 2006).

Hence, different regions of the basal ganglia seem to oscillate in synchrony with specific cortical, cerebellar, and thalamic regions to guarantee neuronal homeostasis. It also implies that irritations in basal ganglia functions may lead to dysbalanced thalamocortical activity and thus to problems in habit forming and/or habit execution, as it seems to be the case in TS. This view is supported by the fact that electrical deep brain stimulation (e.g., thalamus) may work by re-establishing more normal tic/OCB suppressing oscillatory patterns via its effect on striatal neurons (Leckman et al. 2006). In this respect, the error detection system of the anterior cingulate cortex (ACC) may play an important role for the monitoring of such processes. Its activity is increased in OCD and TS (Fitzgerald et al. 2005; Johannes et al. 2001; 2002).

In attempting to explain OCB and its abnormal control processes, Boyer & Lienard (B&L) give an interpretation of Szechtman and Woody's (2004) motivational model of OCD, trying to investigate emotions, perceptions of specific information, typical actions, and inhibition or disinhibition of automatic routines. The model is focusing on the "detection of potential danger" and the following steps. Unfortunately, B&L's interpretation of the model did not have a look at the association of OCB with TS but, fortunately, a slightly modified version of the model itself can be developed for TS as well (Fig. 1). The main difference is the first step where in OCB/OCD the detection system recognizes a cognitive-emotional dissonance, whereas in TS a sensorimotor dissonance is prevailing without any anxiety. As a consequence, the "affect-loop" is not touched in TS while disturbances in the "sensorimotor-loop" are counter-balanced by repetitively acting out the tics which sometimes may mimic ritualized-compulsive behavior, but do not reflect activity of a "security-related-program-loop."

Similarly, this seems to be the case for another core process of ritualized action, namely *safety motivation triggered arousal* (see target article, sect. 3.3). The authors assume that the arousal state may bias the appraisal system in such a way that "just right" or "closure" experience is delayed. Although the latter assumption is close to what happens in patients with TS who show hyperarousal (Kirov et al., in press; Kostanecka-Endres et al. 2003), here again the aspect of danger/safety does not play any role concerning the "just-right" phenomenon in TS.

Thus, the link between OCB/OCD and TS is quite complex (Roessner et al. 2005) and it yields that the disorder specificity of such explanatory models of frontostriatal disorders like TS and OCD is not easy to grasp. This point is strengthened by

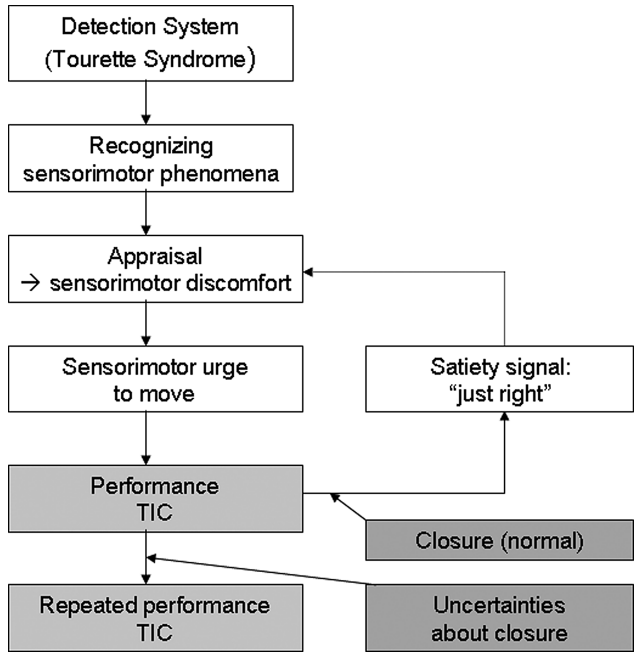

Figure 1 (Rothenberger et al.). Cognitive-Sensorimotor Model of Tic-performance. Adapted from Szechtman and Woody's (2004) Emotional Model on obsessive-compulsive behavior as interpreted by Boyer & Lienard. White rectangles correspond to distinct systems activated, light grey boxes to behavioral results and dark grey boxes to aspects of the processing. Suppression of tics by activating frontal lobes is possible at any stage of the process.

the information that in TS there exists a high frequency of particular sets of associated repetitive behaviors (e.g., nail biting, tooth grinding, nose picking) without the typical compulsory elements (Roger Freeman, personal communication), although these behavioral sets might sometimes be included in more complex OCB and rituals.

Finally, B&L have discussed the developmental aspect of ritualized behavior and focused on the "just-right" phenomenon. They have put it in relationship to anxiety, harm, separation and fears. This might be partly true, especially since many children and adults with OCD and/or TS report separation anxiety in early years. However, in the absence of a proper causal or predictor model a merely cognitive developmental framework would be also tenable. Especially since, in TS, the sensorimotor phenomena and the related behavior show a clear cognitively determined developmental course independent of the duration of the disorder. Usually, children are aware of sensorimotor phenomena as ego-dystonic around the age of ten only (Banaschewski et al. 2003). Also, children with early-onset of OCD have a higher association with TS and probably show more special repetitive behaviors (e.g., nose picking; Roger Freeman, personal communication; Roessner et al. 2005). But it is unclear if they are at higher risk for ritualized behavior in general. Hence, the suggested development of "functional calibration" needs to be included in such models.

To sum up, it may be assumed that in children with TS/OCD spectrum, the coordination and orchestration function of the striatum is more labile and patients need early therapeutic support to successfully calibrate their central nervous habit-forming systems with growth and maturation.

Rituals are rational for the imperfect experimentalist

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Abstract: Humans are, by design, imperfect experimentalists. The cost of testing each step of a process exceeds the benefit of knowing which steps can be eliminated. To an outsider who knows which steps are superfluous, the actors appear superstitious, even ridiculous. Nonetheless, the exact duplication of all steps is rational for the imperfect experimentalist. The case of ritual in autism illustrates this point.

People are imperfect experimentalists. Indeed, in the face of uncertain information, people may not seek and may actively avoid the information that would be necessary to test their working hypotheses, a phenomenon that has been called the "confirmation bias" (Wason 1960). Although this bias leads to inaccuracies, people are imperfect experimentalists by design. In the processes that are important to humans – cooking, childbirth, hunting, or warfare, for example – the cost of meticulously changing each variable to measure its effect on the outcome is much more than the benefit of that knowledge. If a person believes that boiling water during childbirth leads to a healthy birth, there will never be a point at which experimentally eliminating that step is worth the risk of losing a baby. If one believes that carrying a particular talisman into battle leads to success, there will never be a case when leaving it at home in order to test its value will be worth the risk of losing the battle. Humans are imperfect experimentalists by design, and a result of having imperfect information is that it is rational to follow a ritual, even if some steps in that ritual appear far removed from the ultimate goal of the process.

The model proposed by Boyer & Lienard (B&L) explains the ritualized behavior of humans as a product of a cognitive Precaution System. In fact, ritualized behaviors are a result of a more general decision-making process, of which precaution taking is a specific subset. Ritual is rational in situations where one has incomplete information. Imagine that one has to decide whether a precaution has been taken, for example, to ensure that a door has been locked. Once one is certain that the door has been locked, one can attend to something else. While the door is out of sight, one must decide between choice A (the door has been checked, I can relax) or choice B (the door may not have been checked, I need to check it.) Formally, this problem can be represented in terms of Signal Detection Theory. Deciding to check the door, if it is secure, is a False Alarm, if not secure, this action is a Hit. Leaving an unlocked door unchecked is a Miss, and leaving the door when it is secure is a Correct Negative. Signal Detection Theory describes how humans make such a decision under conditions of uncertainty, and it is capable of dealing with changes in the relative cost of each kind of mistake. In the case of the hypothetical Precaution System that B&L describe, the costs of each mistake are strongly unequal: the cost of a Miss (if one is attacked because of the unlocked door) is much greater than the cost of a False Alarm. Therefore, and entirely consistent with B&L's suggestion, there may be a natural bias towards checking.

However, the case of precautions is only one extreme type of decision-making problem, one in which the relative costs of the two types of mistakes are radically unequal. There are other more mundane examples of this problem, in which the cost of each mistake is less unequal, and these cases may also lead to ritual behaviors if people have incomplete information. Take cooking as an example. If a recipe has worked for an individual, for her mother and for her grandmother, it will rarely be worth eliminating an ingredient (or step) to test whether it was necessary. The risk is not dire: one stands to lose a meal, but even this relatively lower cost is not worth taking most of the time. Here too, ritualized behaviors may be maintained, if somewhat less inflexibly.

B&L describe typical behavior and behavior in some neurological disorders, but they fail to mention one disorder that is defined by its ritualistic behavior: autism. Can the rituals of individuals with autism be understood in term of B&L's model? Yes, ritual is rational for those with autism but only if we appreciate that the B&L model is a specific instance of a more general decision-making strategy. Autism is a developmental disorder that is characterized by difficulties in social cognition, language delay, and an unusual attraction to ritualistic behavior. Children and adults with autism can be extremely tied to rituals that they feel compelled to perform, and routines become very rigid. A child with autism may insist that the family remote controls be lined up in a particular order and be touching each other, or that the pillows on the couch be in a particular configuration, or that photos on a shelf be displayed at a particular angle, for example. Although other developmental disorders such as schizophrenia and some learning disabilities may include ritualistic behavior, the rituals of autism are distinct in kind (Baron-Cohen & Wheelwright 1999) and quantity (Szatmari et al. 1989).

In spite of this, B&L do not mention autism in their discussion. The rituals of autism may be difficult to understand in the relatively narrow view of rituals as a product of a cognitive Precaution System, but easier to understand if seen as a product of a more general decision-making strategy, of which precaution is a subset. Children with autism cannot easily make use of social information due to their difficulty understanding and making inferences from the mental states of others, and incomplete information leads to a dependence on rituals. In the autism literature, explanations for rituals are offered that describe a homeostatic mechanism: children with autism perform a ritual to reduce arousal, or to return to a more comfortable state (Hutt & Hutt 1970). This explanation is a viable proximal explanation but lacks any attempt at understanding the ultimate causes of the ritualized behavior. In contrast, we can understand the ritualized behavior of children with autism as an attempt to continue to produce

acceptable outcomes when those with autism have imperfect information. Those with autism are dependent upon ritual precisely because they have imperfect information, particularly social information. One result of this perspective is the prediction that those with autism may be even more tied to rituals in situations that are more socially demanding. Indeed, repetitive behaviors are more pronounced when children with autism are in the presence of unfamiliar adults (compared to familiar adults; Charlop 1983). For imperfect experimentalists with or without autism, the benefits of adhering to a routine that works exceed the risks of testing each step.

Universal sex-specific instantiations of obsessive-compulsive disorder

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Abstract: Numerous sex differences in obsessive-compulsive disorder (OCD) instantiations are likely universal, as the associated evolutionary threats and concerns onto which they map were differentially important to the two sexes. Hence, although some ritualized behaviors or thoughts are indeed culture-specific, others are both culturally and temporally invariant as they are rooted in universal Darwinian etiologies (e.g., the sex differences in OCD symptomatology posited here).

Boyer & Lienard (B&L) have heeded admirably E. O. Wilson's call for the development of consilient research paradigms (Wilson 1998). They have managed to unify disparate research traditions, operating at both the proximate and ultimate levels of analyses, into a coherent and parsimonious model of ritualized behavior. I fully concur with the central premise that obsessive-compulsive disorder (OCD) involves the over-activation of warning systems in evolutionarily relevant areas (Saad 2006), a tenet that is consistent with B&L's ninth proposition (P9; target article, sect. 7.5). In their first proposition (P1; sect. 7.1), B&L posit that fitness-relevant life cycle variables (including biological sex) should serve as strong predictors of the rate of occurrence, the strength, and the contents of intrusive thoughts. This is a very reasonable proposition whose explanatory power can be augmented in two ways: (1) recognizing that P1 applies to a much broader range of OCD instantiations (i.e., it need not be restricted to intrusive thoughts); (2) positing specific hypotheses for a given life cycle variable (in this case, biological sex). Specifically, to the extent that one's biological sex is a defining human polymorphism (certainly the case for a sexually reproducing species), one might reasonably expect sex differences in the symptomatology of OCD (see Saad [in press a] for additional details). This point serves as the crux of my commentary.

Although many social and physical ancestral threats are equally relevant to both sexes (hence no sex differences are expected in OCD manifestations that map onto these threats), some evolutionarily relevant dangers tend to be more sex-specific (and hence yield sex-specific instantiations of OCD). Intrusive thoughts related to the harming of one's infant are more common in women while sexual compulsions are more frequent in men. Women's contamination fears seem to fluctuate as a function of various important fitness-relevant stages including pregnancy status and menstrual cycle. Each of the latter sex-specific findings is perfectly congruent with evolutionary-based predictions. I would posit that ruminative thinking associated with loss of social status (e.g., "I am sure that I say idiotic things at company meetings causing everyone to think that I am a moronic buffoon") is more likely to occur in men, whereas that linked to beauty-related threats (e.g., "I am certain that people think that I am hideously fat and hairy") is much more common in women. In general then, while many ritualized behaviors might indeed be culture-specific (as per B&L's tenth proposition, P10; sect. 7.5), numerous sex-specific forms of OCD-related ritualized behaviors are likely universal as they map onto sex-specific evolutionarily relevant threats and concerns. Tangentially, in discussing culture-specific examples of ritualized behavior, B&L allude to purity of thought concerns in Islam (sect. 7.5). I am uncertain of this example's validity given that this concern is equally inherent to many other religions. For example, religious and moral scrupulosity has been documented quite extensively amongst Christians and Jews (both Inigo de Loyola and Martin Luther were thought to suffer from religious scrupulosity). Hence, religious scrupulosity along with its various forms of ritualized behavior is more likely linked to religiosity per se (irrespective of the religious tradition).

My present point with regard to the evolutionary roots of sex differences in the instantiation of OCD symptoms applies to other psychiatric conditions as well (see Kessler [1998] for a discussion of sex differences across a wide range of psychiatric conditions, albeit void of any evolutionary-based theorizing). I have argued elsewhere that numerous psychiatric afflictions appear to have universal sex-specific manifestations either in their forms and/or their incidence across the two sexes. For example, pornography addicts and pathological gamblers are overwhelmingly more likely to be male, whereas compulsive buyers and individuals suffering from eating disorders are extremely more likely to be females (Saad, in press b). These sex-specific effects are both temporally and culturally invariant and hence seem to have a Darwinian etiology. Incidentally, B&L state that hoarding is a form of OCD that is outside of their evolutionary purview perhaps because the ritualized behaviors in hoarding are not as apparent as those in other forms of OCD. I should mention that the items that women hoard when engaged in a compulsive buying binge typically relate to beauty-enhancing products, hence the evolutionary-based mechanisms are apparent in this case (Saad, in press b). Evolutionarily-congruent findings/explanations have been obtained/proposed for a wide range of psychiatric and medical disorders including De Clérambault's syndrome (Brüne 2001; Brüne & Schröder 2003), erectile dysfunction (Cellerino & Jannini 2005; Gofrit 2006), perfectionism (Dunn et al. 2005), envy (Habimana & Massé 2000; Saad & Gill 2005), social stress (Troisi 2001), sexual disorders (Troisi 2003), persecutory delusions (Walston et al. 1998; Zolotova & Brüne 2006), depression (Mackey & Immerman 2000), body dysmorphic disorder (Phillips et al. 2006), and suicide (Saad, in press a). Generally speaking, key triggers of envy, suicide, perfectionism, social stress, body dismorphic disorder, erotomania, and persecutory delusions assort along sex-specific lines precisely because many evolutionary threats are differentially important to the two sexes.

Two final points: First, to the extent that B&L are applying an evolutionary-based approach in exploring ritualized behavior (including OCD), two non-cited albeit highly relevant papers are those by Polimeni et al. (2005) and Feygin et al. (2006). The former paper argues for the adaptive benefits of OCD via a group selectionist argument, whereas the latter article explores the manifestations of OCD in several domains of evolutionary import including parental and romantic love. Second, B&L repeatedly state that there are no evolutionary/adaptive reasons for humans to engage in wasteful rituals (e.g., the opening line of the epilogue, sect. 9.3). This is puzzling given that B&L are well aware of the costly signaling mechanisms that explain the evolutionary roots of such behaviors (cf. Sosis 2003; Sosis & Alcorta 2003; Sosis & Bressler 2003; also, Hagen & Bryant 2003). The latter point notwithstanding, I accept B&L's distinction between ritualized behaviors and rituals.

To summarize, B&L have provided a powerful conceptual model for exploring ritualized behavior. One proposed area for future research would be to explore universal sex-specific instantiations of ritualized behaviors (as occurs with OCD), a suggestion directly relevant to B&L's propositions 1, 9, and 10.

Morbid jealousy as a function of fitness-related life-cycle dimensions

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Abstract: We suggest that morbid jealousy falls on the extreme end of a jealousy continuum. Thus, many features associated with normal jealousy will be present in individuals diagnosed with morbid jealousy. We apply Boyer & Lienard's (B&L's) prediction one (P1; target article, sect. 7.1) to morbid jealousy, suggesting that fitness-related life-cycle dimensions predict sensitivity to cues, and frequency, intensity, and content of intrusive thoughts of partner infidelity.

Jealousy is a universally experienced emotion proposed to be serving the adaptive purpose of preventing costly partner infidelity (Buss 2003). Jealousy mechanisms may exist on a normally distributed continuum, ranging from extreme hyposensitivity to extreme hypersensitivity (Buss 2000; Easton et al., in press). Individuals diagnosed with Delusional Disorder, Jealous Type (*Diagnostic and Statistical Manual of Mental Disorders*; American Psychiatric Association 2000) or "morbid jealousy" display this perceptual hypersensitivity and tend to exhibit extreme behaviors. These individuals incessantly accuse their partner of infidelity and often without actual verification (Kingham & Gordon 2004; Shepherd 1961). They monitor their partner's whereabouts by calling them incessantly, following their partner everywhere, and spying on their partner (Enoch & Trethowan 1979; Vauhkonen 1968). They show up unexpectedly at their partner's workplace or home. They use non-physical and physical abuse against their partner and may attempt to murder or actually murder their partner as a result of these intense and persistent feelings of jealousy (Buss 2000; Kingham & Gordon 2004; Mowat 1966).

If morbid jealousy is on an extreme end of a jealousy continuum, we hypothesize that individuals with normal jealousy and individuals diagnosed with morbid jealousy may experience many of the same intrusive thoughts and behaviors. As Boyer & Lienard (B&L) note, an important distinction lies not in the thought content but in the appraisal of those thoughts. Consistent with B&L's Precaution System Model, hypersensitive jealousy mechanisms may not be dysfunctional in all cases; in fact, by over-interpreting specific cues to partner infidelity, the mechanisms may serve the adaptive purpose of preventing partner infidelity. The perception, interpretation, and reaction to cues to partner infidelity may depend on specific contextual factors. We argue that the position of an individual along fitness-related life-cycle dimensions will predict the sensitivity to cues to partner infidelity and the frequency, intensity, and contents of intrusive thoughts of partner infidelity. These fitness-related life-cycle dimensions are experienced in a number of different ways.

It has been shown that men more than women are upset when asked to imagine their partner engaging in sexual intercourse with someone else, whereas women more than men are upset when asked to imagine their partner falling in love with someone else (Buss et al. 1992; Buss et al. 1999). Thus, men are more apt to display sexual jealousy whereas women are more apt to display emotional jealousy. We expect to find the same pattern in individuals diagnosed with morbid jealousy, such that a greater percentage of men than women diagnosed with morbid jealousy will focus on a partner's sexual infidelity, and that a greater percentage of women than men diagnosed with morbid jealousy will focus on a partner's emotional infidelity. Furthermore, we expect that men diagnosed with morbid jealousy will obsess on the details of a partner's sexual contact with other men and that women diagnosed with morbid jealousy will obsess on the details of a partner's emotional contact with other women.

Research has also shown that men more than women report a potential rival's social status/wealth as a jealousy eliciting characteristic and that women more than men report physical attractiveness/youth as a jealousy eliciting characteristic in a potential rival (Brase et al. 2004; Buss et al. 2000). We expect to find the same thought pattern in men and women diagnosed with morbid jealousy. In fact, the intensity and frequency of these thoughts may vary as a function of fitness-related life-cycle dimensions. For example, a young man with few resources may be especially likely to focus on a rival's social status/wealth. An aging woman may be particularly attuned to the attractiveness/youth of potential rivals.

We also expect shifts in mate value in one partner relative to the other partner to predict sensitivity to cues of infidelity, and the intensity and frequency of jealous thoughts and feelings. Individual mate value can increase. One partner may experience sudden financial success, career advancement, or social status enhancement, or perhaps increased physical attractiveness through exercise, dieting, or cosmetic surgery. Individual mate value can also decrease. One partner may physically age faster than the other, become seriously ill, handicapped, or infertile. A career setback or a loss in social status may also decrease mate value. The individual with the newly acquired lower mate value may feel less attractive, sexually inadequate, or unworthy as a partner; and may now be perceived by their partner as an unworthy mate (Buss 2000). It may benefit those individuals with the lower mate value to attend to this discrepancy and to be more vigilant in their mate guarding efforts, including experiencing frequent and intense feelings of jealousy, increasing their sensitivity to cues of partner infidelity, and behaving accordingly to prevent partner infidelity.

Finally, we expect rates of actual partner infidelity to reflect the sensitivity to and the frequency, intensity, and contents of intrusive thoughts of partner infidelity. A diagnosis of morbid jealousy requires that the individual's partner is not or has not been unfaithful. However, if jealousy mechanisms are designed to perceive cues to partner infidelity, it is possible that these hypersensitive jealousy mechanisms are functioning as designed, that is, accurately detecting partner infidelity. Perhaps these persistent and obtrusive feelings of jealousy are grounded in reality. By not considering the functionality of jealousy mechanisms, clinicians may be too quick to dismiss the perception of their patients.

A complete understanding of morbid jealousy may come from examining morbid jealousy in relation to normal jealousy. We concur with B&L's Precaution System Model proposal that intrusive thoughts are generally not dysfunctional; and we offer that an examination of the individual context through fitness-related life-cycle dimensions may predict sensitivity to cues to partner infidelity, and the frequency, intensity, and content of intrusive thoughts of partner infidelity. The application of this model to morbid jealousy may help researchers and clinicians enrich their understanding of the disorder and thereby improve treatment of individuals diagnosed with morbid jealousy.

Critical developmental periods of increased plasticity program ritualized behavior

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Abstract: The consideration of humans going through sensitive periods of life, such as childhood and the early postpartum, may be helpful in understanding the cognitive and evolutionary puzzle of human rituals. During such periods, certain brain systems may mediate an increased susceptibility to learn new behaviors, rational or irrational.

The apparently irrational ritual behaviors discussed by Boyer & Lienard (B&L) may be related to the double-edged sword of having windows of increased plasticity. There is considerable evidence from epidemiology, ontogeny, ethology, and neurobiology that patterns of "normal" and adaptive ritual through childhood, romantic love, family life, and religious experience overlap with obsessive-compulsive disorder (OCD) (Feygin et al. 2006). During vulnerable periods, the capacity to recruit reward systems to motivate and learn survival behaviors without reasoned justification might confer significant evolutionary advantages. However, these periods might also render humans susceptible to irrational or psychopathological behaviors transmitted through the impact of comorbid psychopathology, culture and family.

Much of human behavior may be thought of as the result of reward-seeking or harm avoidance so that one might imagine behavior is based on an overall cost function associated to each action in which rational decisions are based on the conscious weighing of "pro's and con's." However, when time is limited, stress is increased, or dangers are great, perhaps survival has evolutionarily favored brains that acted without rational review – that is, that performed rituals. Ritual behavior, then, would include behaviors that do not stand up to rational review, such as behaviors in which faith, rather than verifiable facts, determine actions. Children may represent a developmental window when threats are greater, cognitive capacity is lower, and perhaps even reward/learning circuits are primed to accept whatever they are told, with little rational review. Further, the behavior of children is influenced by the introduction of false positives and negatives. For example, children are told, and they accept, that if they do certain things then fictional entities such as Santa Claus or religious figures will be pleased and perhaps reward them. In the case of the Santa Claus myth, actual material rewards are provided by parents in addition to other parental caring behaviors. Alternatively, children may be threatened with negatives such as imaginary monsters or religious concepts like "hell" for failure to conform to whatever is required of them. Ideas of harm befalling a parent (reminiscent of OCD) may also be introduced. The capacity to be irrational, then, may be programmed during childhood to support a wide variety of fallacious cognitions that may go on to be part of rituals and OCD. It appears that a tendency toward magical thinking may underlie links between superstition and OCD severity (Einstein & Menzies 2004). In the case of religious beliefs, the acceptance of patently un-testable hypotheses (such as the nature of life after death) can even be rewarded, under the general guise of "faith." It is an interesting observation that early-onset OCD is more severe (Rosario-Campos et al. 2001). It might be interesting to study the converse – that is, would a delay of ritual-based teachings to mid-late adolescence result in a decrease in ritual behavior and OCD?

As we might predict, then, increased religiosity (significantly mediated by childhood instruction) is associated with increased OCD. For example, Catholics with a high or moderate degree of religiosity scored higher on measures of OCD-related obsessional thoughts, compulsive washing, intolerance for uncertainty, need to control thoughts, beliefs about the importance of thoughts, and inflated responsibility, than did less religious Catholics (Sica et al. 2002). In another study using self-report questionnaires, differences in OCD-related phenomena between highly religious Protestants, moderately religious Protestants, and atheist/agnostic participants drawn from an undergraduate sample were studied (Abramowitz et al. 2004). Highly religious versus moderately religious Protestants reported greater obsession symptoms and compulsive washing. Also, compared with atheists and agnostics, the highly religious had more obsession symptoms, including compulsive washing, intolerance for uncertainty, need to control thoughts, beliefs about the importance of thoughts, and inflated responsibility. In another study of 45 outpatients with OCD, 42% of patients had religious obsessions (Tek & Ulug 2001). Relationships between religious practices and OCD have also been reported among Hindus (Khanna & Channabasavanna 1988), Orthodox Jews (Greenberg & Shefler 2002), and Muslims (de Bilbao & Giannakopoulos 2005), underscoring the influence of particular religious affiliations on the expression of OCD.

It is likely that many brain systems are involved in ritual, including the fronto-striatal networks mentioned by B&L. Also of particular importance would be the reward systems that normally motivate various behaviors involved in learning and affiliation (Depue & Morrone-Strupinsky 2005). These might, however, be vulnerable to hijacking, such as in the acquisition of irrational, ritualistic, and pathological behaviors in OCD (Leckman & Mayes 1999), and addictions (Kufahl et al. 2005; Swain et al. 2005). Some of these systems have been shown to be activated in parents who are also undergoing a period of increased stress, learning, and preoccupation in the first few months after childbirth (Leckman et al. 1999). Several groups are also contributing to this field using different functional brain imaging experimental paradigms and populations (Swain et al., in press). These imaging studies hold the promise of identifying brain circuits associated with the formation of parent–infant attachment during the critical postpartum period. Some of these areas overlap with the ritual areas suggested by B&L and with OCD regions (Friedlander & Desrocher 2006). For example, first-time parents responding to their own infant's cries versus those of other infants' at 2 weeks postpartum, had activated basal ganglia, orbitofrontal cortex and caudate. These activations were also correlated with measures of OCD-like postpartum preoccupations.

Certain neurotransmitters may be critical to rituals. For example, CSF levels of the affiliative neuropeptide oxytocin are elevated in some individuals with OCD (Leckman et al. 1994). Another example is serotonin since serotonergic drugs are commonly used to treat OCD. In addition, serotonin has been associated with spiritual experiences (Borg et al. 2003), and OCD-related moral or religious scrupulosity can be effectively treated with serotonin reuptake blockers (Fallon et al. 1990). Indeed, much more research is needed on the common and distinct neural correlates of various OCD symptom dimensions with symptom provocation paradigms, combined with neuropsychological tasks and neuroimaging techniques. Certain groups that bear particular attention include "normal" subjects during critical periods such as childhood, or high stress.

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The evolved architecture of hazard management: Risk detection reasoning and the motivational computation of threat magnitudes

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Abstract: The architecture of the hazard management system underlying precautionary behavior makes functional sense, given the adaptive computational problems it evolved to solve. Many seeming infelicities in its outputs, such as behavior with "apparent lack of rational

motivation" or disproportionality, are susceptibilities that derive from the sheer computational difficulty posed by the problem of cost-effectively deploying countermeasures to rare, harmful threats.

Boyer & Lienard's (B&L's) landmark work represents a decisive advance in our understanding of the evolutionary psychology of ritual behavior, viewed as a byproduct of adaptations for avoiding danger. We strongly endorse the view that there is an evolved, species-typical suite of neurocomputational adaptations designed to deal effectively with dangers and the deployment of countermeasures – what we have called *hazard management* or *precaution systems* (Fiddick et al. 2000). We also agree that the themes of ancestrally recurrent danger (e.g., contagion, danger to offspring) that pervade obsessive-compulsive disorder (OCD) ideation, together with the hyperactivation of precautionary checking subroutines, indicate that OCD results from breakdowns in these evolved systems (Cosmides & Tooby 1999). In particular, we have been pursuing the hypothesis that there is an evolved domain-specific inferential specialization designed to reason about whether an appropriate precaution has been taken, conditioned on the presence of the danger it protects against. A growing body of evidence suggests that such a *risk detection specialization* exists (somewhat parallel to the cheater detection system) and is cognitively distinct (Fiddick et al. 2000), neuropsychologically dissociable (e.g., from reasoning about social contracts; Stone et al. 2002), and involves distinct patterns of neural activation, as judged by neuroimaging findings (Ermer et al., in press).

This risk detection reasoning (and attentional) subsystem appears to use cognitive primitives at the level of *hazard$_i$ (present/absent), countermeasure for i (in effect, not in effect)*, and it draws attention to conditions in which a danger may be present but its appropriate precaution may not have been taken. We believe that when this checking subroutine produces the inference that a specific hazard$_i$ might be present in the absence of its specifically associated countermeasure, this output potentiates the regulatory circuitry governing motivations to take associated safeguards. We suspect that this same system, to accomplish its detection function for evolutionarily prepared dangers, accesses what B&L call the *Potential Hazard Repertoire*, and the *Evolutionary Precaution Repertoire*. We therefore view these as evolutionarily prepared subsets of two more encompassing repertoires that include *all represented hazards*, and *all represented countermeasures*, respectively. That is, the risk detection subsystem not only functionally links "innate" countermeasures (e.g., washing) to ancestral hazards (e.g., disease exposure), but also links evolutionarily novel countermeasures (e.g., backing up) to evolutionary novel dangers (e.g., hard disk crashes).

The adaptive computational problems posed by reasoning, however, are dwarfed by the magnitude of the design problems posed by the task of computing valuations in a fitness enhancing way (Tooby et al. 2004). The selective intensity of an adaptive problem is a function of the frequency of the selective event, multiplied by the magnitude of its fitness consequences. Events that (1) happen frequently over the lifespan, (2) where outcomes follow rapidly, and (3) where outcomes can be readily assayed for their value allow the evolution of feedback systems that shape and weight actions reliably (allowing, e.g., motor skill acquisition). In contrast, a selectively significant set of detrimental events (*threats*) will be sufficiently harmful (e.g., disease, predation, ambush, social disgrace) to make it potentially cost-effective to take countermeasures even when their incidence is low. Because their incidence is low, however, sampling error and a paucity of observations will make uncertainty great, accurate ascertainment of their true probabilities difficult, and the change in their probability associated with a given countermeasure or predictive cue even harder to determine. Indeed, a successful precaution may preclude a harmful event from happening, so that it is never observed by an individual. How can the observer tell whether a threat has disappeared, whether the precaution remains necessary, or whether good luck was responsible for the apparent disappearance of a threat that remains real? The rarer an event is, the more its true probability will be hidden from an observer among a large range of possible values.

Indeed, because many threats are produced by design by antagonistically co-evolving organisms, selection often makes threats maximally unpredictable to their victims. Yet the motivational system, in order to allocate effort among possible precautionary actions and other fitness-promoting activities, must compute and assign to each threat (given a set of cues) a value, as an approximate function of its expected cost and its expected probability. That is, for each represented threat, the system must compute a regulatory variable: a *threat index*. It also needs to compute values for cues that predict changes in the probability of the threat, as well as values for the effectiveness of countermeasures. (The categorization of threats ought not to be just a function of their "objective" external resemblance to each other, but more importantly of how similar their countermeasures are: That is, "pollution" is an evolved idea not because it represents a single kind of threat – it does not – but because the environmental threats it lumps together can be attenuated using the same kinds of countermeasures.) Because of their different evidentiary bases, threat indices cannot be computed in the same way in which positive payoffs driving reward-seeking decisions can be. Accordingly, the precautionary system is adaptively designed to produce feelings of "compulsion" (action motivated in a way that is divorced from any proximate goal or confirmatory payoff – unlike, say, foraging). Normally, precautionary compulsions should be trumped whenever situations invite alternative actions whose payoffs exceed the threat index. Although what might be called *optimal defense theory* has some powerful analogies with optimal foraging theory, it also has disanalogies which would have selected for the hazard management system to become a computationally differentiated part of the motivational architecture.

A well-engineered system should supplement observations of the incidence of rare costly events and countermeasures with other sources of information. These include (1) correlated cues to conditions of heightened threat (Neyman-Pearsonian decision theory suggests that the system ought to be biased to overinterpret the diagnosticity of candidate predictors, as in post-traumatic stress disorder [PTSD]); (2) non-frequentist causal models of countermeasures (e.g., physical barriers to threats); (3) decoupled imaginative simulations (Tooby & Cosmides 1990) and quasi-counterfactual representations such as "near misses" (when dysregulated, these recalibrations constitute obsessions); (4) possible transgenerational epigenetic reweighting (see Tooby et al. 2003); (5) genetic inheritance (the heritable personality dimension psychoneuroticism may exist as an adaptation to allow local and transgenerational recalibration of threat indices through genetic or epigenetic reweighting (see Tooby et al. 2003); and (6) social sources of information.

The social dimension especially illuminates collective ritual behavior. Observations gathered by multiple conspecifics provide more accurate estimates of actual threat magnitudes – the adaptationist rationale for circuits that reset threat indices partly based on observed fear reactions in others (Cook & Mineka 1987). Moreover, the high uncertainty hovering over incidences and countermeasure effectiveness leaves the hazard system susceptible to error, volatile reweighting, individual differences, and social entrainment (including manipulation). Seeing others devote considerable effort to a collective ritual presented as a countermeasure advertises their threat indices, inducing observers to reweight. Finally, because of human improvisational intelligence (Tooby & DeVore 1987), we think there is a proper domain for some precautionary ritual behavior, where it functions as preparation for complexly managed, instrumental activity in dangerous and unpredictable environments whose negotiation necessitates high levels of skill acquisition, rapid reaction time, and organized material readiness. Aspects

of military training, seamanship, *katas*, mountain climbing – even medicine concoction and some cooking – exemplify aspects of functional precautionary ritual behavior. This minor caveat aside, B&L have powerfully illuminated underlying commonalities in ritual behavior.

Ritual: Meaningful or meaningless?

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Abstract: In conflating opposing meanings of the term "ritual," arising from historical Western cultural conflicts regarding church and state, this target article begs fundamental questions. Its appeals to cognitive science concepts such as "working memory" are poorly informed and obfuscate what could have been a far more penetrating and less biased discussion of stereotyped human action.

In English, it is not unusual for the same word to come to possess two almost opposite meanings – for example, the word "sanction" – which require careful distinction. The term "ritual" is similar, denoting pointless actions and also those with great meaning for participants. Boyer & Lienard (B&L) (and Cosmides and Tooby, whom they acknowledge as inspirations for this study) seem to have been foxed by this etymological quirk. Otherwise, their use of the term "ritual" to refer simultaneously to both opposite meanings might be regarded as disingenuous.

Much ethnography has been devoted to teasing out authentic interpretations of the rituals that are found universally in every culture (even those of university academics). Cultural anthropologists' definitions of the term "ritual" are indeed vague, for excellent reasons. Because the meanings of rituals are generally deeply embedded in the local network of social institutions and collective representations, which are to a large extent taken for granted by participants in a given culture, it is often difficult to find simple interpretations for specific component actions of any given ritual. For instance, Sperber (1975) found it quite impossible to understand why members of the tribe he studied applied butter to their hair. But absence of evidence is not evidence of absence, as all good scientists are aware.

B&L have adopted their compatriot Sperber's rationalistic bias and are content, at least at the outset of their article, to fully equate cultural ritual with the pathological and apparently irrational behaviour of humans suffering from obsessive-compulsive disorder (OCD), and with the repetitive actions of small children (who perhaps delight in their freshly-acquired ability to give order to their personal space and time). But they do not appear to appreciate that their definition of "ritualized behavior" as "stereotypy, rigidity, repetition and apparent lack of rational motivation" (target article, sect. 1), applies precisely as well to more approved, adult, and non-pathological cultural forms such as theatre, music, and poetry. It is not at all clear how these latter forms might relate to "inferred threats to fitness" arising from a "Hazard-Precaution System" (as the authors call it, perhaps using the term "system" to distance themselves from Pinker's wholesale misuse of the term "module"; see, e.g., Pinker 1997). In any case, cultural ritual clearly serves many purposes, such as worship, dedication, marking a social commitment, enacting a rite of passage, which it would be ridiculous to associate with inferred threats to fitness. Ritual is often effective in these contexts because of its dramatic power, bringing together in a choreographed and synergistic process symbols that have great resonance in the cultural understanding of its protagonists (cf. Victor Turner 1969). Perhaps B&L have had no personal experience of this power, which would explain how easily they have confused the two opposite senses of the term "ritual."

It is also important to stress that religious ritual, like other performative genres, is rarely rigidly repetitive. On the contrary, it is often tailored to suit the occasion and/or the individuals concerned, particularly in rituals that are intended to be curative. Ritual experts frequently draw from an extended repertoire of approved variants, as do Western medical practitioners (e.g., E. L. B. Turner 1992). The relatively invariant form of the proceedings can easily be seen to provide an acceptable context or frame (see Goffman 1974) for social actions, enabling the participants to interpret them appropriately.

Far from "swamping working memory," repetitive ritual actions are typically easily memorized, and thus rapidly become over-learned, relieving any potential burden on working memory and allowing a greater focus on the affective and cognitive content of the ritual context. The reader should be aware that "swamping working memory," a favourite phrase of Boyer, is not an accepted cognitive science concept – perhaps the authors mean "increased attentional load" (e.g., Lavie 2006). Over-learning is also a vital aspect of musical performance. Indeed, humans very often rely on over-learned behaviours, consciously or unconsciously fitting themselves into predictable and thus interpretable roles. Ritual action is thus a particularly striking example of role-play.

To argue that such adherence to custom results from a narrowly defined brain Hazard-Precaution System is question-begging and has limited explanatory power, like Molière's *virtus dormitiva*. In my view, this aspect of human social behaviour is supported by a more "domain-general" brain system (or systems!) for planning, scenario development, and prediction, which uses Bayesian computational algorithms to imaginatively assess the potential benefits and costs of a range of possible actions. Cognitive scientists are familiar with this system as the "central executive" (Baddeley 1990; Norman & Shallice 1980). It is obvious that the ability to acquire, learn, and represent stereotypical patterns for action greatly increases the efficiency of such neural computations by limiting the range of possibilities, and could thus increase evolutionary fitness. B&L are tendentious in separating out actions which they happen to believe are "pointless," as the products of a special evolutionary module which could give rise to the pathological behaviour of patients with OCD.

The appeals to brain science made in this target article are also unconvincing. The authors ascribe a major role in the production of ritualized behaviour to the anterior cingulate cortex (ACC), and ascribe the symptoms of OCD to its defective performance. However, this is one of the largest anatomically defined cortical areas, and recent studies (e.g., Chein & Schneider 2005) show that regions within it support a wide variety of functions, such as domain-general learning, emotional response, placebo effect, and internally directed attention. While indeed part of the subgenual ACC might possibly support the postulated Hazard-Precaution System (Van Laere et al. 2006), this area has also been firmly implicated in mood disorder (Mayberg et al. 2005). The functional anatomy of the ACC is an area of intensive research, and the authors have reached premature conclusions.

Ultimately, B&L reveal their disdain for what quite clearly gives most of us our major motivation, delight, and satisfaction – participation in social rituals such as weddings, funerals, christenings, sporting occasions, graduations, and other initiation ceremonies – by referring to them as a "waste of time" (sect. 9.3). Such an elitist viewpoint undermines the credibility of much of this article.

Ritualized behavior as a domain-general choice of actions

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Abstract: Although we agree that ritualized behavior is a mystery that calls out for an explanation, we do not think that the proposed domain-specific two-component system offers an empirically well-justified and theoretically parsimonious description of the phenomena. Instead, we believe that the deployment of domain-general mechanisms based on choice of actions could also explain the essential features of ritualized behavior.

Fully recognizing that ritualized behavior manifests itself in vastly diversified forms, Boyer & Lienard (B&L) have taken a bold and admirable step in proposing to find a common mechanism that is capable of explaining what they claim to be "core features" across different manifestations of ritual: from pathology in obsessive-compulsive disorder (OCD) to routinely invasive thoughts in adults to various elaborate cultural rituals. Based on various pieces of neuropsychological evidence that link the ritualized behavior observed in OCD sufferers to specific brain pathology in the basal ganglia and cortico-striatal loops, a domain-specific two-component system account has been suggested.

While the account seems quite reasonable in the case of OCD (as well as in other motor and cognitive disorders such as Parkinson's disease), we wonder how far it can be extended to explain ritualized behavior in more complex personal and cultural rituals. In particular, we are not fully convinced by the suggestion that the relatively low-level motor control functions of basal ganglia are primarily responsible for the higher-level ritualized behavior demonstrated in various cultural rituals such as religious ceremonies, ancestor worship, and death rituals. Even the authors constrain their definition of "ritualized behavior" to be "a precisely defined way of organizing a limited range of action" (sect. 1, last para.) (i.e., action ritualization); the gap between motor control functions and ritualized behavior seems too wide to be easily filled. Ritualized behavior in various social scenarios clearly involves more than a failure of motor control, though it may be manifested by rigid, stereotypic, and aimless action sequences.

The authors' proposal for a domain-specific "Hazard Precaution System" for ritualization is also partially based on their observation that most, if not all, ritualized actions have to do with dangers, threats, and hazards that somehow impair individuals' fitness or survival. They argue, for example, that "washers" compulsively seek purity while "checkers" desire security. On their account, when adequate satiation of these desired states is not perceived to have been achieved, precautionary actions have to be taken to correct the situation and from this ritual behavior often arises. Although intuitively appealing, these arguments are difficult (if not impossible) to falsify. First, even from an evolutionary point of view, fitness-related features are quite diversified – food, sex, and pleasure-seeking, to name a few of many, can all be motivating forces for certain types of behavior. It seems that those most commonly observed ritualized actions, such as "washing" and "checking," only cover a tiny subset of these features. To adequately link fitness and ritualized actions, one has to explain this "asymmetry," that is, why some types of fitness features (e.g., "purity" for "washers") are more important (and thus more commonly ritualized) than others. Second, it seems that there is a conflict in the authors' arguments that ritualized actions are often fitness-driven, on one hand, and goal-demoted, on the other. Seeking health and security, which arguably motivates ritualization in the first place, is clearly goal-oriented. The compulsiveness and rigidity demonstrated in ritualized actions may seem senseless on the surface but may not be so beneath. A theory of ritualization has to strike a balance between ultimate fitness-seeking and superficial goal-demotion.

Finally, hazard detection and precaution taking are basic and general neuropsychological mechanisms. In a certain sense, all forms of human behavior can be cast as results of this detection-and-reaction operation. Supplementing this point, many production rule based cognitive architectures, such as ACT-R (Anderson & Lebiere 1998) and Soar (Newell 1990), actually model large domains of human cognitive functions using domain-general rules that are just condition-action pairs. If we conceive of conditions as hazard-related features and actions as precautions plans, these systems, with certain additional constraints, seem to be capable of explaining most of the ritualized behavior mentioned by the authors. In order to claim that hazard detection and precaution generation are specialized systems responsible for ritualized actions, one has to explain why such domain-general mechanisms are insufficient or implausible explanatory devices.

We tend to believe that such domain-general mechanisms are sufficient and may offer a more parsimonious and flexible account for ritualization than the domain-specific two-system proposal. A large body of neuropsychological evidence has suggested that the human brain be viewed as a holistic modular system – while individual modules possess functional specialties embodying rich cognitive functions, causing behavior to emerge when all modules are unified in principled and constrained ways (Farah 2000; O'Reilly & Munakata 2000). The difficulty lies in defining sufficiently rigorous criteria for claiming that some of these modules are part of our evolutionary inheritance, rather than using them as convenient explanatory devices when one doesn't sufficiently consider other alternatives. A striking example concerns the function of Broca's area. Whereas it has long been accepted that Broca's area is specialized for language, it has recently been discovered that the area also plays a role in hierarchical event processing and planning (Koechlin & Jubault 2006). Therefore, it is at least conceivable that contextualized usage of domain-general mechanisms implicated in reasoning and making decisions about simple (but survival-necessary) domains, such as navigating the physical world, could adequately account for ritualization behaviors without sacrificing parsimony. In particular, if we accept that human behavior is generally goal-oriented and that goals are naturally multifaceted due to genetic, evolutionary, social, and cultural constraints, then it is plausible to assume that different modules are evolved to emphasize different types of goals and therefore value actions differently. When the choice of actions preferred by different systems differs, they compete to determine the final decision. Note that this account has been the essence of reinforcement learning (Sutton & Barto 1998) and is supported by a body of neuropsychological and neurocomputational studies (Daw et al. 2005; Sanfey et al. 2003; Wang et al. 2006). Since this account emphasizes the role of executive control in choice of actions, it more closely associates ritualized behavior with the domain-general functions of executive control rather than domain-specific mechanisms.

Uncertainty and rituals

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Abstract: Boyer & Lienard (B&L) elegantly elaborate the links between normal motivational systems and psychopathology and address the evolutionary and cultural context of ritualized behaviors. However, their model omits a key property of the security-motivation (hazard-precaution) system, and this property suggests that ritualized behavior may generate an alternate satiety signal by substituting, in place of uncertainty, a problem that is verifiably solvable.

In the target article, Boyer & Lienard (B&L) build elegantly on our theory that absence of negative feedback in a

security-motivation system generates the symptoms of obsessive-compulsive disorder (OCD) (Szechtman & Woody 2004; Woody & Szechtman 2005). Their article makes contributions to the important theme of conceptualizing psychopathological disorders as dysfunctions of motivational systems (Szechtman & Woody 2006). It does so by elaborating on the normal properties of the security motivation system. In particular, the authors address several important issues, including the evolutionary context of potential danger cues and relevant species-typical behaviors, the developmental and cultural origins of relevant variations in normal behavior, and the importance of learning and cognitive processes in elaborating the workings of the motivational system.

The authors frame their article with the intriguing question, "Why ritualized behavior?" From our perspective, a crucial part of the answer stems from what we consider to be a key property of the security motivation system, but one that was not featured in the authors' interpretation of this system. Namely, the problem addressed by the security motivation system is potential threat, and this problem is inherently open-ended in the following sense: Once the system is activated, there are no stimuli in the external world that provide unequivocal assurance that potential danger is absent. In fact, it is logically impossible to demonstrate that there is no potential danger. Hence, the external environment cannot provide cues for terminating the activity of the security motivation system. It is for this reason that we proposed that the system relies on the performance of security-related behavior itself to provide a satiety signal (which we termed *yedasentience)* as feedback to shut down the system.

The problem of potential threat is also open-ended in the sense that it concerns the prospect of future events, which are inherently uncertain. The issue of uncertainty provides a perspective on the reasons for ritualization that contrasts with those advanced in the target article. In particular, rather than serving to demote goals and swamp working memory, as emphasized by the authors, ritualized behavior may serve to substitute a clearly defined, closed-ended task for the uncertain, open-ended problem of potential threat. A crucial aspect of ritualized behavior is that the question of whether it was performed "just right" is logically answerable, because there are clearly defined rules governing performance of the behavior. Working memory is fully engaged to make sure the behavior is being done correctly, accounting for the high level of concentration during the ritual. In essence, when security-related behaviors do not readily generate the satiety signal in the usual fashion, ritualized behavior may substitute a goal that is verifiably solvable, and thereby generate a substitute satiety signal.

What empirical tests would differentiate the view we are advancing from the authors' interpretation of ritualized behavior? If the function of ritualized behavior is to swamp working memory, then deviations from the ritual should not reduce the effectiveness of the ritual or interrupt its flow. In contrast, if ritualized behavior functions to generate a "just right" satiety signal (yedasentience), then deviations from the ritual should interfere with its effectiveness and provoke starting over from the beginning.

The issue of uncertainty inherent in managing potential danger raises some unique challenges for any organism. One important challenge is how much time to allot to security-related behavior rather than to other survival-related activities. This trade-off admits of no straightforward solution, because it is always possible that further investment in security-related behavior would have been worthwhile, given future events. And yet, an overinvestment in security-related activity may deplete resources necessary to cope with danger when actual danger does materialize. For example, consider a grazing animal. The more time it spends being vigilant for potential predators, the less time it has to graze and nourish itself (Mooring et al. 2004). Paradoxically, if it over-invests in vigilance, it may be insufficiently nourished to cope when real danger does materialize.

Humans are faced with similar uncertainties and a similar trade-off in the allocation of time and resources to being vigilant for potential dangers versus engaging in other survival-related endeavors. Although a rational analysis of potential dangers would take account of their probabilities, our natural, intuitive evaluations are quite different from this (Kahneman et al. 1982). For example, according to Suskind (2006, p. 62), Vice-President Cheney articulated the position that potential threats, rather than being evaluated on the basis of "our analysis, or finding a preponderance of evidence," should instead be evaluated according to a one-percent doctrine: If there is a one percent chance of the reality of the threat, "we have to treat it as a certainty in terms of our response." In essence, if the probability of the threat is more than zero, we need to respond as if it were a certainty. Such a doctrine seems to be a misappropriation of the security motivation system, in the sense that it indicates we should act, once the system is activated, as if the danger were real rather than potential.

It is a trap to seek a sure answer to the question of the absence of potential danger. Nonetheless, in the face of stimuli suggesting potential threat, the security motivation system is readily activated. In this context, we would propose that rituals are more important than B&L suggest in their summary characterization of them as an "occasional byproduct," involving a "waste of time and resources" (sect. 9.3, Epilogue). Rather, rituals, both individual and collective, may serve a necessary role in limiting counterproductive vigilance toward potential threats and providing closure in response to a security-motivation-driven focus on unresolvable uncertainty. We need rituals, even today. Moreover, this potential usefulness of rituals lends considerable importance to further research on the issues advanced in the target article.

Authors' Response

Precaution systems and ritualized behavior

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Abstract: In reply to commentary on our target article, we supply further evidence and hypotheses in the description of ritualized behaviors in humans. Reactions to indirect fitness threats probably activate specialized precaution systems rather than a unified form of danger-avoidance or causal reasoning. Impairment of precaution systems may be present in pathologies other than obsessive-compulsive disorder (OCD), autism in particular. Ritualized behavior is attention-grabbing enough to be culturally transmitted whether or not it is associated with group identity, cohesion, or with any other social aspect of collective ceremonies.

R1. Introduction

Apart from uncertainties caused by the word "ritual," most commentators provided useful suggestions and much-needed additions to our theory of ritualized behavior on several fronts, in particular with regard to the computational and neural requirements of a hazard-management system; the process of ritualization in patients; the

question of a possible comparison between ritualized behavior in obsessive-compulsive disorder (OCD) and in other pathologies; and the dynamics of cultural ceremonies that include ritualized behavior. We discuss each of these themes in turn.

R2. Why no theory of "rituals"?

From the outset, we knew that it would be of some importance to characterize in the most precise terms the domain of behavior we were trying to explain in the target article. This is why we clearly stated (sect. 1 of the target article) that our model was not at all about the vague category of "rituals" but about "ritualized behavior," a precisely identified form of behavior. It is not too uncommon in empirical research programs to abandon ordinary language and create terms that cut across its common categories. So we thought that particular move should be unproblematic – especially given how heavily, explicitly, and repeatedly we labored the point. But the lure of ordinary language is powerful, perhaps irresistible, together with the illusion that its categories must correspond to genuine kinds of objects in the world. This may explain why, for instance, **Turner** sets great store by the etymology of the word "ritual," admittedly a topic of immense interest, although perhaps not for us as we tried to explain behavior. Also, **Hageman** and **Turner** chide us for saying that (cultural) rituals are meaningless, while **Merker**, **Hageman**, and **Foss** are appalled by the notion that all rituals are about fear and anxiety. But, again, we did not make any claims about "rituals." We do not even believe it is possible to say anything specific and explanatory about this vague and confusing category.

Let us just reiterate, then, that "ritual" is a category we can and should dispense with. Instead, we chose to focus on a set of behaviors characterized by goal-demotion, scriptedness, redundancy, and compulsion. These behaviors may or may not be present in any particular situation that we want to call "ritual." What matters to us is why ritualized behavior is compelling and intuitively natural, why it appears at particular points in typical child development, why it becomes pathologically inflated in some conditions, and, most important, why it centers around recurrent themes such as contagion-contamination, assault-predation, and coalitional psychology. Whether a model of this intriguing phenomenon squares with standard or historical understandings of the word "ritual" is a question that can be safely ignored, or left to the philologically minded.

R3. The functional logic of hazard-management

The Hazard-Precaution model starts with the assumption that indirect threats to fitness create a specific adaptive problem: (1) they are quite diverse – as **Eilam** and others point out, it is difficult to see where such threats begin and end; (2) there is no straightforward feedback demonstrating that a threat has been removed, as **Woody & Szechtman** point out, since it is in the nature of such threats that they are not directly observable; (3) appropriate measures cannot be mapped one-to-one on to physically different classes of threats, since each of the latter may require very different precautions depending on the situation, as **Tooby & Cosmides** emphasize. The cognitive systems underpinning such appropriate responses must be (a) smart and (b) specialized, two points that we should emphasize here.

The responses should be smart. In our view, precautionary behavior requires complex computation rather than simply a collection of "instincts" (in the sense of straightforward, unsophisticated reactions to restricted classes of stimuli) as **Behrendt** suggests. Avoiding charging predators may require a unique response, but avoiding potential detection by predators requires context-dependent measures. The same applies, a fortiori, to more complex sources of fitness-threats like contaminated substances or social threats.

The responses should be specialized. It is a consequence of their ecology and fitness effects. A distinction between specific precautions systems may be necessary, as they may have different learning logics and calibration processes during cognitive development. For instance, there seems to be in humans a general preference for open landscapes with plenty of potential refuge and escape routes but also good visibility, which may be interpreted as an evolved precaution against predators (Orians & Heerwagen 1992; Silverman & Choi 2005). There is also a general distaste for festering meats, most probably as a prevention against pathogen ingestion (Fessler 2002; Fessler & Navarrete 2003b). We would assume that these two forms of precautionary processes are handled by distinct specific systems, which orient attention to different cues, trigger specific reactions, and allow learning of associated aspects of situations in different ways. More generally, precautionary behaviors probably correspond to the operation of a variety of systems geared to such special threats as, for example, predation by large animals, assault by conspecifics, social exclusion and status-loss, contamination, and others (we are obviously in no position at this stage to determine the exact contents of this "catalogue"). These different systems have different input formats, follow inferential principles, and produce different outputs.

So, to reformulate what may have been ambiguous in the target article, we did not assume that one should expect to find a unique, integrated Precaution-System in the cognitive architecture of our species. We use the term "precaution system" in the same general way as one would talk about a "mating preference system" or a "foraging system," without specific presumptions as to the diverse neuro-cognitive systems that may support such large functions.

As **Tooby & Cosmides** emphasize, it may make sense to start by considering two encompassing repertoires, of all represented hazards and all represented countermeasures, respectively. But the role of specific inference systems is to establish the particular connections between these repertoires. Functional diversity may be relevant to explaining differences in the extent to which precaution systems are flexible, context-dependent, and open to cultural input. In particular, while some systems seem to take environmental cues as input (e.g., a position in a landscape is intuitively perceived as protected or vulnerable), others require vast amounts of calibration to local conditions or norms (e.g., preserving friendships and coalitions).

Importantly, as **Tooby & Cosmides** point out, each domain of threat is *cognitively* defined. That is, there are no definite physical features that would necessarily mark

off social exclusion threats from assault threats. It is only by interpreting accessible information in a specific way that the organism can identify a particular situation as an example of the former or latter kinds of threat. So the different precaution systems are *not* specialized in physically distinct types of situations, but in types of situations that represent different kinds of threat and require different appropriate counter-measures *for agents at specific stages of their development and belonging to specific social categories*. As such we should expect systematic variations in agents' appraisal, between females and males (**Saad**), infants, children, adolescents, and adults. Social threats, for instance, may consist in a huge variety of utterances, gestures (or in the absence thereof), which only a long chain of inferences can convert into threats to the person's fitness. There may be an infinite number of ways to diminish someone's status – ways that, moreover, differ according to the person's status – but an efficient precaution system should associate them with the unique threat of status-loss. This is why, as **Huppert & Cahill** point out, some pathological obsessions and their normal counterparts often include "modern" themes (e.g., car accidents), which shows that precaution systems are learning systems, not situation-driven fixed responses.

Such flexibility and complexity does not entail the operation of domain-general, all-purpose reasoning processes, as **Wang & Bello** propose. In our view, the general reasoning models proposed are less than compelling descriptions of the computations required. Production-rules are only as good as their fit to particular domains of action, and the problem here is, precisely, that specific rules are required to nudge organisms towards the most appropriate precautions. Moreover, our aim was to model, not the way computational systems in general could handle information about threats and precaution, but how specific biological systems actually do it. Evidence from selective phobias and obsessions, as well as neuro-functional evidence, suggest specialization rather that the operation of general reasoning.

R4. Ritualization process and satiation in OCD

The Hazard-Precaution model does not require a strict demarcation between normal and pathological situations, contrary to what **Foss** contends. Indeed, we emphasized the continuum between normal, sub-clinical, and clinical manifestations. We are content with the assumption that ritualization is pathological to the extent that it constitutes "harmful dysfunction" (Wakefield 1992; 2003), which implies no straightforward demarcation between pathology and the normal case. Also, it is certainly true, as **Huppert & Cahill** point out, that ritualized behavior as described here is not the sole component of OCD symptomatology. But our aim was to describe a specific form of behavior, not to provide a unified account of "OCD" as a clinical construct (which may be a futile pursuit in any case). However, these confusions may result from our own description, as we did not specify to what extend ritualized behaviors could be expected as outcome of the activation of precaution systems.

The main point in the model is that precaution systems trigger particular, species-specific, and contextually appropriate precautionary behaviors. Among these could be included a great many intrusive thoughts and other apparently "irrational" manifestations common in non-clinical populations (Rachman & de Silva 1978). In general, these behaviors span the entire range from elementary actions to highly scripted precautionary sequences. Humans perform many precautionary behaviors on account of the socially transmitted information that such behaviors are appropriate (e.g., burning the sheets and clothes of infected patients), and they often take care to perform these actions in the precise way prescribed. People do not care to modify the established recipes, either because it is simply efficient to adopt the process without much scrutiny or because there is no effective means of verification. What marks off the pathological extreme of precautionary behavior from intricate precautionary behavior recipe are such features as the intensity of the compulsion, the anxiety level in case of non-performance, the compulsion to repeat the precautionary behaviors, and the extend to which the behavior's ritualization is felt as intrusive and overbearing. Obviously, the pathology can include many other responses to obsessive intrusions, as **Huppert & Cahill** emphasize. Those symptoms that do not include ritualized behavior fall outside the scope of this model. In the case of OCD, Huppert & Cahill also point out that the compulsive aspect of ritualized behavior is often driven by hyper-responsibility, typical in the "thought-action fusion" observed in many patients (Foa et al. 1993). This last feature, in precaution-based interpretations, may well be an outcome rather than a cause of the pathology. To the extent that precaution systems orient attention and motivation to potential unwanted effects of own actions, their impairment might result in such inflated construals of one's responsibility.

As we noted above, precautionary behaviors, by their nature, cannot be terminated by the perception that the precaution has been effective. You cannot decide through observation that you have reduced the probability of an event that never happened, as **Eilam**, **Woody & Szechtman**, **Rutherford**, and **Tooby & Cosmides** point out. So it is likely that precaution systems include some termination mechanism, which limits the fitness cost of taking excessive precaution. In principle, this may reside in the precaution scripts themselves as self-terminating processes. However, it would then be difficult to understand why OCD patients, who have the same scripts as normal individuals for precaution actions, still cannot help repeating the actions.

On the basis of animal models and neuro-psychological evidence, Szechtman and Woody proposed that a special circuit provides a satiety signal (Szechtman & Woody 2004) which itself allows a shift to other, non-precaution-related goals. We did include this in our model of the neural circuitry involved in ritual, but perhaps did not do justice to this important component of the neural processes involved.

This may be why **Woody & Szechtman** criticize us for not providing a clear explanation of the use of ritualized behaviors. They also highlight the contrast between the respective predictions of their model and ours. In our view, there is not such a great discrepancy. We accept the central contention of the Szechtman-Woody (henceforth SW) model, that security motivation results (in the normal case) in behaviors that themselves trigger some satiety or just-right signal. We also accept that this signal

is *not* produced by feedback about the objective elimination of threats, since the system's only possible effect is to reduce the likelihood of threats. We agree that the absence or weakness of such a signal is a fundamental piece of the OCD pathology. The real contrast is in the account of the ritualization process in OCD pathologies. In the SW model, the ordinary satiety signal is provided by visceral systems, with input to the limbic system. In cases of excessive ritualization, SW suggest that there is displacement, in the sense that a controllable routine is substituted for the appropriate precaution behaviors, and the fact that it is accomplished as planned triggers the satiety signal. The picture we propose is both a refinement of this idea and a slightly different interpretation.

In our view, the OCD pathology comprises two manifestations that are not usually distinguished in the theoretical models:

(a) Unstoppable reiteration. The behaviors cannot be stopped because they are not felt to be completed: for example, as with patients who incessantly wash their hands or check their door locks. The action is reiterated until (usually) some external occurrence forces the patient to stop, or the satiety signal finally saturates the appraisal system.

(b) Scripted behavior, for example, tapping several pieces of furniture with a particular hand in a particular order, before leaving the room, or washing each body part a certain number of times in a certain order. In this case, the action is terminated once the script is properly performed.

Obviously, the actual symptomatology in most cases includes many combinations of these two types. But it is important to keep this distinction in mind, because it may provide the elements of a (speculative) reconstruction of the dynamics of ritualization. The evidence suggests that unstoppable reiteration is generally concentrated on actions (washing, checking) that are directly relevant to the security concerns of hazard-management systems, such as assault-predation and contamination. On the other hand, at least some of the scripted behaviors escape from this domain. This is why, for instance, some patients have rituals in which the prescribed behavior (e.g., tying one's shoe laces a certain number of times) ends up being detached from the usual precautionary repertoire.

Woody & Szechtman are of course right that one should explain why patients persist in their rituals and why performance must be rigid. In our view, this is not because a substitute satiety signal is provided. Indeed, in cases of unstoppable reiteration, there is no just-right feeling (or it exists in an inefficient or too attenuated form to succeed in decreasing at once the level of anxiety). A solution might be at hand if we follow **Swain** in suggesting the involvement of a reward. What ritualized behavior produces, on the other hand, seems to be a specific reward, in the form of a lowered anxiety level, which we interpreted as the result of making intrusive thoughts less accessible for the duration of the precaution system's activation. So in our view the "substitution" is the replacement of a (absent or inefficient) just-right or satiety signal by a positive reward. The latter is associated with attentional focus on the rules governing exact performance, and therefore reinforces adherence to these rules. In this sense, then, we would include in the model decision-making considerations of the kind suggested by Cavedini and colleagues, consistent with excessive discounting observed in many OCD patients (Cavedini et al. 2006).

R5. Comparison of ritualistic pathologies

Since OCD is characterized by compulsive repetition of apparently unmotivated behaviors, it makes sense to compare it to other pathologies with unwanted or purposeless repetition and stereotypy, notably autism and Gilles de la Tourette's syndrome as well as some forms of Parkinson's disease and schizophrenia. This seems all the more relevant as there is a clear comorbidity between some of these conditions and OCD.

However, we should introduce a caveat here, concerning the use of such terms as "stereotypic" or "ritualistic" in the clinical literature. These terms, when used for symptomatologies as diverse as Huntington's chorea, Tourette's syndrome, and OCD, denote vastly different ways of organizing action. For instance, stereotypy in Tourette's syndrome concerns an idiosyncratic but restricted domain of gestures and utterances, repeated in various situations, outside the patient's control. Autistic repetition also concerns gestures and utterances, but within a larger repertoire, and these are not perceived as alien by the patient. Both Tourette's syndrome and autism contrast with the unstoppable behaviors of OCD patients (generally about evolutionary threats) and their scripted rituals (with high cognitive control). To bring together these disparate phenomena under the umbrella term "stereotypy" may be more misleading than illuminating.

This being said, the problem of stereotypy in autism, underlined by **Kirov**, **Rothenberger, Roessner, & Banaschewski** (**Rothenberger et al.**), **Benga & Benga,** and **Rutherford**, is of great interest to models of OCD. About 90% of adolescent and adult autistic patients display abnormal repetitive behaviors, both stereotyped and purposeless (Seltzer et al. 2003). Do these constitute ritualized behavior in the sense describe in our model? Autistic stereotyped behavior (and to some extent similar behaviors in schizophrenia) differs from typical OCD manifestations: (1) The former are highly variable (all sorts of gestures or movements are used) rather than concentrated (on such themes as checking and cleaning). (2) They are non-motivated (the subject is not aware of any reason for acting stereotypically) rather than motivated (e.g., to prevent accidents or disasters). And, (3) as we discuss further on in this response, though the autistic patient might often be motivated to rehearse precise sets of acts in particular situations felt as threatening or challenging, behaviors and threats seem not to be conceptually linked in autism, whereas the linkage is more often than not the case in OCD. Despite these differences, it makes sense to notice the overlap in the compulsion and repetition and to try and make sense of its possible neural correlates in both disorders.

This is difficult because the neural underpinnings of the autism spectrum are much less circumscribed than those of OCD. In terms of anatomical differences, structural imaging has shown differences between autistic patients and controls in the orbitofrontal cortex (Carper & Courchesne 2000; 2005) and in the cerebellum (Allen et al. 2004).

Functional differences are also numerous, from the orbitofrontal-amygdala connection (Bachevalier & Loveland 2006) and the activation of the Broca and Wernicke language areas (Harris et al. 2006), to more clearly social circuits like medial prefrontal areas (Frith 1996; Happe et al. 1996) and superior temporal sulcus (STS) (Pelphrey et al. 2005). That functional imaging finds so many specific activations in autism is not surprising as the condition typically develops from infancy and therefore affects the overall brain development. In comparison, OCD is often a late developing condition in a partly- or fully-formed brain.

Despite all this, the comparison is highly informative. There are relevant differences between autistic patients and controls in caudate volumes (Sears et al. 1999), as well as hemispheric differences in the caudate in patients (Hollander et al. 2005). Furthermore, the divergence from controls in basal ganglia volume correlates with the severity of stereotypic behavior (Hollander et al. 2005). Specific alteration of the striatum would be consistent with stereotypy symptoms. This would suggest that part of the typical impairments associated with autism might consist in a similar failure to reach closure after performance of particular actions.

There may be deeper similarities, too. The evidence suggests that some aspects of autistic stereotypy may be very close to an impairment of security systems. **Benga & Benga** state that in autism rituals seem to be performed without any clear connection to threat avoidance. In terms of conceptual content, it seems indeed that behaviors and threats are not linked. Note, however, that stereotyped behavior in many autistic patients is triggered or intensified in anxiogenic situations, such as the presence of strangers or forced social interaction (Ahearn et al. 2003). Systematic studies of the onset of stereotypy show that it generally follows the occurrence of an aversive stimulus, and the offset correlates with appearance of attractive stimuli (Gal et al. 2002). Also, one of the major symptoms of autism is reduced exploration of the environment, correlated with restricted growth in particular cortical structures and the cerebellum (Pierce & Courchesne 2001). This would suggest that, for the autistic patient, at least a subset of the stereotypy symptoms are proximally triggered by situations we identified as typical of indirect fitness threats: the presence of strangers, and the need to explore one's environments beyond familiar confines. This certainly does not contribute to an explanation of autism, but may help clarify the true and the misleading similarities.

In this view, then, stereotypy may be a specific distortion of behavior that may or may not be associated with the other features typical of OCD. This also makes it easier to understand the presence of stereotypy in other animal species. Similar pathologies are observed in animals, especially in caged animals that develop stereotypic and purposeless behaviors. One interesting point is that these behaviors are invariable taken from the normal range of (predatory, exploratory, sexual, precautionary) behavior typical of the species. Second, the appearance and severity of the symptoms depend on external factors. For instance, stereotypy is greatly reduced when caged animals are provided with security cues (a covered place out of sight) and with later weaning (in lab rats) (Wurbel et al. 1998).

R6. Ritualized behavior and cultural material

Many commentators focused on our description of ritualized behavior in the context of what are generally called collective ceremonies or rituals. Since this was the least-developed part of the model, we welcome the opportunity to make it more specific. First, we must reiterate that the model is not about "cultural rituals" in general, for the same reason that it is not about "rituals" in general, as explained earlier. According to **Hageman,** and to some extent by **Alcorta & Sosis** and **Merker**, the model proposed carries the assumption that collective ceremonies (to use a fairly neutral term) in general consist in ritualized behavior. But we are only concerned with the occurrence of ritualized behavior, its effects, and its conditions of transmission.

Now, one feature of ritualized behavior is goal-demotion, a disconnection between action-sequences and goal-representations. To the extent that ceremonies include ritualized behavior, they include actions for which an overall goal can be formulated but without the hierarchy of sub-goals that usually accompany parts of the action (Zacks & Tversky 2001). While a sequence of actions is associated with a goal, its components or sub-actions are *not* related to sub-goals. Consider a typical blessing ritual among the Turkana of Eastern Africa, in which the elders smear chyme on the bodies of juniors (Liénard & Boyer 2006). By such smearing elders are said to bestow their protection unto the young men. But why would the operation have to follow a very specific and precise sequence (ritualized behavior) to make that person safer? The overall goal, to protect a person, is not accompanied by sub-goals that would correspond to each of the sub-actions required, namely smearing the forehead first, then the shoulders and the chest repeatedly, then plucking a small quantity of chyme between the big toe and the next toe. The overall goal of the ceremony does not explain why all this should be precisely scripted and rigidly performed. Nor will it be of much use, as most anthropologists know, to invoke the idiosyncratic rationalizations for ritual sequences – rationalizations that people in small-scale societies sometimes provide after much prodding – or the literate theological justifications produced by literate theologians. These justification and rationalizations are fascinating cultural creations, but they do not explain the scriptedness and rigidity which are our object.

Goal-demotion is difficult to understand and may easily lend itself to misinterpretation, if one tries to frame it within everyday categories. For instance, **Turner** seemed distressed by our alleged description of collective rituals as "meaningless," apparently under the influence of our "compatriot" [sic] Dan Sperber. This would be very bad indeed. But we certainly eschew any claims about "meaning" or its absence – the sort of issues we would rather leave to professional philosophers. To ask whether any action has "meaning" or not seems to us even more nebulous than asking whether or not the action belongs to a "ritual." What people understand by the "meaning" of actions is so unconstrained that participants in ceremonies can state either that their actions are extremely meaningful (Bell 1992), or that they are utterly meaningless (Humphrey & Laidlaw 1993); and both can be right, as it is unclear what these claims amount to in terms of cognitive processes, the object of our model.

Features of ritualized behavior include not just goal-demotion and compulsion, but also internal redundancy and rigidity in repetition. In our view, the co-presence of these different features suggests a specific way of processing action-representations. This is why we would resist analogies with other forms of behavior in which we find, singly, either rigidity, or goal-demotion, or other features. For instance, as **Fessler** points out, many recipe-like behaviors would seem to show goal-demotion. True, most people who follow long cooking recipes may do so without representing the particular goals achieved by each step of the recipes. This might count as goal-demotion, but the comparison between cooking and ritualized behavior is not very informative, as it does not say much about the crucial differences: the presence of compulsion, rigidity and internal redundancy in the latter, but not in the former.

This is also why we beg to differ from **Fessler**'s tempting suggestion that most cultural ceremonies may be founded on "magical" associations. The anthropological evidence does suggest that many ceremonies do trigger some spurious causal associations. That is, some action is presented and its result is assumed to obtain. Fessler sees this as a fundamental feature of ritualized action. This would suggest an alternative to our model. In that view, people would be likely to represent spurious causation for uncertain outcomes, and act accordingly (in a "magical" way). The presence of precaution themes would be only a consequence of that process, unsurprising since precautionary thinking is itself generally based on imagined (if not imaginary) causation. However, a problem for that view is to explain why the spurious associations represented should invariably center on the themes of predation, attack, social threat, and contagion.

From our point of view, it seems more parsimonious to see the "magical" flavor of many ceremonies as a predictable consequence of the activation of precaution systems, in itself triggered by precaution themes (invisible danger, for instance). Since precaution systems *always* combine the representation of a distant threat with the representation of a preventative action, they necessarily suggest courses of action for which there is no easy demonstration of efficacy. You cannot demonstrate that the absence of predator attacks was caused by your camouflage, since the former is a null effect, as it were.

This goes to the heart of the distinction between "rituals," a loosely organized category of actions, situations, and behaviors, and the specific phenomenon of ritualized behavior that we described in our model. Note that ritualized behaviors can be found outside of the realm of cultural ritual, for example, in sport, as a way of alleviating anxiety prior to a competition, as **Jackson & Masters** propose. Interactions that comprise ritualized behavior may also include all sorts of other phenomena. Indeed, some forms of cultural transmission may easily piggyback on the attention-grabbing potential of ritualized behavior, and even share some features with it. As **Pyysiäinen** points out, the effects of ritualized behavior on working memory may be found in a whole variety of techniques, including some forms of meditation and mysticism. We certainly concur that the cultural effects of ritualized behavior – for instance, enhancing the salience of particular associations, or making particular events memorable if not explicable – are usually accompanied by a host of other manipulations of mental processes, from music to dancing to alterations of consciousness. These, however, are secondary from the point of view of our discussion in the target article and here: that is, to provide an explanation for the recurrence of ritualized behavior. The fact that ritualized behavior is associated with, for example, magical claims, or hierarchy displays, or the reinforcement of ethnic affiliation, does not explain the compelling nature and rigidity of the ritualized behavior itself.

Our model suggests that ritualization is really diametrical to routinization. In actual ceremonies, one is bound to find *both* highly routinized and highly ritualized behavior. The Precaution model also suggests that, *inasmuch as* there is ritualized behavior in collective ceremonies, one would find activation of precaution systems. Now, as **McCauley** points out, the commitment of some participants in most ceremonies or of most participants in some of them is minimal. This entails that, as far as those participants are concerned, the sequence of behavior does not constitute ritualized behavior as defined here, and is therefore outside the scope of this model. For that same reason, the model does not entail that collective ceremonies in general are about "anxiety" or "precaution," as **Foss** and **Turner** imagined. Many forms of collective action are indeed a source of innocent merriment as much as anguished precaution. But that is clearly irrelevant. What our model implies, in a more precise manner, is that, *inasmuch as* there is ritualized behavior in rituals and ceremonies, it is liable to activate precaution systems in at least some of the participants, and thereby enjoy some transmission advantage.

This is intrinsically an epidemiological claim (Sperber 1996). We are not making claims about the "origins" of particular cultural institutions or the ultimate "reason" why people perform ceremonies – indeed we are not sure that these questions make much sense. We are only considering transmission, and arguing that transmission is intrinsically entropic, as it depends on imperfect acquisition and communication processes. Against this, the presence of highly recurrent features in many collective ceremonies (Dulaney & Fiske 1994) requires an explanation.

We proposed that ceremonies that include such precaution-relevant themes would be more likely to be transmitted than those that do not. Also, as **Orrock** points out, an important effect of ritualized behavior may be to allow recalibration of defenses against indirect threats, which is why we should and do observe connections between particular points in the life-cycle and particular forms of individual and collective ritualization. As **Schipper, Easton, & Shackelford** (**Schipper et al.**) suggest, the specific stage of the life-cycle at which an agent is indeed predicts that agent's sensitivity to specific problems. All this, obviously, is not the same as saying that "low-level motor control functions of basal ganglia are primarily responsible for higher-level ritualized behavior demonstrated in various cultural rituals," a claim that **Wang & Bello** find odd – perhaps because it could not be found in the target article.

R7. Ritualized behavior as adaptation

A central question is whether evolved mental capacities are specifically geared to the production of collective

action with ritualized behavior. As we said in the target article, most functionalist accounts of ritualized behavior so far flounder because they provide an account of social or cognitive outcomes that would be optimally provided *without* scripted, rigid, goal-demoted, et cetera, action-sequences. If "rituals" convey religious knowledge or maintain social identity, many non-ritual forms of interaction do that just as well.

By contrast, **Merker** and **Alcorta & Sosis** offer a more refined explanation, centered on the costly nature of many ceremonies – costly not only in terms of resources but also in pain and danger – suggesting that a deliberate diminution of one's own fitness is the point of the whole exercise. In this sense human ceremonies could be compared to various traits and behaviors that impose a handicap on their bearers and therefore advertise a surplus of fitness potential (Zahavi & Zahavi 1997). They could be more precisely defined as a strategic form of costly signaling (Grafen 1990).

We briefly – perhaps too briefly – discussed this possible interpretation. We think **Merker** and **Alcorta & Sosis** suggest something both plausible and important, namely, that some forms of social behavior may constitute self-imposed fitness-losses, and that we may have evolved dispositions for identifying such behaviors and interpreting them as paradoxical fitness-signals, according to the handicap principles (Zahavi & Zahavi 1997). However, we have reservations on two fronts.

First, the association between ritualized behavior and costly performances do not explain the features of ritualized behavior. We agree that ritualized behavior may be co-present with various forms of signaling, including costly, handicap-based signaling, in a great many social ceremonies. However, as we said in the target article, a whole variety of social interaction processes are contingently associated with specific episodes of ritualized behavior in specific groups. That is, it is certainly impossible to engage in ritualized behavior with other people without, at the same time, communicating some information about status, or about commitment, or about conflicts, and so forth. In our view, however, these processes – including the occurrence of costly signaling – are not good candidates for a general model of ritualized behavior because (a) they are not invariably associated with the latter, and (b) even if they were frequent enough, they would not explain why the behavior is *ritualzed*. For example, blood letting (through penile incisions, for instance) can be done ritualistically (in the precise sense adopted here) or matter-of-factly in front of everyone. Both behaviors could be conceived of as costly signaling. But this would not account for the differences between the two kinds of behavior.

Second, our challenge was to explain why ritualized behavior is so consistently associated with such themes as contagion, assault, and other fitness threats. This is where the association with signaling, even if it was general, would be of little explanatory help, without additional specific hypotheses.

We have similar reservations about the various uses of "ritual" as described in cultural anthropology. For instance, **Alcorta & Sosis** are probably right in suggesting that, in many cases, an outcome of ritualized behavior is that particular conceptual associations are strengthened as a result of attention-grabbing experience. However, we should also note that in many situations of ritualized behavior, the main focus of possible query would be the connection between goals and recipes, and that is precisely what remains obscure to most participants. Most rituals do not communicate much or communicate very well, in terms of transmitting unambiguous norms or concepts (see reviews in Bloch 1974; Lawson & McCauley 1990; Liénard & Boyer 2006; Sperber 1975; Staal 1990).

R8. Outstanding questions

Our aim was to contribute to an integrated explanation of ritualized behavior, starting from deep models of neurocognitive function (Szechtman & Woody 2004) and of hazard-management (Cosmides & Tooby 1999). Although there has been substantial progress in the neuropsychology and neurophysiology of such conditions as OCD, there remain great lacunae in our understanding of normal and pathological threat-management. Some of these uncertainties stem from a lack of relevant evidence, particularly in the description of OCD (and other conditions') symptomatology.

First, theoretical models, such as the one put forward in our target article but also most current interpretations of ritualization, would require specific descriptions of symptomatic evolution in patients, from the first manifestations to the clinical presentation observed by the therapist or neuropsychologist. The paucity of detailed case histories makes it very difficult to test any claims about the dynamics of ritualization, which is crucial to validating models in terms of security-motivation or working memory processes.

Second, we have only rather vague, impressionistic descriptions of what we call ritualized or stereotypic behaviors in the various pathologies, from Tourette's syndrome to OCD, schizophrenia, and autism. As noted above, there are important differences between purposeless reiterated gestures, unstoppable goal-directed behaviors, and complexly scripted precautionary measures. But this distinction is only the beginning. Very few clinical descriptions provide us with a detailed account of who does what, when, and how often. A brilliant exception is **Eilam**'s research into the parameters of ritualized behavior in some OCD patients (Eilam et al. 2006). We consider that such highly specific ethological descriptions of patient presentation should constitute a major element in our understanding of the underlying impairment.

REFERENCES

The letters "a" and "r" before author's initials stand for target article and response references, respectively.

Abdel-Khalek, A. M. & Lester, D. (1998) Reliability of the Arabic Obsessive-Compulsive Scale in Kuwaiti and American students. *Psychological Reports* 83(3):1470. [aPB]

Abed, R. T. & de Pauw, K. W. (1998) An evolutionary hypothesis for obsessive compulsive disorder: A psychological immune system? *Behavioural Neurology* 11(4):6. [aPB]

Abramowitz, J. S., Deacon, B. J., Woods, C. M. & Tolin, D. F. (2004) Association between Protestant religiosity and obsessive-compulsive symptoms and cognitions. *Depression and Anxiety* 20(2):70–76. [JES]

Abramowitz, J. S., Schwartz, S. A., Moore, K. M. & Luenzmann, K. R. (2003) Obsessive-compulsive symptoms in pregnancy and the puerperium: A review of the literature. *Journal of Anxiety Disorders* 17(4):461–78. [aPB]

Adler, C. M., McDonough-Ryan, P., Sax, K. W., Holland, S. K., Arndt, S. & Strakowski, S. M. (2000) fMRI of neuronal activation with symptom provocation in unmedicated patients with obsessive compulsive disorder. *Journal of Psychiatric Research* 34(4–5):317–24. [aPB]

Adolphs, R. (2002) Social cognition and the human brain. In: *Foundations in social neuroscience*, ed. J. T. Cacioppo, G. G. Berntson, R. Adolphs, C. S. Carter, R. J. Davidson, M. K. McClintock, B. S. McEwen, M. J. Meaney, D. L. Schacter, E. M. Sternberg, S. S. Suomi & S. E. Taylor, pp. 313–32. MIT Press. [CSA]

Ahearn, W. H., Clark, K. M., Gardenier, N. C., Chung, B. I. & Dube, W. V. (2003) Persistence of stereotypic behavior: Examining the effects of external reinforcers. *Journal of Applied Behavior Analysis* 36(4):439–48. [rPB]

Alcorta, C. (2006) Religion and the life course: Is adolescence an "experience expectant" period for religious transmission? In: *Where God and man meet: How the brain and evolutionary sciences are revolutionizing our understanding of religion and spirituality*, ed. P. McNamara, pp. 55–80. Praeger. [CSA]

Alcorta, C. & Sosis, R. (2005) Ritual, emotion and sacred symbols: The evolution of religion as an adaptive complex. *Human Nature* 16:323–59. [CSA]

Alcorta, C. & Sosis, R. (forthcoming) Ritual: Signals, songs, and sentiments. In: *Encyclopedia of human-animal relationships*, ed. M. Bekoff. Greenwood. [CSA]

Al-Issa, I. (2000) Does the Muslim religion make a difference in psychopathology? In: *Al-Junun: Mental illness in the Islamic world*, ed. I. Al-Issa, pp. 315–53. International Universities Press. [aPB]

Allen, G., Müller, R.-A. & Courchesne, E. (2004) Cerebellar function in autism: Functional magnetic resonance image activation during a simple motor task. *Biological Psychiatry* 56(4):269–78. [rPB]

Almond, P. (1982) *Mysticism and religious doctrine*. Mouton. [IP]

American Psychiatric Association (1995) *Diagnostic and statistical manual of mental disorders, 4th edition*. American Psychiatric Association. [aPB]

(2000) *Diagnostic and statistical manual of mental disorders, 4th edition* (Text revision). American Psychiatric Association. [LDS]

Anderson, J. R. & Lebiere, C. (1998) *The atomic components of thought*. Erlbaum. [HW]

Andresen, J. & Forman, R. K. C., eds. (2000) *Cognitive models and spiritual maps: Interdisciplinary explorations of religious experience*. Imprint Academic. [IP]

Arnold, P. D., Zai, G. & Richter, M. A. (2004) Genetics of anxiety disorders. *Current Psychiatry Reports* 6(4):243–54. [aPB]

Arrindell, W. A., de Vlaming, I. H., Eisenhardt, B. M., van Berkum, D. E. & Kwee, M. G. (2002) Cross-cultural validity of the Yale-Brown Obsessive Compulsive Scale. *Journal of Behavior Therapy and Experimental Psychiatry* 33(3–4):159–76. [aPB]

Atance, C. M. & O'Neill, D. K. (2005) The emergence of episodic future thinking in humans. *Journal of Learning and Motivation* 36:126–44. [OB]

Bachevalier, J. & Loveland, K. A. (2006) The orbitofrontal-amygdala circuit and self-regulation of social-emotional behavior in autism. *Neuroscience and Biobehavioral Reviews* 30(1):97–117. [rPB]

Baddeley, A. D. (1990) *Human memory: Theory and practice*. Oxford University Press. [RT]

(2000) Short-term and working memory. In: *The Oxford handbook of memory*, ed. E. Tulving & F. I. M. Craik, pp. 77–92. Oxford University Press. [aPB]

Baldwin, D. A. & Baird, J. A. (1999) Action analysis: A gateway to intentional inference. In: *Early social cognition: Understanding others in the first months of life*, ed. P. Rochat, pp. 215–40. Erlbaum. [aPB]

Baldwin, D. A., Baird, J. A., Saylor, M. M. & Clark, M. A. (2001) Infants parse dynamic action. *Child Development* 72(3):708–17. [aPB]

Ball, G. F. (1999) The neuroendocrine basis of seasonal changes in vocal behavior among songbirds. In: *The design of animal communication*, ed. M. D. Hauser & M. Konishi, pp. 213–54. MIT Press. [CSA]

Banaschewski, T., Siniatchkin, M., Uebel, H. & Rothenberger, A. (2003) Compulsive phenomena in children with tic disorder and attention deficit-hyperactive disorder. *Zeitschrift für Kinder- und Jugendpsychiatrie und Psychotherapie* 31:203–211. (Article in German). [RK]

Banaschewski, T., Woerner, W. & Rothenberger, A. (2003) Premonitory sensory phenomena and suppressibility of tics in Tourette Syndrome – developmental aspects in children. *Developmental Medicine and Child Neurology* 45:700–703. [AR]

Barker-Collo, S. L. (2003) Culture and validity of the Symptom Checklist-90-Revised and profile of mood states in a New Zealand student sample. *Cultural Diversity and Ethnic Minority Psychology* 9(2):185–96. [aPB]

Baron-Cohen, S. (1997) *The maladapted mind: Classic readings in evolutionary psychopathology*. Psychology Press. [aPB]

Baron-Cohen, S. & Wheelwright, S. (1999) Obsessions in children with autism or Asperger syndrome: A content analysis in terms of core domains of cognition. *British Journal of Psychiatry* 175:484–90. [MDR]

Barrett, H. C. (1999) Human cognitive adaptations to predators and prey. Doctoral Dissertation, Department of Anthropology, University of California, Santa Barbara. [aPB]

(2005) Cognitive development and the understanding of animal behavior. In: *Origins of the social mind: Evolutionary psychology and child development*, ed. B. J. Ellis & D. F. Bjorklund, pp. 438–67. Guilford Press. [aPB]

Barth, F. (1987) *Cosmologies in the making: A generative approach to cultural variation in inner New Guinea*. Cambridge University Press. [RNM]

(1993) *Balinese worlds*. University of Chicago Press. [aPB]

Bauer, P. J. & Mandler, J. M. (1990) Remembering what happened next: Very young children's recall of event sequences. In: *Knowing and remembering in young children*, ed. R. Fivush & J. Hudson. Cambridge University Press. [OB]

Bauer, P. J., Kroupina, M. G., Schwade, J. A., Dropik, P. L. & Wewerka, S. S. (1998) If memory serves, will language? Later verbal accessibility of early memories. *Development and Psychopathology* 10:655–79. [OB]

Bechara, A. (2004) The role of emotion in decision-making: Evidence from neurological patients with orbitofrontal damage. *Brain and Cognition* 55:30–40. [JLO]

Becker, K., Jennen-Steinmetz, C., Holtmann, M., El-Faddagh, M. & Schmidt, M. H. (2003) Comorbidity of compulsive disorders in childhood and adolescence. *Zeitschrift für Kinder- und Jugendpsychiatrie und Psychotherapie* 31:175–85. (Article in German). [RK]

Behrendt, R. P. (2005) Passivity phenomena: Implications for the concept of self. *Neuro-Psychoanalysis* 7:185–207. [R-PB]

Bell, C. M. (1992) *Ritual theory, ritual practice*. Oxford University Press. [rPB]

(1997) *Ritual: Perspectives and dimensions*. Oxford University Press. [JHH]

Benga, I. (2005) *Folkloric tradition and its oral transmission.* Ecco Cluj. [OB]

Ben-Pazi, A., Szechtman, H. & Eilam, D. (2001) The morphogenesis of motor rituals in rats treated chronically with the dopamine agonist quinpirole. *Behavioral Neuroscience* 115:1301–17. [DE]

Bertschy, G. & Ahyi, R. G. (1991) Obsessive-compulsive disorders in Benin: Five case reports. *Psychopathology* 24(6):398–401. [aPB]

Beyer, S. (1973) *The cult of Tara: Magic and ritual in Tibet*. University of California Press. [IP]

Biederman, J. & Faraone S. V. (2005) Attention-deficit hyperactivity disorder. *Lancet* 366:237–48. [RK]

Biederman, J., Faraone, S. V., Keenan, K., Benjamin, J., Krifcher, B., Moore, C., Sprich Buckminste, S., Ugag, K., Jellinek, M. S. & Steingard, R. (1992) Further evidence for family genetic risk factors in attention deficit hyperactivity disorder: Patterns of comorbidity in probands and relatives psychiatrically and pediatrically referred samples. *Archives of General Psychiatry* 49:728–38. [RK]

Birch, L. L. (1990) The control of food intake by young children: The role of learning. In: *Taste, experience, and feeding*, ed. E. D. Capaldi & T. L. Powley, pp. 116–35. USical Association. [aPB]

Bjorklund, D. F. & Pellegrini, A. D. (2002) *The origins of human nature: Evolutionary developmental psychology.* American Psychological Association. [aPB]

Blair, R. J. R. (2001) Neurocognitive models of aggression, the antisocial personality disorders, and psychopathy. *Journal of Neurology, Neurosurgery and Psychiatry* 71(6):727–31. [aPB]

Blier, P., Habib, R. & Flament, M. F. (2006) Pharmacotherapies in the management of obsessive-compulsive disorder. *Canadian Journal of Psychiatry* [*Revue Canadienne de Psychiatrie*] 5:417–30. [RK]

Bloch, M. (1974) Symbols, song, dance, and features of articulation: Is religion an extreme form of traditional authority? *European Journal of Sociology* 15:55–81. [arPB]

Bloch, M. & Parry, J., eds. (1982) *Death and the regeneration of life.* Cambridge University Press. [aPB]

Bond, G. D. (1988) *The Buddhist revival in Sri Lanka*. South Carolina University Press. [IP]

Borg, J., Andree, B., Soderstrom, H. & Farde, L. (2003) The serotonin system and spiritual experiences. *American Journal of Psychiatry* 160(11):1965–69. [JES]

Bornstein, M. H. & Krinsky, S. J. (1985) Perception of symmetry in infancy: The salience of vertical symmetry and the perception of pattern wholes. *Journal of Experimental Child Psychology* 39(1):1–19. Available at: http://elsevier.com; http://www.academicpress.com/jecp [aPB]

Bornstein, M. H. & Stiles-Davis, J. (1984) Discrimination and memory for symmetry in young children. *Developmental Psychology* 20(4):637–49. [aPB]

Boyd, R. & Richerson, P. J. (1985) *Culture and the evolutionary process.* University of Chicago Press. [aPB]

(1992) Punishment allows the evolution of cooperation (or anything else) in sizable groups. *Ethology and Sociobiology* 13(3):171–95. [aPB]

(1995) Life in the fast lane: Rapid cultural change and the human evolutionary process. In: *Origins of the human brain. Symposia of the Fyssen Foundation*, ed. J. C. Jean-Pierre Changeux, pp. 155–69. Clarendon Press/Oxford University Press. [aPB]

Boyer, P. (1990) *Tradition as truth and communication*. Cambridge University Press. [OB]

(1993) Cognitive aspects of religious symbolism. In: *Cognitive aspects of religious symbolism*, ed. P. Boyer. Cambridge University Press. [OB]

(1994) *The naturalness of religious ideas: A cognitive theory of religion.* University of California Press. [aPB]

Boyer, P. (2001a) *Et l'homme créa les dieux*. Gallimard. [OB]

(2001b) *Religion explained: The evolutionary origins of religious thought*. Basic Books. [RNM]

Bradbury, J. W. & Vehrencamp, S. L. (2000) Economic models of animal communication. *Animal Behaviour* 59(2):259–68. [aPB]

Bradshaw, J. L. & Sheppard, D. M. (2000) The neurodevelopmental frontostriatal disorders: Evolutionary adaptiveness and anomalous lateralization. *Brain and Language* 73(2):297–320. [aPB]

Brase, G. L., Caprar, D. V. & Voracek, M. (2004) Sex differences in responses to relationship threats in England and Romania. *Journal of Social and Personal Relationships* 21:763–78. [LDS]

Brugger, P. & Graves, R. E. (1997) Testing vs. believing hypothesis: Magical ideation in the judgement of contingencies. *Cognitive Neuropsychiatry* 2(4):251–72. [DMTF]

Brüne, M. (2001) De Clérambault's syndrome (erotomania) in an evolutionary perspective. *Evolution and Human Behavior* 22:409–15. [GS]

Brüne, M. & Schröder, S. G. (2003) Erotomania variants in dementia. *Journal of Geriatric Psychiatry and Neurology* 16:232–34. [GS]

Bruner, A. & Revusky, S. H. (1961) Collateral behavior in humans. *Journal of the Experimental Analysis of Behavior* 4(4):349–50. [DMTF]

Burkert, W. (1996) *Creation of the sacred: Tracks of biology in early religions.* Harvard University Press. [aPB]

Buss, D. M. (1989) Sex differences in human mate preferences: Evolutionary hypotheses tested in 37 cultures. *Behavioral and Brain Sciences* 12:1–49. [aPB]

(2000) *The dangerous passion: Why jealousy is necessary in love and sex*. Free Press. [LDS]

(2003) *The evolution of desire: Strategies of human mating (revised edition)*. Basic Books. [LDS]

Buss, D. M., Larsen, R. J., Westen, D. & Semmelroth, J. (1992) Sex differences in jealousy: Evolution, physiology, and psychology. *Psychological Science* 3:251–55. [LDS]

Buss, D. M., Shackelford, T. K., Choe, J., Buunk, B. P. & Dijkstra, P. (2000) Distress about mating rivals. *Personal Relationships* 7:235–43. [LDS]

Buss, D. M., Shackelford, T. K., Kirkpatrick, L. A., Choe, J., Lim, H. K., Hasegawa, M., Hasegawa, T. & Bennett, K. (1999) Jealousy and the nature of beliefs about infidelity: Tests of competing hypotheses about sex differences in the United States, Korea, and Japan. *Personal Relationships* 6:125–50. [LDS]

Buswell, R. E., Jr. (1992) *The Zen monastic experience: Buddhist practice in contemporary Korea*. Princeton University Press. [IP]

Cacioppo, J. T., Gardner, W. L. & Berntson, G. G. (2002) The affect system has parallel and integrative processing components: Form follows function. In: *Foundations in social neuroscience*, ed, J. T. Caccioppo, G. G. Berntson, R. Adolphs, C. S. Carter, R. J. Davidson, M. K. McClintock, B. S. McEwen, M. J. Meaney, D. L. Schacter, E. M. Sternberg, S. S. Suomi & S. E. Taylor, pp. 493–522. MIT Press. [CSA]

Calamari, J. E., Wiegartz, P. S., Riemann, B. C., Cohen, R. J., Greer, A., Jacobi, D. M., Jahn, S. C. & Carmin, C. (2004) Obsessive-compulsive disorder subtypes: An attempted replication and extension of a symptom-based taxonomy. *Behaviour Research and Therapy* 42(6):647–70. Available at: http://elsevier.com; http://www.elsevier.com/inca/publications/store/2/6/5/. [aPB]

Campbell, K. M., de Lecea, L., Severynse, D. M., Caron, M. G., McGrath, M. J., Sparber, S. B., Sun, L.-Y. & Burton, F. H. (1999) OCD-like behaviors caused by a neuropotentiating transgene targeted to cortical and limbic D1+ neurons. *Journal of Neuroscience* 19(12):5044–53. [aPB]

Canales, J. J. & Graybiel, A. M. (2000) A measure of striatal function predicts motor stereotypy. *Nature Neuroscience* 3(4): 377–83. Available at: http://www.nature.com/ [aPB]

Cardinal, R., Parkinson, J., Hall, J. & Everitt, B. (2002) Emotion and motivation: The role of the amygdala, ventral striatum and prefrontal cortex. *Neuroscience and Biobehavioral Reviews* 26:321–52. [CSA]

Carper, R. A. & Courchesne, E. (2000) Inverse correlation between frontal lobe and cerebellum sizes in children with autism. *Brain: A Journal of Neurology* 123(4):836–44. [rPB]

(2005) Localized enlargement of the frontal cortex in early autism. *Biological Psychiatry* 57(2):126–33. [rPB]

Castellanos, F. X. & Tannock, R. (2002) Neuroscience of attention-deficit/hyperactivity disorder: The search for endophenotypes. *Nature Reviews. Neuroscience* 3:617–28. [RK]

Cavedini, P., Gorini, A. & Bellodi, L. (2006) Understanding obsessive-compulsive disorder: Focus on decision making. *Neuropsychology Review* 16(1):3–15. [rPB]

Cellerino, A. & Jannini, E. A. (2005) Male reproductive physiology as a sexually selected handicap? Erectile dysfunction is correlated with general health and health prognosis and may have evolved as a marker of poor phenotypic quality. *Medical Hypotheses* 65:179–84. [GS]

Charlop, M. H., Schreibman, L., Mason, J. & Vesey, W. (1983) Behavior-setting interactions of autistic children: A behavioral mapping approach to assessing classroom behaviors. *Analysis and Intervention in Developmental Disabilities* 3:359–71. [MDR]

Charney, D. S., Menkes, D. B. & Heninger, G. R. (1981) Receptor sensitivity and the mechanism of action of antidepressant treatment. Implications for the etiology and therapy of depression. *Archives of General Psychiatry* 38:1160–80. [RK]

Chein, J. M. & Schneider, W. (2005) Neuroimaging studies of practice-related change: fMRI and meta-analytic evidence of a domain-general control network for learning. *Brain Research. Cognitive Brain Research* 25(3):607–23. [RT]

Clark, D. M. (1999) Anxiety disorders: Why they persist and how to treat them. *Behaviour Research and Therapy* 37: S5–27. [aPB]

Cochran, A. & Stubbs, J. (1968) *The search for the perfect swing*. Heinemann. [RCJ]

Cook, M. & Mineka, S. (1987) Second order conditioning and overshadowing in the observational conditioning of fear in monkeys. *Behaviour Research and Therapy* 25:349–64. [JT]

Cosmides, L. (1989) The logic of social exchange: Has natural selection shaped how humans reason? Studies with the Wason selection task. *Cognition* 31(3):187–276. [aPB]

Cosmides, L. & Tooby, J. (1994) Origins of domain specificity: The evolution of functional organization. In: *Mapping the mind: Domain specificity in cognition and culture*, ed. L. A. Hirschfeld, S. A. Gelman, pp. 85–116. Cambridge University Press. [aPB]

(1999) Toward an evolutionary taxonomy of treatable conditions. *Journal of Abnormal Psychology* 108(3):453–64. [arPB, JT]

(2000) Evolutionary psychology and the emotions. In: *Handbook of emotions*, ed. M. Lewis, pp. 91–115. Guilford Press. [JLO]

Curio, E. (1993) Proximate and developmental aspects of antipredator behavior. *Advances in the Study of Behavior* 22:135–238. [aPB]

D'Aquili, E. G. & Newberg, A. B. (1993) Religious and mystical states: A neuropsychological model. *Zygon* 28:177–200. [JHH]

(1999) *The mystical mind: Probing the biology of religious experience*. Fortress. [JHH]

Davidson, J. M. (1976) The physiology of meditation and mystical states of consciousness. *Perspectives in Biology and Medicine* 19:345–80. [JHH]

Davidson, R. J. (2000) Affective style, psychopathology, and resilience: Brain mechanisms and plasticity. *Philosophical Transactions of the Royal Society of London B* 359:1395–411. [JHH]

(2004) Well-being and affective style: Neural substrates and biobehavioural correlates. *American Psychologist* 55:1196–214. [JHH]

Davidson, R. J., Kabat-Zinn, J., Schumacher, J., Rosenkranz, M., Muller, D., Santorelli, S. F., Urbanowski, F., Harrington, A., Bonus, K. & Sheridan, J. F. (2003) Alterations in brain and immune function produced by mindfulness meditation. *Psychosomatic Medicine* 65:564–70. [JHH]

Daw, N. D., Niv, Y. & Dayan, P. (2005) Uncertainty-based competition between prefrontal and dorsolateral striatal systems for behavioral control. *Nature Neuroscience* 8:1704–11. [HW]

de Bilbao, F. & Giannakopoulos, P. (2005) Effect of religious culture on obsessive compulsive disorder symptomatology: A transcultural study in monotheistic religions. *Revue Medicale Suisse* 1(43):2818–21. [JES]

Dehaene, S. & Changeux, J. P. (2000) Reward-dependent learning in neuronal networks for planning and decision-making. In: *Cognition, emotion, and autonomic responses: The integrative role of the prefrontal cortex and limbic structures*, ed. H. B. M. Uylings, C. G. van Eden, J. P. D. deBruin, M. G. P. Feenstra & C. M. A. Pennartz, pp. 219–30. Elsevier. [CSA]

Depue, R. A. & Morrone-Strupinsky, J. V. (2005) A neurobehavioral model of affiliative bonding: Implications for conceptualizing a human trait of affiliation. *Behavioral and Brain Sciences* 28(3):313–50; discussion 350–95. [JES]

Dijksterhuis, A., Bos, M. W., Nordgren, L. F. & van Baaren, R. B. (2006) On making the right choice: The deliberation-without-attention effect. *Science* 311:1005–1007. [JLO]

Dolan, R. (2000) Emotional processing in the human brain revealed through functional neuroimaging. In: *The new cognitive neurosciences, 2nd edition*, ed. M. Gazzaniga, pp. 1115–32. MIT Press. [CSA]

Douglas, M. (1982) *Natural symbols: Explorations in cosmology.* Pantheon Books. [aPB]

Duchaine, B., Cosmides, L. & Tooby, J. (2001) Evolutionary psychology and the brain. *Current opinion in neurobiology* 11(2):225–30. [aPB]

Dulaney, S. & Fiske, A. P. (1994) Cultural rituals and obsessive-compulsive disorder: Is there a common psychological mechanism? *Ethos* 22(3):243–83. [arPB]

Dunn, J. G. H., Gotwals, J. K. & Dunn, J. C. (2005) An examination of the domain specificity of perfectionism among intercollegiate student-athletes. *Personality and Individual Differences* 38:1439–48. [GS]

Durham, W. H. (1991) *Coevolution: Genes, cultures and human diversity.* Stanford University Press. [aPB]

Durkheim, E. (1947) *The elementary forms of the religious life.* Collier Books. [aPB]

Easton, J. A., Schipper, L. D. & Shackelford T. K. (in press) Why the adaptationist perspective must be considered: The example of morbid jealousy. *Behavioral and Brain Sciences*. [LDS]

Ecker, W. & Engelkamp, J. (1995) Memory for actions in obsessive-compulsive disorder. *Behavioural and Cognitive Psychotherapy* 23(4):349–71. Available at: http://www.cup.org; http://uk.cambridge.org/journals/bcp/ [aPB]

Eilam, D., Zor, R., Szechtman, H. & Hermesh, H. (2006) Rituals, stereotypy and compulsive behavior in animals and humans. *Neuroscience and Biobehavioral Reviews* 30(4):456–71. [rPB, DE]

Einstein, D. A. & Menzies, R. G. (2004) The presence of magical thinking in obsessive compulsive disorder. *Behaviour Research and Therapy* 42(5):539–49. [JES]

Eisen, J. L., Phillips, K. & Rasmussen, S. A. (1999) Obsessions and delusions: The relationship between obsessive-compulsive disorder and the psychotic disorders. *Psychiatric Annals* 29:515–22. [aPB]

Enoch, M. D. & Trethowan, W. H. (1979) The Othello syndrome. In: *Uncommon psychiatric syndromes*. John Wright. [LDS]

Ermer, E., Guerin, S., Cosmides, L., Tooby, J. & Miller, M. (in press) Theory of mind broad and narrow: Reasoning about social exchange engages TOM areas, precautionary reasoning does not. *Social Neuroscience*. [JT]

Evans, D. W. & Gray, F. L. (2000) Compulsive-like behavior in individuals with Down syndrome: Its relation to mental age level, adaptive and maladaptive behavior. *Child Development* 71:288–300. [OB]

Evans, D. W., Gray, F. L. & Leckman, J. F. (1999) The rituals, fears and phobias of young children: Insights from development, psychopathology and neurobiology. *Child Psychiatry and Human Development* 29(4):261–76. [aPB]

Evans, D. W., Leckman, J. F., Carter, A., Reznick, J. S., Henshaw, D., King, R. A. & Pauls, D. (1997) Ritual, habit and perfectionism: The prevalence and development of compulsive-like behavior in normal young children. *Child Development* 68:58–68. [OB, aPB]

Evans, D. W., Milanak, M. E., Medeiros, B. & Ross, J. L. (2002) Magical beliefs and rituals in young children. *Child Psychiatry and Human Development* 33(1):43–58. Available at: http://www.wkap.nl; http://www.wkap.nl/journalhome.htm/0009-398X [aPB]

Fallon, B. A., Liebowitz, M. R., Hollander, E., Schneier, F. R., Campeas, R. B., Fairbanks, J., Papp, L. A., Hatterer, J. A. & Sandberg, D. (1990) The pharmacotherapy of moral or religious scrupulosity. *Journal of Clinical Psychiatry* 51(12):517–21. Available at: http://www.psychiatrist.com/ [aPB, JES]

Farah, M. J. (2000) *The cognitive neuroscience of vision*. Blackwell. [HW]

Farrar, M. J. & Goodman, G. S. (1992) Developmental changes in event memory. *Child Development* 63:173–87. [OB]

Felson, R. B. & Gmelch, G. (1979) Uncertainty and the use of magic. *Current Anthropology* 20(3):587–89. [DMTF]

Fentress, J. C. (1976) Dynamic boundaries of patterned behavior: Interaction and self-organization. In: *Growing points in ethology*, pp. 135–67. Cambridge Univesity Press. [DE]

Fessler, D. M. T. (2002) Reproductive immunosuppression and diet: An evolutionary perspective on pregnancy sickness and meat consumption with CA comment. *Current anthropology* 43(1):43. [arPB]

Fessler, D. M. T. & Navarrete, C.D. (2003a) Domain-specific variation in disgust sensitivity across the menstrual cycle. *Evolution and Human Behavior* 24(6):406–17. Available at: http://elsevier.com; http://www.elsevier.com/inca/publications/store/5/0/5/7/6/0/ [aPB]

Fessler, D. M. T. & Navarrete, C. D. (2003b) Meat is good to taboo: Dietary proscriptions as a product of the interaction of psychological mechanisms and social processes. *Journal of Cognition and Culture* 3(1):1–40. Available at: http://www.brill.nl [arPB]

Fessler, D. M. T., Arguello, A. P., Mekdara, J. M. & Macias, R. (2003) Disgust sensitivity and meat consumption: A test of an emotivist account of moral vegetarianism. *Appetite* 41(1):31–41. Available at: http://elsevier.com; http://www.academicpress.com/appetite. [aPB]

Feygin, D. L., Swain, J. E. & Leckman, J. F. (2006) The normalcy of neurosis: Evolutionary origins of obsessive-compulsive disorder and related behaviors. *Progress in Neuro-Psychopharmacology and Biological Psychiatry* 30(5):854–64. [GS, JES]

Fiddick, L., Cosmides, L. & Tooby, J. (2000) No interpretation without representation: The role of domain-specific representations and inferences in the Wason selection task. *Cognition* 77(1):1–79. [aPB, JT]

Fisher, C. B., Ferdinandsen, K. & Bornstein, M. H. (1981) The role of symmetry in infant form discrimination. *Child Development* 52(2):457–62. Available at: http://www.blackwellpublishing.com [aPB]

Fiske, A. P. (n.d.) Learning a culture the way informants do: Observing, imitating, and participating. [DMTF]

Fiske, A. P. & Haslam, N. (1997) Is obsessive-compulsive disorder a pathology of the human disposition to perform socially meaningful rituals? Evidence of similar content. *Journal of Nervous and Mental Disease* 185(4): 211–22. [aPB]

Fitzgerald, K. D., Welsh, R. C., Gehring, W. J., Abeslon, J. L., Himle, J. A., Liberzon, I. & Taylor, S. F. (2005) Error-related hyperactivity of the anterior cingulated cortex in obsessive-compulsive disorder. *Biological Psychiatry* 57(3):287–94. [aPB, R-PB, AR]

Fivush, R. & Slackman, E. (1986) The acquisition and development of scripts. In: *Event knowledge: Structure and function in development*, ed. K. Nelson. Erlbaum. [OB]

Foa, E. B., Huppert, J. D. & Cahill, S. P. (2006) Update on emotional processing theory. In: *The nature and treatment of pathological anxiety*, ed. B. O. Rothbaum, pp. 2–24. Guilford Press. [JDH]

Foa, E. B., Ilai, D., McCarthy, P. R., Shoyer, B. & Murdock, T. (1993) Information processing in obsessive-compulsive disorder. *Cognitive Therapy and Research* 17(2):173–89. Available at: http://www.wkap.nl; http://www.wkap.nl/journalhome.htm/0147–5916 [arPB]

Foa, E. B., Kozak, M. J., Goodman, W. K. & Hollander, E. (1995) DSM-IV field trial: Obsessive-compulsive disorder. *American Journal of Psychiatry* 152:654. [JDH]

Foa, E. B., Steketee, G. & Milby, J. B. (1980) Differential effects of exposure and response prevention in obsessive-compulsive washers. *Journal of Consulting and Clinical Psychology* 48:71–79. [JDH]

Forman, R. K. C. (1990) Introduction: Mysticism, constructivism, and forgetting. In: *The problem of pure consciousness: Mysticism and philosophy*, ed. R. K. C. Forman. Oxford University Press. [IP]

(1993) Mystical knowledge: Knowledge by identity. *Journal of the American Academy of Religion* 61:705–38. [IP]

Foster, D. J., Weigand, D. A. & Baines, D. (2005) The effect of removing superstitious behavior and introducing a pre-performance routine on basketball free-throw performance. *Journal of Applied Sport Psychology* 18:82–86. [RCJ]

Fragaszy, D. M. & Perry, S., eds. (2003) *The biology of traditions: Models and evidence*. Cambridge University Press. [BM]

Franklin, M. E. & Foa, E. B. (2002) Cognitive behavioral treatments for obsessive compulsive disorder. In: *A guide to treatments that work, 2nd edition*, ed. P. E. Nathan & J. M. Gorman, pp. 367–86. Oxford University Press. [JDH]

Freud, S. (1928) *Die Zukunft einer Illusion.* Internationaler Psychoanalytischer Verlag. [aPB]

Friedlander, L. & Desrocher, M. (2006) Neuroimaging studies of obsessive-compulsive disorder in adults and children. *Clinical Psychology Review* 26(1):32–49. [JES]

Frith, C. D. (1996) Brain mechanisms for "Having a theory of mind." *Journal of Psychopharmacology* 10:9–15. [rPB]

Gabbard, G. O. (1990) *Psychodynamic psychiatry in clinical practice*. American Psychiatric Press. [R-PB]

Gais, S., Lucas, B. & Born, J. (2006) Sleep after learning aids memory recall. *Learning and Memory* 13:259–62. [RK]

Gal, E., Dyck, M. & Passmore, A. (2002) Sensory differences and stereotyped movements in children with autism. *Behaviour Change* 19(4):207–219. [rPB]

Gazzaniga, M. S. & Miller, M. B. (2000) Testing Tulving: The split brain approach. In: *Memory, consciousness, and the brain: The Tallinn Conference*, ed. E. Tulving, pp. 307–11. Psychology Press. [aPB]

Geller, D. A. (2006) Obsessive-compulsive and spectrum disorders in children and adolescents. *The Psychiatric Clinics of North America* 29:353–70. [RK]

Geller, D. A., Biederman, J., Faraone, S., Spencer, T., Doyle, R., Mullin, B., Magovcevic, M., Zaman, N. & Farrell, C. (2004) Re-examining comorbidity of Obsessive Compulsive and Attention Deficit Hyperactivity Disorder using an empirically derived taxonomy. *European Child and Adolescent Psychiatry* 13:83–91. [RK]

Gerholm, T. (1988) On ritual: A postmodernist view. *Ethnos* 53:191–203. [JHH]

Giedd, J. N., Rapoport, J. L., Garvey, M. A., Perlmutter, S. & Swedo, S. E. (2000) MRI assessment of children with obsessive-compulsive disorder or tics associated with streptococcal infection. *American Journal of Psychiatry* 157(2):281–3. http://www.appi.org http://ajp.psychiatryonline.org/ [aPB]

Gimello, R. M. (1983) Mysticism in its contexts. In: *Mysticism and religious traditions*, ed. S. Katz. Oxford University Press. [IP]

Gluckman, M. (1975) Specificity of social-anthropological studies of ritual. *Mental Health and Society* 2(1–2):1–17. http://www.karger.ch [aPB]

Gmelch, G. (1978) Baseball magic. *Human Nature* 1(8):32–40. [DMTF]

Goffman, E. (1974) *Frame analysis: An essay on the organization of experience*. Harper and Row. [RT]

Gofrit, O. N. (2006) The evolutionary role of erectile dysfunction. *Medical Hypotheses* 67:1245–49. [GS]

Gombrich, R. (1988) *Theravāda Buddhism: A social history from ancient Benares to modern Colombo*. Routledge. [IP]

Gomot, M., Bernard, F. A., Davis, M. H., Belmonte, M. K., Ashwin, C., Bullmore, E. T. & Baron-Cohen, S. (2006) Change detection in children with autism: An auditory event-related fMRI study. *Neuroimage* 29:475–84. [OB]

Grados, M. A., Walkup, J. & Walford, S. (2003) Genetics of obsessive-compulsive disorders: New findings and challenges. *Brain Development* 25: S55–61. [aPB]

Grafen, A. (1990) Biological signals as handicaps. *Journal of Theoretical Biology* 144(4):517–46. [rPB]

Gray, R. (2004) Attending to the execution of a complex sensorimotor skill: Expertise differences, choking, and slumps. *Journal of Experimental Psychology: Applied* 10:42–54. [RCJ]

Graybiel, A. M. (1998) The basal ganglia and chunking of action repertoires. *Neurobiology of Learning and Memory* 70(1–2):119–36. [aPB]

Greenberg, D. & Shefler, G. (2002) Obsessive compulsive disorder in ultra-orthodox Jewish patients: A comparison of religious and non-religious symptoms. *Psychology and Psychotherapy* 75(2):123–30. [JES]

Greenough, W. T. (1986) What's special about development? Thoughts on the bases of experience sensitive synaptic plasticity. In: *Developmental neuropsychobiology*, ed. W. T. Greenough & J. M. Juraska, pp. 387–408. Academic Press. [CSA]

Habimana, E. & Massé, L. (2000) Envy manifestations and personality disorders. *European Psychiatry* 15:15–21. [GS]

Hageman, J. (2002) Assessing the implications of spiritual self-healing paradigms. Unpublished manuscript, Saybrook Graduate School and Research Center, San Francisco. [JHH]

(2005) Hypnotizability and dissociation in spirituality: Cross-cultural experiences related to health and well-being. *Dissertation Abstracts* 66(5):2805B. (UMI No. AAT 3175360) [JHH]

Hagen, E. H. (2002) Depression as bargaining: The case postpartum. *Evolution and Human Behavior* 23(5):323–36. Available at: http://elsevier.com; http://www.elsevier.com/inca/publications/store/5/0/5/7/6/0/ [aPB]

Hagen, E. H. & Bryant, G. A. (2003) Music and dance as a coalition signaling system. *Human Nature* 14:21–51. [GS]

Handelman, D. (1998) *Theorizing through models and mirrors, in models and mirrors: Towards an anthropology of public events*. Berghahn Books. [JHH]

Happaney, K., Zelazo, P. D. & Stuss, D. T. (2004) Development of orbitofrontal function: Current themes and future directions. *Brain and Cognition* 55(1):1–10. [aPB]

Happe, F., Ehlers, S., Fletcher, P., Frith, U., Johansson, M., Gillberg, C., Dolan, R., Frackowiak, R., Frith, C. (1996) "Theory of mind" in the brain: Evidence from a PET scan study of Asperger syndrome. *NeuroReport: An International Journal for the Rapid Communication of Research in Neuroscience* 8:197–201. [rPB]

Harcourt, A. H. & de Waal, F. B., eds. (1992) Coalitions and alliances in humans and other animals. *Oxford University Press.* [aPB]

Harris, G. J., Chabris, C. F., Clark, J., Urban, T., Aharon, I., Steele, S., McGrath, L., Condouris, K. & Tager-Flusberg, H. (2006) Brain activation during semantic processing in autism spectrum disorders via functional magnetic resonance imaging. *Brain and Cognition* 61(1):54–68. [rPB]

Hasselquist, D., Bensch, S. & von Schantz, T. (1996) Correlation between song repertoire, extra-pair paternity and offspring survival in the great reed warbler. *Nature* 381:229–32. [BM]

Heidegger, M. (1927/1962) *Being and time*, trans. J. Macquarie & E. Robinson. Blackwell. [R-PB]

Hekiganroku (1961) *The blue cliff records*, trans. and ed. R. D. M. Shaw. Michael Joseph. [IP]

Henrich, J. & Gil-White, F. J. (2001) The evolution of prestige: Freely conferred deference as a mechanism for enhancing the benefits of cultural transmission. *Evolution and Human Behavior* 22(3):165–96. [DMTF]

Henry, M. C., Perlmutter, S. J. & Swedo, S. E. (1999) Anorexia, OCD, and streptococcus. *Journal of the American Academy of Child and Adolescent Psychiatry* 38(3):228. [aPB]

Hermans, D., Martens, K., De Cort, K., Pieters, G. & Eelen, P. (2003) Reality monitoring and metacognitive beliefs related to cognitive confidence in obsessive-compulsive disorder. *Behaviour Research and Therapy* 41(4):383–401. [aPB]

Hermesh, H., Masser-Kavitzky, R. & Gross-Isseroff, R. (2003) Obsessive-compulsive disorder and Jewish religiosity. *Journal of Nervous and Mental Disease* 191(3):201–3. Available at: http://www.lww.com/; http://www.jonmd.com/ [aPB]

Hobson, J. A. (2005) Sleep is of the brain, by the brain and for the brain. *Nature* 437:1254–56. [RK]

Hocart, A. M. & Needham, R. (1970) *Kings and councillors: An essay in the comparative anatomy of human society.* University of Chicago Press. [aPB]

Hodgson, R. J. & Rachman, S. (1972) The effects of contamination and washing in obsessional patients. *Behaviour Research and Therapy* 10(2):111–7. Available at: http://elsevier.com; http://www.elsevier.com/inca/publications/store/2/6/5/ [aPB]

(1977) Obsessional-compulsive complaints. *Behaviour Research and Therapy* 15(5):389–95. Available at: http://elsevier.com; http://www.elsevier.com/inca/publications/store/2/6/5/ [aPB]

Hogue, D. A. (2006) Healing of the self-in-context: Memory, plasticity, and spiritual practice. In: *Spiritual transformation and healing: Anthropological, theological, neuroscientific, and clinical perspectives*, ed. H. D. Koss-Chioino & P. Hefner, pp. 223–38. Altamira Press. [JHH]

Hollander, E., Anagnostou, E., Chaplin, W., Esposito, K., Haznedar, M. M., Licalzi, E., Wasserman, S., Soorya, L. & Buschsbaum, M. (2005) Striatal volume on magnetic resonance imaging and repetitive behaviors in autism. *Biological Psychiatry* 58(3):226–32. [rPB]

Hounie, A. G., Pauls, D. L., Mercadante, M. T., Rosario-Campos, M. C., Shavitt, R. G., de Mathis, M. A., de Alvarenga, P. G., Curi, M. & Miguel, E. C. (2004) Obsessive-compulsive spectrum disorders in rheumatic fever with and without Sydenham's chorea. *The Journal of Clinical Psychiatry* 65:994–99. [RK]

Howe, M. L. & Courage, M. L. (1993) On resolving the enigma of infantile amnesia. *Psychological Bulletin* 113:305–26. [OB]

Humphrey, C. & Laidlaw, J. (1993) *Archetypal actions. A theory of ritual as a mode of action and the case of the Jain Puja*. Clarendon Press. [rPB]

Hutt, C. & Hutt, S. J. (1970) Stereotypies and their relation to arousal: A study of autistic children. In: *Behaviour studies in psychiatry*, ed. C. Hutt & S. J. Hutt, pp. 175–204. Pergamon Press. [MDR]

Huxley, A. (1946/1959) *The perennial philosophy*. Collins Fontana. [IP]

Jackson, R. C. (2003) Preperformance routine consistency: Temporal analysis of goal kicking in the Rugby Union World Cup. *Journal of Sports Sciences* 21:803–14. [RCJ]

Janata, P. & Grafton, S. T. (2003) Swinging in the brain: Shared neural substrates for behaviors related to sequencing and music. *Nature Neuroscience* 6(7): 682–7. [aPB]

Janik, V. M. & Slater, P. J. B. (1997) Vocal learning in mammals. *Advances in the Study of Behavior* 26:59–99. [BM]

Jerison, H. (2000) Paleoneurology and the biology of music. In: *The origins of music*, eds. N. L. Wallin, B. Merker & S. Brown, pp. 176–96. MIT Press. [aPB]

Johannes, S., Wieringa B. M., Nager, W., Muller-Vahl, K. R., Dengler, R. & Munte, T. F. (2002) Excessive action monitoring in Tourette syndrome. *Journal of Neurology* 249:961–66. [AR]

Johannes, S., Wieringa, B. M., Nager, W., Rada, D., Dengler, R., Emrich, H. M., Munte, T. F. & Dietrich, D. E. (2001) Discrepant target detection and action monitoring in obsessive-compulsive disorder. *Psychiatry Research* 108: 101–10. [AR]

Kaas, J. H., Hackett, T. A. & Tramo, M. J. (1999) Auditory processing in primate cerebral cortex. *Current Opinion in Neurobiology* 9(2):164–70. [aPB]

Kahneman, D. & Tversky, A., eds. (2000) *Choices, values, and frames*. Cambridge University Press. [BM]

Kahneman, D., Slovic, P. & Tversky, A., eds. (1982) *Judgment under uncertainty: Heuristics and biases.* Cambridge University Press. [EZW]

Kanner, L. (1943) Autistic disturbances of affective contact. *Nervous Child* 2: 217–50. [OB]

Kaplan, A. & Hollander, E. (2003) A review of pharmacologic treatments for obsessive-compulsive disorder. *Psychiatric Services* 54(8):1111–8. [aPB]

Katz, S. (1983) The "conservative" character of mysticism. In: *Mysticism and religious traditions*, ed. S. Katz. Oxford University Press. [IP]

(1985) Recent work on mysticism. *History of Religions* 25:76–86. [IP]

Kaye, W. H., Bulik, C. M., Thornton, L., Barbarich, N. & Masters, K. (2004) Comorbidity of anxiety disorders with anorexia and bulimia nervosa. *The American Journal of Psychiatry* 161:2215–21. [RK]

Keller, C. M. & Keller, J. D. (1996) *Cognition and tool use: The blacksmith at work.* Cambridge University Press. [aPB]

Kessler, R. C. (1998) Sex differences in DSM-III-R psychiatric disorders in the United States: Results from the National Comorbidity Survey. *Journal of the American Medical Women's Association* 53:148–58. [GS]

Khanna, S. & Channabasavanna, S. M. (1988) Phenomenology of obsessions in obsessive-compulsive neurosis. *Psychopathology* 21(1):12–18. [JES]

Khanna, S., Kaliaperumal, V. G. & Channabasavanna, S. M. (1990) Clusters of obsessive-compulsive phenomena in obsessive-compulsive disorder. *British Journal of Psychiatry* 156:51–4. Available at: http://www.rcpsych.ac.uk/; http://bjp.rcpsych.org/ [aPB]

Kim, C. H., Chang, J. W., Koo, M.-S., Kim, J. W., Suh, H. S., Park, I. H. & Lee, H. S. (2003) Anterior cingulotomy for refractory obsessive-compulsive disorder. *Acta Psychiatrica Scandinavica* 107(4): 283–90. Available at: http://www.blackwellpublishing.com; http://www.blackwellmunksgaard.com/actapsych [aPB]

Kingham, M. & Gordon, H. (2004) Aspects of morbid jealousy. *Advances in Psychiatric Treatment* 10:207–15. [LDS]

Kirov, R., Banaschewski, T., Uebel, H., Kinkelbur, J. & Rothenberger, A. (in press) REM-sleep alterations in children with tic disorder and attention-deficit/hyperactivity disorder comorbidity: Impact of hypermotor symptoms. *European Child and Adolescent Psychiatry*. [AR]

Knight, C., Power, C. & Mithen, S. (1998) The origins of anthropomorphic thinking. *The Journal of the Royal Anthropological Institute* 4(1):129–31. [aPB]

Koechlin, E. & Jubault, T. (2006) Broca's Area and the hierarchical organization of human behavior. *Neuron* 50:963–74. [HW]

Kostanecka-Endres, T., Banaschewski, T., Kinkelbur, J., Wüllner, I., Lichtblau, S., Cohrs, S., Rüther, E., Woerner, W., Hajak, G. & Rothenberger, A. (2003) Disturbed sleep in children with Tourette Syndrome – a polysomnographic study. *Journal of Psychosomatic Research* 55:23–29. [AR]

Krebs, J. R. & Inman, A. J. (1994) Learning and foraging: Individuals, groups, and populations. In: *Behavioral mechanisms in evolutionary ecology*, ed. L. A. Real, pp. 46–65. The University of Chicago Press. [aPB]

Kufahl, P. R., Li, Z., Risinger, R. C., Rainey, C. J., Wu, G., Bloom, A. S., & Li, S. J. (2005) Neural responses to acute cocaine administration in the human brain detected by fMRI. *Neuroimage* 28(4):904–14. [JES]

Kurzban, R. & Leary, M. R. (2001) Evolutionary origins of stigmatization: The functions of social exclusion. *Psychological Bulletin* 127(2):187–208. [aPB]

Kurzban, R., Tooby, J. & Cosmides, L. (2001) Can race be erased? Coalitional computation and social categorization. *Proceedings of the National Academy of Sciences USA* 98(26):15387–92. Available at: http://www.pnas.org/cgi/content/full/98/26/15387 http://www.pnas.org. [aPB]

Labad, J., Menchâon, J. M., Alonso, P., Segaláas, C., Jimâenez, S. & Vallejo, J. (2005) Female reproductive cycle and obsessive-compulsive disorder. *Journal of Clinical Psychiatry* 66(4):428–35; quiz 546. [aPB]

Lavie, N. (2006) The role of perceptual load in visual awareness. *Brain Research* 1080(1):91–100. [RT]

Lawson, E. T. & McCauley, R. N. (1990) *Rethinking religion: Connecting cognition and culture*. Cambridge University Press. [rPB, RNM]

Leckman, J. F. (2002) Tourette's syndrome. *Lancet* 360:1577–86. [RK]

(2003) Phenomenology of tics and natural history of tic disorders. *Brain and Development* 25: S24–8. [aPB]

Leckman, J. F. & Mayes, L. C. (1999) Preoccupations and behaviors associated with romantic and parental love: Perspectives on the origin of obsessive-compulsive disorder. *Child Adolescent Psychiatry Clinics of North America* 8(3): 635–65. [JES]

Leckman, J. & Riddle, A. (2000) Tourette's Syndrome: When habit-forming systems form habits of their own? *Neuron* 28:349–54. [AR]

Leckman, J. F., Feldman, R., Swain, J. E., Eicher, V., Thompson, N. & Mayes, L. C. (2004) Primary parental preoccupation: Circuits, genes, and the crucial role of the environment. *Journal of Neural Transmission* 111(7):753–71. [aPB]

Leckman, J. F., Goodman, W. K., North, W. G., Chappell, P. B., Price, L. H., Pauls, D. L., Anderson, G. M., Riddle, M. A., McSwiggan-Hardin, M., McDougle, C. J., Barr, L. C. & Cohen, D. J. (1994) Elevated cerebrospinal fluid levels of oxytocin in obsessive-compulsive disorder: Comparison with Tourette's syndrome and healthy controls. *Archives of General Psychiatry* 51(10):782–92. [JES]

Leckman, J. F., Mayes, L. C., Feldman, R., Evans, D. W., King, R. A. & Cohen, D. J. (1999) Early parental preoccupations and behaviors and their possible relationship to the symptoms of obsessive-compulsive disorder. *Acta Psychiatrica Scandinavica Supplementum* 396:1–26. [JES]

Leckman, J. F., Peterson, B. S., Pauls, D. L. & Cohen, D. J. (1997) Tic disorders. *The Psychiatric Clinics of North America* 20:839–61. [RK]

Leckman, J. F., Vaccarino, F. M., Kalanithi, P. S. & Rothenberger, A. (2006) Annotation: Tourette syndrome: A relentless drumbeat – driven by misguided brain oscillations. *Journal of Child Psychology and Psychiatry* 47: 537–50. [AR]

LeDoux, J. (2003) The emotional brain, fear, and the amygdala. *Cellular and Molecular Neurobiology* 23(4–5):727–38. [aPB]

Lemelson, R. (2003) Obsessive-compulsive disorder in Bali: The cultural shaping of a neuropsychiatric disorder. *Transcultural Psychiatry* 40(3):377–408. [aPB]

Leonard, H. L., Goldberger, E. L., Rapoport, J. L., Cheslow, D. L. & Swedo, S. E. (1990) Childhood rituals: Normal development or obsessive-compulsive symptoms? *Journal of the American Academy of Child and Adolescent Psychiatry* 29(1):17–23. [aPB]

Levinson, D. F. (2006) The genetics of depression: A review. *Biological Psychiatry* 60:84–92. [RK]

Lewin, A. B., Storch, E. A., Adkins, J., Murphy, T. K. & Geffken, G. R. (2005) Current directions in pediatric obsessive-compulsive disorder. *Pediatric Annals* 34:128–34. [RK]

Liao, C. & Masters, R. S. W. (2002) Self-focused attention and performance failure under psychological stress. *Journal of Sport and Exercise Psychology* 24:289–305. [RCJ]

Liegeois-Chauvel, C., de Graaf, J. B., Laguitton, V. & Chauvel, P. (1999) Specialization of left auditory cortex for speech perception in man depends on temporal coding. *Cerebral Cortex* 9(5):484–96. [aPB]

Liénard, P. & Boyer, P. (2006) Why cultural rituals? A cultural selection model of ritualized behaviour. *American Anthropologist* 108(4):814–27. [arPB]

Lorberbaum, J. P., Newman, J. D., Horwitz, A. R., Dubno, J. R., Lydiard, R. B., Hamner, M. B., Bohning, D. E. & George, M. S. (2002) A potential role for thalamocingulate circuitry in human maternal behavior. *Biological Psychiatry* 51(6):431–45. [aPB]

Lorenz, K. (1963/2002) *On aggression*. Routledge. [R-PB]

Mackey, W. C. & Immerman, R. S. (2000) Depression as a counter for women against men who renege on the sex contract. *Psychology, Evolution and Gender* 2:47–71. [GS]

Mahgoub, O. M. & Abdel-Hafeiz, H. B. (1991) Pattern of obsessive-compulsive disorder in eastern Saudi Arabia. *British Journal of Psychiatry* 158: 840–2. [aPB]

Maina, G., Albert, U., Bogetto, F., Vaschetto, P. & Ravizza, L. (2000) Recent life events and obsessive-compulsive disorder (OCD): The role of pregnancy/delivery. *Psychiatry Research* 89(1):49–58. [aPB]

Malinowski, B. (1948) *Magic, science and religion*. Doubleday. [DMTF]

Maren, S. & Quirk, G. J. (2004) Neuronal signalling of fear memory. *Nature Reviews: Neuroscience* 5(11):844–52. [aPB]

Marler, P. (1999) On innateness: Are sparrow songs "learned" or "innate"? In: *The design of animal communication*, ed. M. D. Hauser & M. Konishi, pp. 293–318. MIT Press. [CSA]

Masi, G., Perugi, G., Toni, C., Millepiedi, S., Mucci, M., Bertini, N. & Akiskal, H. S. (2004) Obsessive-compulsive bipolar comorbidity: Focus on children and adolescents. *Journal of affective Disorders* 78:175–83. [RK]

Masters, R. S. W. (1992) Knowledge, knerves and know-how: The role of explicit versus implicit knowledge in the breakdown of a complex motor skill under pressure. *British Journal of Psychology* 83:343–58. [RCJ]

Masters, R. S. W., Polman, R. C. J. & Hammond, N. V. (1993) Reinvestment: A dimension of personality implicated in skill breakdown under pressure. *Personality and Individual Differences* 14:655–66. [RCJ]

Mataix-Cols, D., do Rosario-Campos, M. C. & Leckman, J. F. (2005) A multidimensional model of obsessive-compulsive disorder. *The American Journal of Psychiatry* 162(2):228–38. [aPB]

Maxwell, J. P., Masters, R. S. W. & Eves, F. F. (2003) The role of working memory in motor learning and performance. *Consciousness and Cognition* 12: 376–402. [RCJ]

May, W. F. (1991) *The patient's ordeal*. Indiana University Press. [JHH]

Mayberg, H. S., Lozano, A. M., Voon, V., McNeely, H. E., Seminowicz, D., Hamani, C., Schwalb, J. M. & Kennedy, S. H. (2005) Deep brain stimulation for treatment-resistant depression. *Neuron* 45(5):651–60. [RT]

McCauley, R. N. & Lawson, E. T. (2002) *Bringing ritual to mind: Psychological foundations of cultural forms*. Cambridge University Press. [JHH, RNM]

McDougall, W. (1924) *An outline of psychology, 2nd edition*. Methuen. [R-PB]

Mendelson, M. J. & Lee, S. P. (1981) The effects of symmetry and contour on recognition memory in children. *Journal of Experimental Child Psychology* 32(3):373–88. [aPB]

Merker, B. (2005) The conformal motive in birdsong, music and language: An introduction. In: *The neurosciences and music II: From perception to performance*, ed. G. Avanzini, L. Lopez, S. Koelsch & M. Majno, pp. 17–28. *Annals of the New York Academy of Sciences*, *vol.* 1060. [BM]

Merker, B. (in press) Ritual foundations of human uniqueness. In: *Communicative musicality*, ed. S. Malloch & C. Trevarthen. Oxford University Press. [BM]

Metcalf, P. & Huntington, R. (1991) *Celebrations of death. The anthropology of mortuary ritual, 2nd edition*. Cambridge University Press. [aPB]

Moll, G. H., Heinrich, H., Trott, G., Wirth, S. & Rothenberger, A. (2000) Deficient intracortical inhibition in drug-naive children with attention-deficit hyperactivity disorder is enhanced by methylphenidate. *Neuroscience Letters* 284:121–25. [RK]

Mooring, M. S., Blumstein, D. T. & Stoner, C. J. (2004) The evolution of parasite-defence grooming in ungulates. *Biological Journal of the Linnean Society* 81:17–37. [EZW]

Morris, J. S., Ohman, A. & Dolan, R. J. (1998) Conscious and unconscious emotional learning in the human amygdala. *Nature* 393:467–70. [CSA]

Morris, M. W. & Murphy, G. L. (1990) Converging operations on a basic level in event taxonomies. *Memory and Cognition* 18(4):407–18. Available at: http://www.psychonomic.org/; http://www.psychonomic.org/mrc.htm [aPB]

Mowat, R. R. (1966) *Morbid jealousy and murder: A psychiatric study of morbidly jealous murders at Broadmoor*. Tavistock. [LDS]

Mumonkan (1966) *Zen classics, vol. 4*, trans. R. H. Blyth. Hokuseido Press. [IP]

Murphy, D. & Stich, S. (2000) Darwin in the madhouse:Evolutionary psychology and the classification of mental disorders. In: *Evolution and the human mind: Modularity, language and meta-cognition*, ed. P. Carruthers & A. Chamberlain, pp. 62–92. Cambridge University Press. [aPB]

Neil, G. I. (1982) Demystifying sport superstition. *International Review of Sport Sociology* 17:99–124. [RCJ]

Nelson, K. (1993) Explaining the emergence of autobiographical memory in early childhood. In: *Theories of memory*, ed. A. F. Collins, S. E. Gathercole, P. A. Conway & P. E. Morris. Erlbaum. [OB]

(1986) *Event knowledge: Structure and function in development*. Erlbaum. [OB]

(1996) *Language in cognitive development: The emergence of the mediated mind*. Cambridge University Press. [OB]

Nesse, R. M. (1998) Emotional disorders in evolutionary perspective. *British Journal of Medical Psychology* 71(4):397–415. Available at: http://www.bps.org.uk; http://www.bps.org.uk/publications/jHP_1.cfm [aPB]

Nesse, R. M. & Williams, G. C. (1996) *Evolution and healing: The new science of Darwinian medicine*. Phoenix. Available at: http://www.loc.gov/catdir/description/orion051/96215507.html [aPB]

Nestadt, G., Samuels, J., Riddle, M. A., Liang, K. Y., Bienvenu, O. J., Hoehn-Saric, R., Grados, M. & Cullen, B. (2001) The relationship between obsessive-compulsive disorder and anxiety and affective disorders: Results from the Johns Hopkins OCD Family Study. *Psychological Medicine* 31:481–87. [RK]

Newell, A. (1990) *Unified theories of cognition*. Harvard University Press. [HW]

Newtson, D. (1973) Attribution and the unit of perception of ongoing behavior. *Journal of Personality and Social Psychology* 28:28–38. [aPB]

Neziroglu, F., Anemone, R. & Yaryura-Tobias, J. A. (1992) Onset of obsessive-compulsive disorder in pregnancy. *American Journal of Psychiatry* 149(7):947–50. [aPB]

Norman, D. A. & Shallice, T. (1980) *Attention to action: Willed and automatic control of behavior*. University of California, San Diego, CHIP Report No. 99. [RT]

Nottebohm, F. (1976) Discussion paper. Vocal tract and brain: A search for evolutionary bottlenecks. In: *Origins and evolution of language and speech*, ed. S. R. Harnad, H. D. Steklis & J. Lancaster, pp. 643–49. *Annals of the New York Academy of Sciences*, vol. 280. [BM]

Nowicki, S., Searcy, W. A. & Peters, S. (2002) Brain development, song learning and mate choice in birds: A review and experimental test of the "nutritional stress hypothesis." *Journal of Comparative Physiology A: Sensory, Neural, and Behavioral Physiology* 188:1003–1004. [BM]

Ogai, M., Iyo, M., Mori, N. & Takei, N. (2005) A right orbitofrontal region and OCD symptoms: A case report. *Acta Psychiatrica Scandinavica* 111(1):74–6; discussion 6–7. [aPB]

Okasha, A., Saad, A., Khalil, A. H., el Dawla, A. S. & Yehia, N. (1994) Phenomenology of obsessive-compulsive disorder: A transcultural study. *Comprehensive Psychiatry* 35(3):191–7. [aPB]

Opie, I. & Opie, P. (1960) *The lore and language of schoolchildren*. Oxford University Press. [BM]

O'Reilly, R. C. & Munakata, Y. (2000) *Computational explorations in cognitive neuroscience*. MIT Press. [HW]

Orians, G. H., & Heerwagen, J. H. (1992) Evolved responses to landscapes. In: *The adapted mind: Evolutionary psychology and the generation of culture*, ed. J. H. Barkow, L. Cosmides & J. Tooby. Oxford University Press. [rPB]

Pahnke, W. & Richards, W. A. (1969) Implications of LSD and experimental mysticism. In: *Altered states of consciousness*, ed. C. T. Tart. Wiley. [IP]

Pardo, J., Fox, P. T. & Raichle, M. E. (1991) Localization of a human system for sustained attention by positron emission tomography. *Nature* 349:61–64. [CSA]

Payne, R. J. H. (1998) Gradually escalating fights and displays: The cumulative assessment model. *Animal Behaviour* 56(3):651–62. Available at: http://elsevier.com; http://www.academicpress.com/anbehav [aPB]

Pediatric OCD Treatment Study (POTS) Team. (2004) Cognitive-behavior therapy, sertraline, and their combination for children and adolescents with obsessive-compulsive disorder: The Pediatric OCD Treatment Study (POTS) randomized controlled trial. *JAMA: The Journal of the American Medical Association* 292:1969–76. [RK]

Pelphrey, K. A., Morris, J. P. & McCarthy, G. (2005) Neural basis of eye gaze processing deficits in autism. *Brain: A Journal of Neurology* 128(5):1038–1048. [rPB]

Penner, H. (1983) The mystical illusion. In: *Mysticism and religious traditions*, ed. S. Katz. Oxford University Press. [IP]

Perner, J. & Ruffman, T. (1995) Episodic memory and autonoetic consciousness: Developmental evidence and a theory of childhood amnesia. *Journal of Experimental Child Psychology* 59:516–48. [OB]

Peterson, B. S., Pine, D. S., Cohen, P. & Brook, J. S. (2001) Prospective, longitudinal study of tic, obsessive-compulsive, and attention-deficit/hyperactivity disorders in an epidemiological sample. *Journal of the American Academy of Child and Adolescent Psychiatry* 40:685–95. [RK]

Phillips, K. A., Menard, W. & Fay, C. (2006) Gender similarities and differences in 200 individuals with body dysmorphic disorder. *Comprehensive Psychiatry* 47:77–87. [GS]

Piaget, J. (1952) *The origins of intelligence in the child*. Basic Books. [OB]

Pierce, K. & Courchesne, E. (2001) Evidence for a cerebellar role in reduced exploration and stereotyped behavior in autism. *Biological Psychiatry* 49(8):655–64. [rPB]

Pinker, S. (1997) *How the mind works*. Norton. [RT]

Pitman, R. K. (1987) A cybernetic model of obsessive-compulsive psychopathology. *Comprehensive Psychiatry* 28(4):334–43. [aPB]

Ploghaus, A., Becerra, L., Borras, C. & Borsook, D. (2003) Neural circuitry underlying pain modulation: Expectation, hypnosis, placebo. *Trends in Cognitive Sciences* 7:197–200. [R-PB]

Polimeni, J., Reiss, J. P. & Sareen, J. (2005) Could obsessive-compulsive disorder have originated as a group-selected adaptive trait in traditional societies? *Medical Hypotheses* 65:655–64. [GS]

Povinelli, D. J., Landau, K. R. & Perilloux, H. K. (1996) Self-recognition in young children using delayed versus live feedback: Evidence for a development asynchrony. *Child Development* 67:1504–54. [OB]

Povinelli, D. J., Bering, J. M. & Giambrone, S. (2000) Toward a science of other minds: Escaping the argument by analogy. *Cognitive Science* 24(3):509–41. Available at: http://elsevier.com: http://www.elsevier.com/inca/publications/store/6/2/0/1/9/4/ [aPB]

Profet, M. (1993) Pregnancy sickness as adaptation: A deterrent to maternal ingestion of teratogens. In: *The adapted mind. Evolutionary psychology and the generation of culture*, ed. J. Barkow, L. Cosmides & J. Tooby. Oxford University Press. [aPB]

Proudfoot, W. (1985) *Religious experience*. University of California Press. [IP]

Pyysiäinen, I. (2001) *How religion works: Towards a new cognitive science of religion*. Brill. [IP]

Rachman, S.(1993) Obsessions, responsibility, and guilt. *Behaviour Research and Therapy* 31:149–54. [JDH]

Rachman, S. & de Silva, P. (1978) Abnormal and normal obsessions. *Behaviour Research and Ther*apy 16(4):233–48. [arPB]

Rachman, S. & Shafran, R. (1998) Cognitive and behavioral features of obsessive-compulsive disorder. In: *Obsessive-compulsive disorder: Theory, research, and treatment*, ed. R. P. Swinson, M. M. Antony, S. Rachman & M. S. Richter, pp. 51–78. Guilford Press. [aPB]

Rachman, S., Hodgson, R. & Marks, I. M. (1971) The treatment of chronic obsessive-compulsive neurosis. *Behaviour Research and Therapy* 9(3): 237–47. [aPB]

Radomsky, A. S., Rachman, S. & Hammond, D. (2001) Memory bias, confidence and responsibility in compulsive checking. *Behaviour Research and Therapy* 39(7):813–22. [aPB]

Rapoport, J. L. (1990) Obsessive compulsive disorder and basal ganglia dysfunction. *Psychological Medicine* 20(3):465–9. [aPB]

(1991) Recent advances in obsessive-compulsive disorder. *Neuropsychopharmacology* 5(1):1–10. Available at: http://www.nature.com/; http://www.nature.com/npp/ [aPB]

Rapoport, J. L. & Fiske, A. (1998) The new biology of obsessive-compulsive disorder: Implications for evolutionary psychology. *Perspectives in Biology and Medicine* 41(2):159–75. [aPB]

Rappaport, R. A. (1971) The sacred in human evolution. *Annual Review of Ecology and Systematics* 2:23–44. [JLO]

(1979) *Ecology, meaning and religion*. North Atlantic Books. [aPB]

(1999) *Ritual and religion in the making of humanity*. Cambridge University Press. [aPB]

Rauch, S. L., Jenike, M. A., Alpert, N. M., Baer, L., Breiter, H. C., Savage, C. R. & Fischman, A. J. (1994) Regional cerebral blood flow measured during symptom provocation in obsessive-compulsive disorder using oxygen 15-labeled carbon dioxide and positron emission tomography. *Archives of General Psychiatry* 51(1):62–70. [aPB]

Rauch, S. L., Whalen, P. J., Curran, T., Shin, L. M. & Coffey (2001) Probing striato-thalamic function in obsessive- compulsive disorder and Tourette syndrome using neuroimaging methods. *Advances in Neurology* 85:207- 24. [aPB]

Rauch, S. L., Whalen, P. J., Savage, C. R., Curran, T., Kendrick, A., Brown, H. D., Bush, G., Breiter, H. C. & Rosen, B. R. (1997) Striatal recruitment during an implicit sequence learning task as measured by functional magnetic resonance imaging. *Human Brain Mapping* 5(2):124–32. [aPB]

Richerson, P. J. & Boyd, R. (2004) *Not by genes alone: How culture transformed human evolution.* The University of Chicago Press. [DMTF]

Rifkin, A. (1985) Evidence for a basic level in event taxonomies. *Memory and Cognition* 13(6):538–56. Available at: http://www.psychonomic.org/; http://www.psychonomic.org/mrc.htm [aPB]

Rilling, J. K., Gutman, D. A., Zeh, T. R., Pagnoni, G., Berns, G. S. & Kilts, C. D. (2002) A neural basis for social cooperation. *Neuron* 35:395–405. [CSA]

Rode, C., Cosmides, L., Hell, W. & Tooby, J. (1999) When and why do people avoid unknown probabilities in decisions under uncertainty? Testing some predictions from optimal foraging theory. *Cognition* 72(3): 269–304. [aPB]

Roessner, V., Becker, A., Banaschewski, T. & Rothenberger, A. (2005) Tic disorders and obsessive compulsive disorder: Where is the link? *Journal of Neural Transmission* 69:69–99. [AR]

Rogers, L. J. & Kaplan, G. (2000) *Songs, roars, and rit*uals. Harvard University Press. [CSA]

Romanski, L. M., Tian, B., Fritz, J., Mishkin, M., Goldman-Rakic, P. S. & Rauschecker, J. P. (1999) Dual streams of auditory afferents target multiple domains in the primate prefrontal cortex. *Nature Neuroscience* 2(12): 1131–6. [aPB]

Rosario-Campos, M. C., Leckman, J. F., Mercadante, M. T., Shavitt, R. G., Prado, H. S., Sada, P., Zamignani, D. & Miguel, E. C. (2001) Adults with early-onset obsessive-compulsive disorder. *American Journal of Psychiatry* 158(11): 1899–903. [JES]

Rothenberger, A. & Banaschewski, T. (2006) Tic disorders. In: *A clinician's handbook of child and adolescent psychiatry tic-disorders*, ed. C. Gillberg, R. Harrington & H. C. Steinhausen, pp. 598–624. Cambridge University Press. [RK]

Rothenberger, A., Banaschewski, T., Heinrich, H., Moll, G. H., Schmidt, M. H. & van't Klooster, B. (2000) Comorbidity in ADHD-children: Effects of coexisting conduct disorder or tic disorder on event-related brain potentials in an auditory selective-attention task. *European Archives of Psychiatry and Clinical Neuroscience* 250:101–10. [RK]

Rowe, C. (1999) Receiver psychology and the evolution of multi-component signals. *Animal Behaviour* 58:921–31. [CSA, aPB]

Rozin, P., Haidt, J. & McCauley, C. R. (1993) Disgust. In: *Handbook of emotions*, ed. M. Lewis & J. M. Haviland. The Guilford Press. [aPB]

Saad, G. (2006) Sex differences in OCD symptomatology: An evolutionary perspective. *Medical Hypotheses* 67:1455–59. [GS]

Saad, G. (in press a) Suicide triggers as sex-specific threats in domains of evolutionary import: Negative correlation between global male-to-female suicide ratios and average per capita Gross National Income. *Medical Hypotheses*. [GS]

Saad, G. (in press b) *The evolutionary bases of consumption*. Erlbaum. [GS]

Saad, G. & Gill, T. (2005) Sex-specific triggers of envy: An evolutionary perspective. Paper presented at the Annual Meeting of the Human Behavior and Evolution Society, Austin, Texas, June 3, 2005. [GS]

Sagvolden, T., Johansen, E. B., Aase, H. & Russell, V. A. (2005) A dynamic developmental theory of attention-deficit/hyperactivity disorder (ADHD) predominantly hyperactive/impulsive and combined subtypes. *Behavioral and Brain Sciences* 28:397–419; discussion 419–68. [RK]

Salkovskis, P. M. (1985) Obsessional-compulsive problems: A cognitive-behavioural analysis. *Behaviour Research and Therapy* 23(5):571–83. [aPB]

Salkovskis, P. M., Wroe, A. L., Gledhill, A., Morrison, N., Forrester, E., Richards, C., Reynolds, M. & Thorpe, S. (2000) Responsibility attitudes and interpretations are characteristic of obsessive compulsive disorder. *Behaviour Research and Therapy* 38(4):347–72. Available at: http://elsevier.com; http://www.elsevier.com/inca/publications/store/2/6/5/ [aPB]

Sanfey, A. G., Rilling, J. K., Aronson, J. A., Nystrom, L. E. & Cohen, J. D. (2003) The neural basis of economic decision-making in the Ultimatum Game. *Science* 300:1755–58. [HW]

Sasson, Y., Zohar, J., Chopra, M., Lustig, M., Iancu, I. & Hendler, T. (1997) Epidemiology of obsessive-compulsive disorder: A world view. *Journal of Clinical Psychiatry* 58:7–10. [aPB]

Saxena, S., Brody, A. L., Maidment, K. M., Smith, E. C., Zohrabi, N., Katz, E., Baker, S. K. & Baxter, L. R., Jr. (2004) Cerebral Glucose Metabolism in Obsessive-Compulsive Hoarding. *American Journal of Psychiatry* 161(6):1038–48. Available at: http://www.appi.org; http://ajp.psychiatryonline.org/ [aPB]

Saxena, S., Brody, A. L., Schwartz, J. M. & Baxter, L. R. (1998) Neuroimaging and frontal-subcortical circuitry in obsessive-compulsive disorder. *British Journal of Psychiatry* 173(Suppl 35):26–37. Available at: http://www.rcpsych.ac.uk/; http://bjp.rcpsych.org/ [aPB]

Schank, R. C. & Abelson, R. P. (1977) *Scripts, plans, goals and understanding: An enquiry into human knowledge structures*. Erlbaum. [OB]

Schnider, A., Treyer, V. & Buck, A. (2005) The human orbitofrontal cortex monitors outcomes even when no reward is at stake. *Neuropsychologia* 43(3):316–23. [aPB]

Schoenbaum, G., Setlow, B., Saddoris, M. P. & Gallagher, M. (2003) Encoding predicted outcome and acquired value in orbitofrontal cortex during cue sampling depends upon input from basolateral amygdala. *Neuron* 39: 855–67. [CSA]

Schutz, L. E. (2005) Broad-perspective perceptual disorder of the right hemisphere. *Neuropsychology Review* 15:11–27. [CSA]

Schwalb, J. M. & Kennedy, S. H. (2005) Deep brain stimulation for treatment-resistant depression. *Neuron* 45(5):651–60. [RT]

Sears, L. L., Vest, C., Mohamed, S., Bailey, J., Ranson, B. J. & Piven, J. (1999) An MRI study of the basal ganglia in autism. *Progress in Neuro-Psychopharmacology and Biological Psychiatry* 23(4):613–24. [rPB]

Seligman, M. E. P. (1971) Phobias and preparedness. *Behavior Therapy* 2:307–20. [JDH]

Seltzer, M. M., Krauss, M. W., Shattuck, P. T., Orsmond, G., Swe, A. & Lord, C. (2003) The symptoms of autism spectrum disorders in adolescence and adulthood. *Journal of Autism and Developmental Disorders* 33(6):565–81. [rPB]

Serruya, D. & Eilam, D. (1996) Stereotypies, compulsions, and normal behavior, in the context of motor routines in the rock hyrax (*Procavia capensis*). *Psychobiology* 24:235–46. [DE]

Sharf, R. H. (1995) Buddhist modernism and the rhetoric of meditative experience. *Numen* 42:228–83. [IP]

(1998) Experience. In: *Critical terms for religious studies*, ed. M. C. Taylor. University of Chicago Press. [IP]

Shepherd, M. (1961) Morbid jealousy: Some clinical and social aspects of a psychiatric symptom. *Journal of Mental Science* 107:687–753. [LDS]

Shooka, A., Al-Haddad, M. K. & Raees, A. (1998) OCD in Bahrain: A phenomenological profile. *International Journal of Social Psychiatry* 44(2):147–54. [aPB]

Sica, C., Novara, C. & Sanavio, E. (2002) Religiousness and obsessive-compulsive cognitions and symptoms in an Italian population. *Behaviour Research and Therapy* 40(7):813–23. [JES]

Sidanius, J. & Pratto, F. (1999) *Social dominance: An intergroup theory of social oppression and hierarchy*. Cambridge University Press. [aPB]

Silk, J. B., Kaldor, E. & Boyd, R. (2000) Cheap talk when interests conflict. *Animal Behaviour* 59(2):423–32. [aPB]

Silverman, I. & Choi, J. (2005) Locating places. In: *The handbook of evolutionary psychology*, ed. D. M. Buss. Wiley. [rPB]

Smith, A. M., Adler, C. H., Crews, D., Wharen, R. E., Laskowski, E. R., Barnes, K., Valone Bell, C., Pelz, D., Brennan, R. D., Smith, J., Sorenson, M. C. & Kaufman, K. R. (2003) The "yips" in golf: A continuum between a focal dystonia and choking. *Sports Medicine* 33:13–31. [RCJ]

Smith, W. R. (1889) *Lectures on the religion of the Semites, first series: The fundamental institutions.* Appleton. [aPB]

Snowdon, C. T. & Elowson, A. M. (1992) Ontogeny of primate vocal communication. In: *Topics in primatology, vol. 1: Human origins*, ed. T. Nishida, F. B. M. de Waal, W. McGrew, P. Marler & M. Pickford, pp. 279–90. Tokyo University Press. [BM]

Sodersten, P. & Bergh, C. (2006) Comorbidity of anxiety with eating disorders and OCD. *American Journal of Psychiatry* 163:327–29. [RK]

Sørensen, J. (2005) Ritual as action and symbolic expression. In: *The cultural heritage of medieval rituals: Genre and ritual*, ed. E. Østrem, M. B. Rrunn, N. H. Peterson & J. Fleischer, pp. 49–64. Museum Tusculanum Press. [JHH]

Sosis, R. (2000) Religion and intragroup cooperation: Preliminary results of a comparative analysis of utopian communities. Cross-Cultural Research: *The Journal of Comparative Social Science* 34(1):70–87. [aPB]

(2003) Why aren't we all Hutterites? Costly signaling theory and religious behavior. *Human Nature* 14:91–127. [GS]

Sosis, R. & Alcorta, C. (2003) Signaling, solidarity, and the sacred: The evolution of religious behavior. *Evolutionary Anthropology* 12:264–74. [GS]

Sosis, R. & Bressler, E. R. (2003) Cooperation and commune longevity: A test of the costly signaling theory of religion. *Cross-Cultural Research* 37:211–39. [GS]

Spear, L. P. (2000) The adolescent brain and age-related behavioral manifestations. *Neuroscience and Biobehavioral Reviews* 24:417–63. [CSA]

Speer, N. K., Swallow, K. M. & Zacks, J. M. (2003) Activation of human motion processing areas during event perception. *Cognitive, Affective and Behavioral Neuroscience* 3(4):335–45. [aPB]

Sperber, D. (1975) *Rethinking symbolism*. Cambridge University Press. [rPB, RT]

(1985) Anthropology and psychology. Towards an epidemiology of representations. *Man* 20:73–89. [aPB]

(1994) The modularity of thought and the epidemiology of representations. In: *Mapping the mind: Domain-specificity in cognition and culture*, ed. L. A. Hirschfeld & S. A. Gelman. Cambridge University Press. [aPB]

(1996) *Explaining culture: A naturalistic approach*. Blackwell. [arPB, DMTF]

(2000) An objection against memetics. In: *Darwinizing culture: The status of memetics as a science*, ed. R. Aunger. Oxford University Press. [aPB]

Staal, F. (1979) The meaninglessness of ritual action. *Numen* 26:2–22. [JHH]

(1990) *Rules without meaning: Ritual, mantras, and the human sciences*. P. Lang. [rPB]

Stace, W. T. (1960) *Mysticism and philosophy*. Macmillan. [IP]

Stevens, A. & Price, J. (2000) *Evolutionary psychiatry: A new beginning.* Routledge. [aPB]

Stickgold, R. (2005) Sleep-dependent memory consolidation. *Nature* 437:1272–78. [RK]

Stickgold, R. & Walker, M. P. (2005) Memory consolidation and reconsolidation: What is the role of sleep? *Trends in Neurosciences* 28:408–15. [RK]

Stone, V. E., Cosmides, L., Tooby, J., Kroll, N. & Knight, R. T. (2002) Selective impairment of reasoning about social exchange in a patient with bilateral limbic system damage. *Proceedings of the National Academy of Sciences USA* 99(17):11531–36. [JT]

Strachey, J., ed. (1976) *Standard edition of the complete psychological works of Sigmund Freud*. W. W. Norton. [JHH]

Suskind, R. (2006) *The one percent doctrine.* Simon & Schuster. [EZW]

Sutton, R. S. & Barto, A. G. (1998) *Reinforcement learning: An introduction*. MIT Press. [HW]

Swain, J. E., Lorberbaum, J. P., Kose, S. & Strathearn, L. (in press) The brain basis of early parenthood: Psychology, physiology and in vivo functional neuro-imaging studies. *Journal of Child Psychology and Psychiatry*. [JES]

Swain, J. E., Mayes, L. C. & Leckman, J. F. (2005) Endogenous and exogenous opiates modulate the development of parent–infant attachment. *Behavioral and Brain Sciences* 28(3):364–65. [JES]

Swanson, J. M., Sergeant, J. A., Taylor, E., Sonuga-Barke, E. J., Jensen, P. S. & Cantwell, D. P. (1998) Attention-deficit hyperactivity disorder and hyperkinetic disorder. *Lancet* 351:429–33. [RK]

Szatmari, P., Barolucci, G. & Bremner, R. (1989) Asperger's syndrome and autism: Comparison of early history and outcome. *Developmental Medicine and Child Neurology* 31:709–20. [MDR]

Szechtman, H. & Woody, E. (2004) Obsessive-compulsive disorder as a disturbance of security motivation. *Psychological Review* 111(1):111–27. Available at: http://www.apa.org/journals/rev.html [arPB, AR, EZW]

(2006) Obsessive-compulsive disorder as a disturbance of security motivation: Constraints on comorbidity. *Neurotoxicity Research* 10(2):103–112. [EZW]

Szechtman, H., Sulis, W. & Eilam, D. (1998) Quinpirole induces compulsive checking behavior in rats: A potential animal model of obsessive-compulsive disorder (OCD). *Behavioral Neuroscience* 112(6):1475–85. [aPB, DE]

Tart, C. T., ed. (1969) *Altered states of consciousness*. Wiley. [IP]

Tek, C. & Ulug, B. (2001) Religiosity and religious obsessions in obsessive-compulsive disorder. *Psychiatry Research* 104(2):99–108. [JES]

Thornhill, R. (1998) Darwinian aesthetics. In: *Handbook of evolutionary psychology: Ideas, issues, and applications*, ed. C. B. Crawford & D. L. Krebs, pp. 543–72. Erlbaum. [aPB]

Tolin, D. F., Abramowitz, J. S., Brigidi, B. D., Amir, N., Street, G. P. & Foa, E. B. (2001) Memory and memory confidence in obsessive-compulsive disorder. *Behaviour Research and Therapy* 39(8):913–27. [aPB]

Tooby, J. & Cosmides, L. (1990) The past explains the present: emotional adaptations and the structure of ancestral environments. *Ethology and Sociobiology* 11:375–424. [JT]

(1996) Friendship and the banker's paradox: Other pathways to the evolution of adaptations for altruism. In: *Evolution of social behaviour patterns in primates and man*, ed. W. G. Runciman & J. M. Smith. Oxford University Press. [aPB]

Tooby, J., Cosmides, L. & Barrett, H. C. (2003) The second law of thermodynamics is the first law of psychology: Evolutionary developmental psychology and the theory of tandem, coordinated inheritances. *Psychological Bulletin* 129(6):858–65. [JT]

(2004) Resolving the debate on innate ideas: Learnability constraints and the evolved interpenetration of motivational and conceptual functions. In: *The innate mind: Structure and content*, ed. P. Carruthers, S. Laurence & S. Stich. Oxford University Press. [JT]

Tooby, J. & DeVore, I. (1987) The reconstruction of hominid behavioral evolution through strategic modeling. In: *Primate models of hominid behavior*, ed. W. Kinzey. SUNY Press. [aPB, JT]

Tranel, D., Bechara, A. & Denburg, N. L. (2002) Asymmetric functional roles of right and left ventromedial prefrontal cortices in social conduct, decision-making, and emotional processing. *Cortex* 38:589–612. [CSA]

Troisi, A. (2001) Gender differences in vulnerability to social stress: A Darwinian perspective. *Physiology and Behavior* 73:443–49. [GS]

(2003) Sexual disorders in the context of Darwinian psychiatry. *Journal of Endocrinological Investigation* 26:54–57. [GS]

Tulving, E. & Markovitsch, H. J. (1998) Episodic and declarative memory: Role of the hippocampus. *Hippocampus* 8:108–204. [OB]

Turner, E. L. B. (1992) *Experiencing ritual: A new interpretation of African healing*. University of Pennsylvania Press. [RT]

Turner, V. W. (1969) *The ritual process*. Aldine. [RT]

Ursu, S., Stenger, V. A., Shear, M. K., Jones, M. R. & Carter, C. S. (2003) Overactive action monitoring in obsessive-compulsive disorder: Evidence from functional magnetic resonance imaging. *Psychological Science* 14(4):347–53. [aPB]

Van Laere, K., Nuttin, B., Gabriels, L., Dupont, P., Rasmussen, S., Greenberg, B. D. & Cosyns, P. (2006) Metabolic imaging of anterior capsular stimulation in refractory obsessive-compulsive disorder: A key role for the subgenual anterior cingulate and ventral striatum. *Journal of Nuclear Medicine* 47(5):740–47. [RT]

Van Veen, V. & Carter, C. S. (2002) The anterior cingulate as a conflict monitor: fMRI and ERP studies. *Physiology and Behavior: The Pittsburgh Special Issue* 77(4–5): 477–82. [aPB]

Vauhkonen, K. (1968) *On the pathogenesis of morbid jealousy.* Kunnallispaino. [LDS]

Wakefield, J. C. (1992) Disorder as harmful dysfunction: A conceptual critique of DSM–III's definition of mental disorder. *Psychological Review* 99(2): 232–47. [rPB]

(2003) Dysfunction as a factual component of disorder. *Behaviour Research and Therapy* 41(8):969–90. [rPB]

Walitza, S., Wewetzer, C., Warnke, A., Gerlach, M., Geller, F., Gerber, G., Gorg, T., Herpertz-Dahlmann, B., Schulz, E., Remschmidt, H., Hebebrand, J. & Hinney, A. (2002) 5-HT2A promoter polymorphism – 1438G/A in children and adolescents with obsessive-compulsive disorders. *Molecular Psychiatry* 7:1054–57. [RK]

Walston, F., David, A. S. & Charlton, B. G. (1998) Sex differences in the content of persecutory delusions: A reflection of hostile threats in the ancestral environment? *Evolution and Human Behavior* 19:257–60. [GS]

Wang, H., Coble, C. & Bello, P. (2006) Cognitive-affective interactions in human decision-making: A neurocomputational approach. In: *Proceedings of the Twenty-Eighth Annual Conference of the Cognitive Science Society*, ed. R. Sun & N. Miyake, pp. 2341–46. Erlbaum. [HW]

Wason, P. C. (1960) On the failure to eliminate hypotheses in a conceptual task. *Quarterly Journal of Experimental Psychology* 12:129–40. [MDR]

Watanabe, J. M. & Smuts, B. B. (1999) Explaining religion without explaining it away: Trust, truth, and the evolution of cooperation in Roy A. Rappaport's "The obvious aspects of ritual." *American Anthropologist* 101:98–112. Available at: http://www.aaanet.org [CSA, aPB]

Wegner, D. M. (1994) Ironic processes of mental control. *Psychological Review* 101(1):34–52. Available at: http://www.apa.org; http://www.apa.org/journals/rev.html [aPB]

Wegner, D. M. & Erskine, J. A. K. (2003) Voluntary involuntariness: Thought suppression and the regulation of the experience of will. *Consciousness and Cognition: An International Journal* 12(4):684–94. Available at: http://elsevier.com; http://www.academicpress.com/concog [aPB]

Wegner, D. M. & Schneider, D. J. (2003) The white bear story. *Psychological Inquiry* 14(3–4):326–9. Available at: http://www.erlbaum.com/ [aPB]

Wegner, D. M., Schneider, D. J., Carter, S. R. & White, T. L. (1987) Paradoxical effects of thought suppression. *Journal of Personality and Social Psychology* 53(1):5–13. Available at: http://www.apa.org; http://www.apa.org/journals/psp.html [aPB]

Weissman, M. M., Bland, R. C., Canino, G. J., Greenwald, S., Hwu, H. G., Lee, C. K., Newman, S. C., Oakley-Browne, M. A., Rubio-Stipec, M., Wickramaratne, P. J., Wittchen, H.-U., & Eng-Kung, Y. (1994) The cross national epidemiology of obsessive compulsive disorder. The Cross National Collaborative Group. *Journal of Clinical Psychiatry* 55:5–10. [aPB]

Welch-Ross, M. K. (1995) An integrative model of the development of autobiographical memory. *Developmental Review* 15:338–65. [OB]

Whitehouse, H. (1995) *Inside the cult: Religious innovation and transmission in Papua New Guinea*. Clarendon Press. [RNM]

(2004) *Modes of religiosity: A cognitive theory of religious transmission*. AltaMira Press. [IP]

Williams, K. E. & Koran, L. M. (1997) Obsessive-compulsive disorder in pregnancy, the peurperium, and the premenstruum. *Journal of Clinical Psychiatry* 58(7):330–4. Available at: http://www.psychiatrist.com/ [aPB]

Wilson, E. O. (1998) *Consilience: The unity of knowledge*. Abacus. [GS]

Wingfield, J. C., Jacobs, J. D., Soma, K., Maney, D. L., Hunt, K., Wisti-Peterson, D., Meddle, S., Ramenofsky, M. & Sullivan, K. (1999) Testosterone, aggression, and communication: Ecological bases of endocrine phenomena. In: *The biology of communication*, ed. M. Konishi & M. D. Hauser, pp. 255–84. MIT Press. [CSA]

Winterer, G., Adams, C. M., Jones, D. W. & Knutson, B. (2002) Volition to action – an event-related fMRI study. *Neuroimage* 17:851–58. [R-PB]

Woody, E. Z. & Szechtman, H. (2005) Motivation, time course, and heterogeneity in obsessive-compulsive disorder: Response to Taylor, McKay, and Abramowitz (2005). *Psychological Review* 112:658–61. [EZW]

Wurbel, H., Chapman, R. & Rutland, C. (1998) Effect of feed and environmental enrichment on development of stereotypic wire-gnawing in laboratory mice. *Applied Animal Behaviour Science* 60(1):69–81. [rPB]

Wynn, T. (1993) Layers of thinking in tool behavior. In: *Tools, language and cognition in human evolution*, ed. K. R. Gibson & T. Ingold, pp. 389–406. Cambridge University Press. [aPB]

Yohanan, M., Aulakh, J. S., Weith, J. & Hawkins, J. W. (2006) Comorbidity of anxiety with eating disorders and OCD. *American Journal of Psychiatry* 163:2. [RK]

Yuen, T., Bradshaw, J. L., Sheppard, D., Lee, P. & Georgiou-Karistianis, N. (2005) Inhibition of return in children with Tourette's syndrome and comorbid forms: A preliminary study. *Child Neuropsychology: A Journal on Normal and Abnormal Development in Childhood and Adolescence* 11:393–411. [RK]

Zacks, J. M. & Tversky, B. (2001) Event structure in perception and conception. *Psychological Bulletin* 127(1):3–21. [arPB, DE]

Zacks, J. M., Braver, T. S., Sheridan, M. A., Donaldson, D. I., Snyder, A. Z., Ollinger, J. M., Buckner, R. L. & Raichle, M. E. (2001a) Human brain activity time-locked to perceptual event boundaries. *Nature Neuroscience* 4(6):651–5. [aPB]

Zacks, J. M., Tversky, B. & Iyer, G. (2001b) Perceiving, remembering, and communicating structure in events. *Journal of Experimental Psychology: General* 130(1): 29–58. [aPB, DE]

Zahavi, A. & Zahavi, A. (1997) *The handicap principle: A missing piece of Darwin's puzzle*. Oxford University Press. [arPB, BM]

Zalla, T., Pradat-Diehl, P. & Sirigu, A. (2003) Perception of action boundaries in patients with frontal lobe damage. *Neuropsychologia* 41(12):1619–27. [aPB]

Zalla, T., Verlut, I., Franck, N., Puzenat, D. & Sirigu, A. (2004) Perception of dynamic action in patients with schizophrenia. *Psychiatry Research* 128(1):39–51. [aPB]

Ziemann, U., Paulus, W. & Rothenberger, A. (1997) Decreased motor inhibition in Tourette's disorder: Evidence from transcranial magnetic stimulation. *American Journal of Psychiatry* 154:1277–84. [RK]

Zohar, A. H. & Felz, L. (2001) Ritualistic behavior in young children. *Journal of Abnormal Child Psychology* 29(2):121–8. [aPB]

Zohar, J., Kennedy, J. L., Hollander, E. & Koran, L. M. (2004) Serotonin-1D Hypothesis of Obsessive-Compulsive Disorder: An Update. *Journal of Clinical Psychiatry* [Special Issue: *Beyond Refractory Obsessions and Anxiety States: Toward Remission*] 65(Suppl14):18–21. [aPB]

Zolotova, J. & Brüne, M. (2006) Persecutory delusions: Reminiscence of ancestral hostile threats? *Evolution and Human Behavior* 27:185–92. [GS]