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THE NEW BIOLOGY OF OBSESSIVE-COMPULSIVE DISORDER: IMPLICATIONS FOR EVOLUTIONARY PSYCHOLOGY

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Obsessive compulsive disorder (OCD) is a chronic psychiatric disease in which thoughts and habits run wild. Obsessive thoughts such as unreasonable doubts (am I a bad person? did I lock the door? do I have AIDS? did I harm someone?) or compulsive habits (praying, repeating, ordering, checking, cleaning, or washing) consume hours of the patients' time [1]. Typically, sufferers are aware that these symptoms are "crazy" but cannot control them. The ritualistic nature of OCD symptoms is striking. Repetitive counting or washing is accompanied by a sense that these behaviors are necessary to ward off discomfort or danger. Some OCD patients have commented on the similarity between their new and peculiar thoughts and behaviors and religious rituals or magical practices of other cultures.

If the epidemiological studies are correct, as many as 2 million people in the United States have this disorder [2]. Until recently, most sufferers kept their disorder secret because of the embarrassment over the bizarre and irrational nature of their thoughts and rituals. The public awareness of the probable neurological nature of the disorder and the availability of effective treatments has increased recognition and referral of OCD patients.

The last two decades of research have greatly advanced our understand-

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ing of OCD, which now is possibly the psychiatric syndrome for which there is the most specific and convincing information on the neural circuitry mediating the underlying abnormal behaviors. Diverse lines of evidence indicate that dysfunction of cortical-basal ganglia circuitry underlies OCD. This raises important questions about the evolutionary basis for neural control of these behaviors. The existence of such specificity in the "hard wiring" of human behaviors as basic to everyday functions as cleaning, checking, and ordering, or concern about dangers to self or others, suggests a biological basis for universal categories of certain thoughts and rituals.

The notion of psychiatric disorder as just another part of medical biology is nothing new. However, some of the symptoms of OCD—such as excessive prayer, ordering and counting, over-scrupulous concern about acceptable behavior, pollution, and purity, and rituals resembling imitative magic—are generally assumed to be culturally mediated and not thought to be so closely tied to specific brain circuitry. If there is a strong biological component, then the identity of these categories, their breadth, and how their mediating circuitry came to exist are exciting and researchable questions.

The debates over such conceptualizations extend beyond psychiatry and medicine to touch linguistics, psychology, anthropology, and evolutionary biology. The recent advances in the neurobiology of OCD, with converging evidence from genetics, brain imaging, immunology, and epidemiology, now suggest empirical research on the universality of fundamental types of human action, and on the joint role of biology and culture in shaping such complex actions. This paper will review recent biological and anthropological studies of OCD in order to suggest ways in which the study of disease may illuminate some fundamental issues in the social and behavioral sciences.

Biological Research on Obsessive Compulsive Disorder

PHARMACOLOGY

The new look at OCD began with studies showing that clomipramine, a tricyclic drug with average antidepressant and antianxiety effects, had unique efficacy in treating OCD [3, 4]. This medication, and the four others to date that are equally effective anti-obsessional treatments, have in common their ability to block the reuptake of serotonin by brain neurons, with relatively little effect on norepinephrine reuptake. More recently, more selective serotonin reuptake inhibitors have become the drugs of choice for this disorder because a large percent of patients can tolerate their side effects [5].

The efficacy of these serotonergic drugs (and lack of efficacy of antidepressants that block reuptake of norepinephrine) inspired a "serotonin hypothesis" of OCD [6]. However, the delayed action of these drugs, sug-

gesting multiple effects on other neurotransmitters, and numerous other biochemical studies of OCD patients and controls, have not yet indicated any primary abnormality of serotonin metabolism in this disorder.

ASSOCIATED NEUROLOGICAL DISORDERS

More striking findings have connected OCD and the basal ganglia. Literally "lower nerve knots," these subcortical gray matter masses have long been associated with neurological disorders of motor control. As shown in Figure 1, the basal ganglia circuitry extends via the thalamus to the frontal cortex.

Most intriguing have been the identification of neurological diseases associated with OCD, all of which involve the basal ganglia and/or the orbitofrontal cortex. These range from OCD following von Economo's encephalitis, a disease which usually caused basal ganglia injury, to cases of OCD following other damage to the basal ganglia (typically involving the globus pallidus and head of the caudate nucleus), such as those resulting from carbon monoxide poisoning, anoxia or allergic reaction to bee sting, or cases following infection [7–9]. An example of the last are toxoplasmic lesions of the basal ganglia leading to OCD, but which improve with effective treatment of the toxoplasmosis [10]. Most recently—and the focus of specific discussion in this paper—there has been evidence that the autoimmune response in the basal ganglia to streptococcal infection may lead to OCD.

Since basal ganglia disorders are typically associated with movement disorders, it is not surprising that several movement disorders show increased rates of comorbidity with OCD; these include Huntington's disease, Parkinson's disease and the best studied, Tourette's syndrome [11–13]. A genetic relation between Tourette's syndrome and OCD is suggested not only by the high comorbidity of the two, but also by the increased rate of tics or Tourette's syndrome in families of patients with OCD, and conversely by the increased rate of OCD in families of patients with Tourette's syndrome, independent of whether OCD or tics were comorbid in the proband [14, 15].

NEUROIMAGING

Neuroimaging advances have allowed study of brain functioning in "typical" OCD patients, i.e., those without any known neurological disorder. Studies using electroencephalology, single photon electroencephalography, positron emission tomography, and functional magnetic resonance imaging have shown with remarkable consistency (compared with studies on other psychiatric disorders), that circuitry (see Fig. 1) involving orbitofrontal/cingulate cortex and the basal ganglia—most particularly the caudate nuclei—are metabolically different in OC patients [16–18].

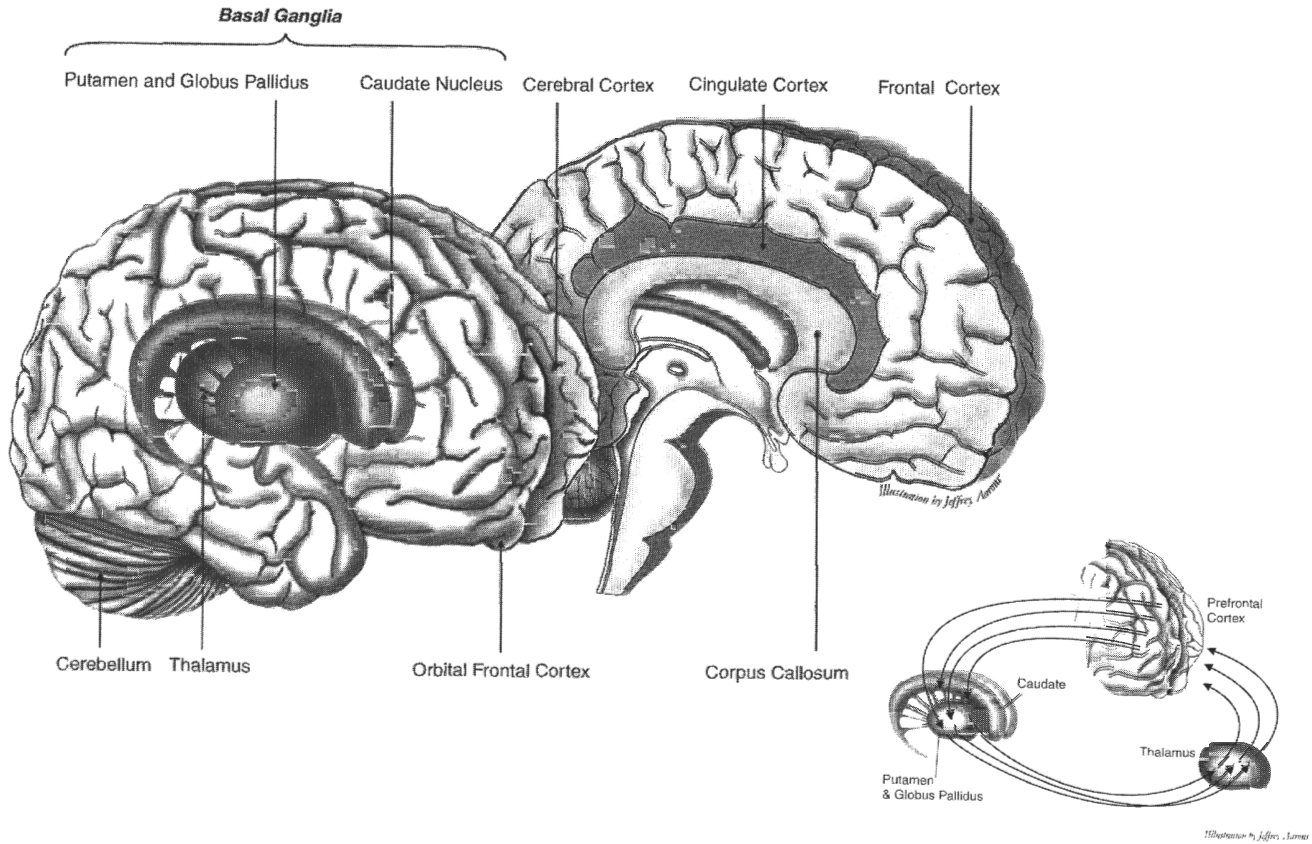

FIG. 1.—Frontal cortex basal ganglia circuits.

A second generation of studies has used the greater temporal resolution of either oxygen-15 positron emission tomography or functional magnetic resonance imaging to study OCD patients before and during symptom provocation, such as by exposing a patient to a feared contaminant [19–21]. Here again selective increases in regional brain blood flow that correlated with symptom intensity were found in the caudate and orbitofrontal cortex.

NEUROPHYSIOLOGICAL STUDIES RELEVANT TO "OCD CIRCUITRY"

While the fundamental features of the basal ganglia evolved with primitive vertebrate and prevertebrate ancestors, the frontal cortex has only appeared much more recently in evolution [22]. Nevertheless, at least in primates, the frontal cortex and basal ganglia function cooperatively in information processing.

Long known to play a role in movement, this circuitry is now recognized as instrumental for a spectrum of behaviors including the planning of complex motor acts. Parallel circuits from the cortex through the basal ganglia and thalamus back to the cortex are thought to play a role in these functions [23, 24]. As summarized by Wise, et al., and others, the brain is thought to have as a primary function the acquisition of adaptive behaviors—that is, behaviors which promote survival and procreation [25–27]. The intimate interaction of frontal cortex and basal ganglia has an interesting implication for the evolution of behavior.

The basal ganglia receive information from most of the cortex but then project back (via the thalamus) primarily to the frontal lobe (see Fig. 1). Evidence is accumulating that the frontal cortex and basal ganglia participate in different but related aspects of response learning. Wise, et al., have speculated that the frontal cortex acts when new rules need to be learned and older ones rejected (such as when correct and incorrect cues are switched during a learning task), whereas the basal ganglia potentiate previously learned rules based on environment and context [25]. This potentiation influences the choice of a particular rule to guide behavior [25, 28].

These findings suggest that neurons in these circuits encode a large amount of rule-based information converging on the caudate and putamen from the cortex, which can be of importance for novelty-based or for context-based "decision making" [28]. The role of pathways that utilize dopamine (a major neurotransmitter in the caudate nucleus) may be to promote both the learning of new rules as well as activating previously learned rules [25]. The view that the basal ganglia function in potentiating rules and detecting novelty in those rules suggests possible models for the inappropriate repetitive behaviors seen in OCD.

More complex behaviors require the related information processing to be more abstract. From a neurophysiological perspective, direct sensory

elicitation of motor programs is less important, while more complex interactions are more important.

Much of this research has used situations in which the "correct" behavior is dependent on a context established by an earlier stimulus. Such context-dependent behavior provides an appealing model for OCD, in which the behaviors might be appropriate given one set of stimuli (e.g., when danger is present or when contamination is a real issue) but are meaningless in their absence.

Given the mounting evidence that basal ganglia damage can set off secondary OCD, which can be reversed with specific treatment, OCD might be seen as both an inappropriate "recognition" of a behavioral context that does not exist and/or an "excess of rule potentiation"–causing or releasing behaviors outside of an appropriate context, manifested as obsessive thoughts or compulsive actions.

The details of such a model are still to be worked out. But we have, to an unprecedented event in psychiatry: a model of a human disorder in which a relatively narrow group of rather complex behaviors appears to be released through damage to relatively selective areas of the brain.

SYDENHAM'S CHOREA AND AUTOIMMUNE OCD

Most recently, a strong association has been demonstrated between OCD and Sydenham's chorea (St. Vitus dance), a childhood movement disorder associated with rheumatic fever, which is thought to be a result of an autoimmune response to Group A beta-hemolytic streptococcal infection, directed at portions of the basal ganglia [29–31]. OCD or some of its symptoms are seen in 70 percent of Sydenham's chorea cases. Swedo and her colleagues have also documented post-streptococcal cases of childhood-onset OCD in individuals who lacked the neurological symptoms of Sydenham's chorea. They have suggested that many childhood-onset OCD cases are modern-day equivalents of Sydenham's chorea, with phenotypic changes perhaps secondary to mutation in the streptococcus itself, or perhaps just an unrecognized *form fruste* of Sydenham's chorea [32, 33].

Therapeutically, this finding of a probable autoimmune-caused OCD (a neuropsychiatric equivalent of Sydenham's chorea) raises the clinical possibility that immunosuppressant and even antibiotic treatments will be effective in treating or preventing OCD [34, 35]. Such studies are ongoing at the National Institute of Mental Health in Bethesda, MD.

Intriguingly, an antigen on the surface of peripheral blood mononuclear cells (labeled "D8/17") is thought to be a marker for the genetic tendency to generate abnormal antibodies to Group A beta-hemolytic streptococcus [36]. The vast majority (95 percent) of Sydenham's chorea or rheumatic fever cases are D8/17 positive (that is, they have a high frequency of cells that bind this monoclonal antibody), in contrast to the less than 5 percent

of healthy populations having such a high frequency of positive cells. Most important, it appears that Dr. Swedo's cases of childhood-onset OCD following streptococcal infection were also characterized by the D8/17 lymphocyte marker [32]. It may be that other childhood OCD cases without clear histories of streptococcal infection will also have high frequencies of this marker [37].

The D8/17 susceptibility marker, by discriminating patients vulnerable to post-streptococcal tissue damage, may provide a feasible method for studying the behavioral "release" hypothesis of OCD. The observation that the B cell marker identifies so few healthy individuals, but such a high percentage of those with susceptibility to an autoimmune response to streptococcus infection [32, 37]—presumably (in cases of Sydenham's chorea or autoimmune OCD) by damage to the basal ganglia—presents a unique research opportunity for the use of a biological marker to test hypotheses about neural control of normal and abnormal ritualistic behaviors. There are a variety of reasons why the new biology of OCD can facilitate research across the social sciences.

Culture, Ritual, and Brain Evolution

CROSS-CULTURAL CONSTANCY OF OBSESSIVE COMPULSIVE DISORDER

Case reports and epidemiological studies from diverse cultures indicate that OCD occurs in virtually all human groups (for reviews, see [38–40]). When standard interviews are used, roughly similar prevalence rates have been obtained in the United States, Canada, Puerto Rico, Germany, Taiwan, Korea, and New Zealand [41]. The symptoms are strikingly similar in cultures where OCD has been described, although there are some interesting differences in cultural details between patients from the United States, Denmark, India, Japan, Benin, Saudi Arabia, and ultra orthodox Jews in Israel [39, 42–50]. The cultural differences that have been found in these studies are mostly related to religious shaping of contamination concerns and scrupulosity.

The degree of similarity in the symptoms of patients in different cultures depends on the coarseness of the categories used for comparison, of course. However, at the level that symptoms are described by various diagnostic interviews and scales, OCD appears to be universal. Similarly, the serotonin uptake-inhibiting drugs are effective anti-OCD agents in the many and varied cultural settings in which they have been used.

From an anthropological perspective, it may not be so surprising that the rituals of OCD are so similar across cultures. The repetitive, precise, and symbolic natures of many religious and secular rituals are also similar across many different cultures. Freud noted the cultural implications of

OCD: "It is easy to see the resemblance between the neurotic ceremonials of obsessions and compulsions and the sacred acts of religious ritual" [51].

In the only empirical demonstration of Freud's observations to date, Fiske and colleagues have shown that the actions, thoughts, and concerns of meaningful, culturally legitimated religious rituals correspond, item for item, with the symptoms of OCD [38, 52]. In theory at least, the brain imaging studies of OCD along with Fiske's work would predict that the same selective brain circuitry is activated in religious and perhaps some secular ritual. If similar circuitry controls both culturally appropriate ritualistic behaviors and OCD, then when these circuits are hyperactivated or otherwise disturbed, does OCD result?

The symptoms of OCD are remarkably complex, well formed, and psychologically sophisticated. They are not only invariant across cultures, but independent of life experience, in that children have almost identical symptoms to those of adults [1]. These aspects of OCD are surprisingly precise and involve a limited number of integrated complex actions, affects, and ideas, such as fear of contamination, the need for purification, prayer, scrupulous concern in observing religious precepts, counting, and concern with thresholds or doors. Vertebrate ethologists have described "fixed action patterns," which include complex social behaviors such as imprinting, combat, courtship, grooming, and feeding, and which are similarly integrated and complex [53]. But OCD reveals a hitherto unsuspected precision and definition in the neural control of sophisticated human behaviors.

As with most disorders, there is no sharp line between normal and abnormal ritualistic behaviors. It is also likely, then, that if basal ganglia circuits control pathological OCD symptoms, they might also control the corresponding actions of normal life. This interference is corroborated by two studies that have investigated culturally meaningful, socially sanctioned rituals that are typical of religious observances, healing, and life-cycle transitions [38, 52]. In these studies, coders analyzed ethnographers' published descriptions of culturally meaningful collective rituals from two different stratified samples of world cultures.

Actions and concerns corresponding precisely to the diagnostic symptoms of OCD occurred much more often in religious rituals than in secular rituals or in non-ritual activities in the same cultures. (A control list of symptoms of other psychopathologies occurred much less often in cultural rituals and did not discriminate between cultural rituals, religious or secular, and other activities.) The resemblance of ceremonies to OCD rituals were striking. For example, a West African funerary ritual required mourners to circle the deceased's house precisely three times, wearing white clothing. Grave offerings are to be arranged in a precise way. The deceased's children must confess any sexual transgressions. Something feared but unspecified will result from failure to do these things correctly [field notes, Dr. Alan Fiske]. Around the world, weddings, curing rites, and religious

observances are characteristically composed of similar elements. This universal repertoire corresponds closely to the symptoms of OCD.

This suggests that despite their manifest diversity, culturally meaningful rituals are composed in part from a universal repertoire of elements corresponding closely to the symptoms of OCD. These behaviors and ideas do not fundamentally depend on any particular cultural meaning system: direct innate neural control appears to be a most parsimonious explanation for the invariance of these actions, affects, and ideas.

MODULAR NEURAL CONTROL OF THOUGHT AND BEHAVIOR

If this diverse set of OCD behaviors and ideas are controlled by a delimited neural circuit, then the anatomical modularity of such control is striking. A wealth of other research supports such brain organization. For example, perceptual processes appear to be highly modular in the sense that they operate relatively independently and do not directly share information [54, 55]. Similarly, memory involves several different, more or less independent systems, associated with distinct ways of learning, retrieval, and knowing, some of which can be anatomically differentiated [56–59].

Humans and other animals have evolved different kinds of learning and competencies which are specific to particular functional domains and which can be selectively impaired [60–64]. The parallels with brain and language capabilities are also evident [65, 66]. Nevertheless, the cluster of human behaviors, affects, and ideas symptomatic of OCD and typical of culturally meaningful rituals is unique. At present, there is no other equally well-defined, complex, and subtle human behavior with comparable specificity of neural control.

The neural control of OCD-like behaviors and thoughts is obviously not (and could not be) totally independent of context; culture inevitably translates neural proclivities into concrete actions. For example, showering is a common symptom of OCD—but only where there is plumbing. Nomads who live in tents do not check door locks or stoves. Scrupulosity must be scrupulosity *with respect to* culturally defined secular or religious practices. Secular American OCD patients often fear HIV infection. This observation raises the interesting question of how to formulate pancultural definitions of these actions and concerns.

Is it possible to formulate universal definitions of these OCD-like actions and feelings? For example, is it extreme *washing* that is characteristic of OCD and cultural rituals? Or is it an extreme attempt to *purify?* If people who dwell in the desert never bathe, but purify themselves with smoke, is this the equivalent to a shower? Clearly we need to define pollution and purity in a manner that applies appropriately to any culture. Or, again, what constitutes a "repetitious ritual"? Clearly, part of what makes a repetitive ritual a symptom of disease is the inner compulsion to do something

that one finds meaningless, wishes not to do, and that interferes with functioning. But other criteria are operative, as it is selected actions that are enlisted to be OCD rituals. A proposed list of neurologically mediated pancultural complex behaviors and thoughts would include:

- avoidance of contact and contamination with polluting substances, including bodily wastes and potentially hazardous substances in the environment;
- cleaning or purifying the self;
- watching for impending danger or harm;
- collecting and hoarding;
- observing social rules or religious prescriptions (scrupulosity);
- feeling horror, repugnance, and guilt about violation (horrific, perverse, or forbidden obsessions);
- making sure that a task has been properly completed so as to avert a danger (checking and doubting);
- repeating a task that is incomplete or improperly done (perfectionism);
- making sure to obtain and verify important information;
- arranging things in an appropriate spatial configuration, temporal order, or motoric pattern;
- counting repetitively.

It is obvious that such a list is arbitrary, as categories overlap, e.g., repetition may be perfectionism and/or protection from danger. Many items are overlapping and cross-cutting: a concern with contamination is likely to be a form of checking, a competitive ritual, and at the same time involve washing. Which of these descriptions is more fundamental than the others? Clinical approaches to such questions have typically proceeded by factor analysis or cluster analysis of symptoms in large samples of patients with OCD. For example, several such surveys show that symptoms of symmetry and ordering tend to occur together, as do symptoms dealing with cleanliness and washing, and obsessions and checking, while the symptom of hoarding occurs more independently of other symptoms (for review see [67]). However, these studies only tell us which symptoms co-occur; they do not approach the deeper question of what is the root or core.

Advances in OCD research have opened up a new prospect of formulating valid categories for characterizing the behaviors of this disorder. An alternate, neurologically validated taxonomy might be obtained, for example, by a survey of OCD symptoms second to basal ganglia damage in children with Sydenham's chorea across diverse cultures. This study would provide a culture-free screen to examine the category issue in OCD, since it would avoid preconceived and perhaps culturally biased symptom lists. Ethnographic studies, as well as the more commonly used research diagnostic ratings of such cases, would extend other, language-based observations on universal categories [68]. Geographic regions with high rates of Sydenham's chorea, such as Brazil or the Northern Territories of Australia, would be choice sites for such surveys [69, 70].

Ethnographic follow-up would permit researchers to explore the way

people interpret and integrate "ritualistic" behavior and "obsessive" thought into their personal lives and cultures. Such studies would enable us to ascertain the nature and limits of cultural variations in both symptoms and in normal ritual behavior and ideation. This should permit researchers to distinguish the relative roles of neurology and culture in shaping both pathological symptoms and normal behavior, and allow researchers to better understand the interaction of neurology and culture. Thus, recent advances offer good prospects for further progress in characterizing what constitutes OCD and its basic symptoms. Hand in hand with this will come advances in understanding the corresponding normal behaviors and thoughts.

EVOLUTION

The evolution of a brain module that directly organizes these complex and seemingly diverse ideas and behaviors does not necessarily imply that they share a common adaptive function or have a common social psychological significance. All of the symptoms of OCD seem to involve problems in selecting and controlling actions, ideas, or concerns: patients attend to one concern or perform one action that is contextually inappropriate. Likewise, once a particular act or thought has started, patients are unable to move on to the next appropriate concern.

Most of the behaviors that characterize OCD seem also to be related to boundaries, order, rules, or right and wrong. Purity and pollution are matters of order and separation [71], while repetition is the most basic way of creating order (consider musical themes). There may be basic neurologically controlled rules of human behavior that involve discerning or creating patterned regularity—that is, after all, the most basic principle of learning and adaptation. In tandem with such rules, there seem to be information storage systems by categories such as "danger" and "purity" that become abnormally activated by the disordered rule system of OCD.

In humans, the meaning of most situations is culturally defined, and social needs are among our most fundamental. Human adaptation is socially organized [72]. Dunbar has hypothesized that while grooming behaviors are important for smaller group size, the evolution of a larger neocortex and of language permits human affiliative behavior through the use of language as a means of social "grooming" [73]. Language and ritual are hypothesized to promote group cohesion in larger functional units. Such a model might link some grooming behaviors seen in OCD with the vigilant monitoring of the social acceptability of the patients' own behavior, to ensure group acceptance and bonding.

It is beyond this brief review to discuss the mechanisms by which adaptive behaviors affect brain evolution, but the models proposed here do not exclude the possibility that culturally derived ritualistic behaviors themselves,

including attention and ideation, provide or reinforce other stimuli for brain evolution (see [74]). Among the prospects opened up by the recent advances in understanding OCD, one of the most interesting remains the investigations of how universal forms of action, thought, and emotion are formulated in culture-specific terms and expressed in individually distinctive lives.

NEUROBIOLOGY AND CULTURAL RITUALS

The extrapolation from OCD research findings to normal behaviors in everyday life remains to be explored. Assuming that some basal ganglia circuitry dysfunction causes OCD, this does not necessarily mean that these circuits have any role in controlling the corresponding behaviors of normal life. There are many sub-clinical and completely normal manifestations of OCD-like behaviors and thoughts; people vary in the degree to which they are concerned about pollution and washing, order and certainty, transgressions and scrupulous observance of religious precepts, and so forth. Various models of human social behavior as an evolutionary force have been proposed [63]. The new research on OCD lets one ask whether these normal and appropriate variations are related (in linear or stepwise fashion) to levels of activation of OCD brain circuitry or to susceptibility to basal ganglia impairment such as that indicated by the D8/17 marker [32, 37].

It is possible, for example, at least in societies where the rheumatogenic Group A beta-hemolytic streptococcus is prevalent, that D8/17 reactivity might be associated with individual differences in compulsivity in the subclinical range. An examination of individual differences in the practice of secular and culturally normal rituals in relation to D8/17 reactivity and/or exposure to streptococcus would be feasible in certain isolate communities. In principle, a group of individuals with high levels of the D8/17 marker might be followed from birth, with regular documentation of exposure to Group A beta-hemolytic streptococcus and evidence for the development of ritualistic behavior.

Similarly, there are many societies in which culturally meaningful rituals and purification practices (or use of magical numbers, colors, and spatial arrays) are much more prevalent than they are in the modern United States. Are these correlations obtained there? Is it conceivable that cross-cultural variation in the prevalence and importance of ritual and purity is partly a function of autoimmune effects of particular streptococcal (or other) infections? A brain imaging study would be feasible, at least in principle, to compare activation across various culturally meaningful rituals and that seen in obsessive compulsive disorder: if a common circuitry were seen with that of OCD, neurophysiology will have born out Freud's speculation that "obsessional neurosis presents a travesty of private religion" [75].

These highly speculative possibilities merit investigation because of their importance, if confirmed.

People conduct culturally meaningful rituals when they need to create, affirm, and coordinate the meaning of an ambiguous or stressful situation: when a person is born, becomes an adult, marries, is ill, dies, or seeks to cope with the ultimate problems and questions that religion addresses. It makes sense that in these recurrent situations, people would collectively draw upon their shared neural mechanisms for discovering and constructing meaning. Rituals incorporating elements that these circuits use to define the adaptive meaning of the situation would resonate with human neuropsychology; people would be moved by them and tend to reproduce them. That is, if these neural circuits determine the selection of action rules by seeking to find the meaning in the situation, then people would be highly susceptible to rituals that offered salient, striking, and repeatedly reiterated patterns, spatial configurations, numbers, cultural precepts, touching, or contact and boundary demarcations—especially with respect to contamination and purification. Such rituals would diffuse readily and be replicated persistently.

Arguments against sociobiology focus on the lack of mechanism, evidence, or testability of biological determinism for complex human behaviors [76]. It has been the thesis of this paper, however, that recent advances in the biology of OCD provide testable hypotheses about the universality of biologically based mental categories and the continuity between culture and psychopathology. This can be a model for utilizing medical advances to address the ways that evolution, the brain, individual development, and culture work together to shape action, affect, and ideas.

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