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Review article

# The normalcy of neurosis: Evolutionary origins of obsessive–compulsive disorder and related behaviors

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**Abstract**

One of the most curious questions plaguing subscribers of evolutionary theory is how natural selection's fine-tuned editing function could allow disease to persist. For evolutionary psychiatrists, the existence of psychopathology is thus perplexing. To illustrate a potential answer to one instance of this broad question, we examine the correlates of obsessive–compulsive disorder (OCD) within our normal repertoire of thought and action. The evidence presents a picture of OCD as a dysregulation of normal behaviors and mental states throughout the course of human development. We speculate that such correspondence may be more than a coincidence and that OCD is a consequence of a dysregulation of the neural circuits that are crucially involved in threat detection and harm avoidance. These neural systems are also likely to underlie aspects of religious experience and ritual as well as the wonders of romantic and early parental love.


*Keywords:* Attachment; Childhood; Development; Evolution; Neuropsychology; Obsessive–compulsive disorder; Pregnancy; Psychiatry; Religion; Ritual

**Contents**



*Abbreviations:* APA, American Psychiatric Association; DSM-IV, Diagnostic and Statistical Manual of Mental Disorders — Fourth Edition; CRI, Childhood Routines Inventory; OCD, obsessive–compulsive disorder.

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## 1. Introduction

*My father and I were in the laundry room and we were having a crisis. It was the strangest thing, but I couldn't stop crying. And there were a few other weird things: I was wearing a yarmulke and a nightgown, for one, and then there were my hands, red and raw and wrapped in plastic baggies. My lip was split. There were paper towels under my feet. And weirdest of all, everything I owned seemed to be in the washing machine, whites and colors, clothes and shoes, barrettes and backpacks, all jumbled together. Huh.*

*"Huh," my father said, examining the Reebok Esprit Hello Kitty stew churning through permanent press. "You want to tell me what happened here?"*

*Wasn't it obvious? The fumes from the bacon my sister had microwaved for dessert had tainted everything I owned, so now it all had to be washed. But this sort of rational explanation hadn't been going over well with my father lately…*

—Jennifer Traig
*Devil in the Details: Scenes from an Obsessive Girlhood*, 2004

There exists a wide literature detailing the parallels between normal anxious–intrusive thoughts and harm-avoidant behaviors and obsessive–compulsive disorder (OCD), from both anecdotal and empirical perspectives. Most normal rituals are believed to address problems, avert bad luck, or facilitate transformation. Tribal cultures cast spells to ward off evil spirits, Westerners knock on wood to avoid bad luck (ref?), and many societies require ceremonial rites of passage from childhood to adulthood. Just as normal individuals engage in ritual to make things "right with the world, either in alignment with a past, present, or future desired state of affairs," individuals afflicted with OCD perform compulsions to "bring the world back into alignment" (Smay, working paper, p. 14). Winnicott (1953) argued that culturally sanctioned rituals occupy a curious middle ground between the internal and external world, serving as *transitional phenomena:* positive, constructive, reparative acts that mend or fill an absence or lack.

OCD attacks an individual's most personal space—close interpersonal relationships and the intimate home environment. Though the compulsions associated with this disorder may seem random, the individual may perceive them as the only way to bear anxiety about family, romantic and interpersonal relationships, self-esteem, and privacy. Given that most people cope with stress through ritual and reliance on interpersonal relationships to differing degrees, we surmise that the anxiety-relieving function of these behaviors may be an outgrowth of an evolutionarily useful mechanism.

We proceed to review evidence from epidemiology, ontogeny, ethology, and neurobiology and trace the patterns of normal ritual through childhood, romantic love, family life, and religion. Integrating findings across disciplines, we suggest that OCD is a dysregulation of evolutionarily conserved behaviors and mental states critical to human survival.

## 2. Definitions

Obsessive–compulsive disorder (OCD) is characterized first by the persistence of obsessions: anxiety-provoking intrusive thoughts, impulses, or mental images that govern the individual's mental life (A.P.A., 2000; Stein, 2002). Individuals are aware of the abnormality of these obsessions; their sense of helplessness in refraining from an irrational and absurd behavior induces even further anxiety. The apparent contradiction between individuals' general view of themselves and the bizarre scenarios they perpetually imagine cause *ego dystonia*, which means guilt or distress to one's concept of self. The second component of OCD is the prevalence of compulsions: urges to perform a series of repetitive behaviors according to a rigid set of rules, often performed in private to hide one's shame.

In the past, the obsessions and compulsions of OCD were viewed as disparate elements, but they have recently begun to be integrated into a dimensional approach (Evans and Leckman, 2005; Mataix-Cols et al., 2005). In this model, the individual's particular obsessions provoke a state of anxiety about particular risks. A corresponding compulsion for each risk provides temporary relief from the particular anxiety. Thus compulsions, bizarre as it may seem, are often the only things the individual can think to do in order to avoid a perceived risk. These compulsions are often illogical. To an outside mind, they may have nothing to do with preventing the specific risk. Subjectively, however, they provide those plagued by intrusive thoughts a means of control over their mental lives.

## 3. Evidence from epidemiology

One of the most common psychiatric disorders, OCD affects as many as 3.0% of children, adolescents, and adults (A.P.A., 2000). Wilson (1998) argued that this high lifetime prevalence supports the notion of OCD as a dysregulation of an adaptive trait rather than the outcome of a harmful genetic mutation.

Across cultures, OCD demonstrates a level of universality. Fontenelle and colleagues (2004) compared 101 Brazilian adult individuals with OCD with 15 clinical samples from Europe, Asia, Africa, North America, and Latin America. They found a universal predominance of females as opposed to males, early age at onset, and pairing of obsessions with compulsions, concluding that cultural variations have little influence on the central features of OCD.

A comparison of epidemiologic data in 7 international communities demonstrated the lifetime and annual prevalence of the disorder to be exceptionally consistent (Horwath and Weissman, 2000), replicating U.S. data across 5 sites. Among diverse regions in North America, the Caribbean, Europe, the Orient, and the Pacific Rim, lifetime prevalence for OCD fell between 1.9 per 100 (in Korea) and 2.5 per 100 (in Puerto Rico). Annual prevalence stayed consistent within the narrow range of 1.8 per 100 (in Puerto Rico) to 1.1 per 100 (in Korea and New Zealand). A recent Australian study using DSM-IV criteria

(A.P.A., 2000) in an adult cohort of over 10,000 individuals found a much lower annual rate, however: just 0.6% (Crino et al., 2005).

Though symptoms may fluctuate in severity and even disappear over the course of a lifetime, researchers have noted two peaks of onset. Early-onset OCD occurs in children under the age of 12, and adult-onset OCD occurs in the post-pubertal years. Pregnancy (Buttolph et al., 1998), marital problems, and the illness or death of a relative (Ingram, 1961) heighten the risk. On the whole, challenges that threaten the integrity or safety of close relationships tend to provoke or intensify obsessive–compulsive symptoms.

Strikingly, at least three independent studies have reported that 90% of normal adults experience intrusive thoughts with content similar to that of pathological obsessions (Rachman and de Silva, 1978; Salkovskis and Harrison, 1984; Freeston et al., 1991). In interviews with 125 university students about their cognitive intrusions and compulsive symptoms, 99% of subjects reported intrusions; 92% had developed systematic activities to respond to those intrusions (Freeston et al., 1991). Muris et al. (1997) observed a similarly high frequency of normal rituals: 54.7% of the 150 normal adults they surveyed experienced idiosyncratic rituals. In individuals with OCD, obsessions and compulsions tended to be more frequent, longer lasting, more difficult to dismiss, more often associated with negative affect, and more persistent, but continuity between abnormal and normal compulsions was apparent. Indeed, even expert raters in the study had difficulty distinguishing between normal and abnormal compulsions.

## 4. Evolutionary "just so" stories: obsessive–compulsive behavior as a response to threat

There are at least four major categories of obsessive–compulsive dyads; each brings with it a characteristic threat domain and mental state. We can map these categories onto the developmental trajectory on the basis of their increased prevalence at certain time periods in the typical individual population (Evans and Leckman, 2005; Mataix-Cols et al., 2005).

Obsessions and compulsions in the *aggressive* threat domain concern fears about one's well-being and that of loved ones. This translates into intrusive thoughts and images about separation or loss. In older children and adults, it creates an impulsive sense of responsibility for the prevention of these scenarios. Individuals may seek physical proximity to those from whom they fear separation—for instance, a child may request that the mother reads a bedtime story in a ritualistic manner every night in order to ensure that she remains close by for that time. A compulsion to "check on" the object of one's concern may provide reassurance that the loved one is safe. To reduce anxiety about harm befalling one's child, parents may continually check on their infant at measured intervals throughout the night, even when they "know" that the baby is fine. Further, individuals may act to avoid perceived dangers by excluding themselves from purportedly risky scenarios. For example, a father may stay home from a family outing, convinced that a car accident will kill off the family unless one parent stays home. This category of concerns prevails when one is most vulnerable to separation from or harm to close loved ones: in early childhood during the formation of bonds with parents and caregivers; in early family life during pregnancy, delivery, and early parenthood, and at times of threat to loved ones due to injury or other external circumstances.

Obsessions and compulsions in the *physical security* threat domain provoke anxiety about one's immediate home environment. Lack of symmetry or exactness makes the individual sensitive to the placement of objects in the physical environment. One may wince at seeing a clothespin fastened slightly left of center and feel an impulse to move it to the symmetrical position. Such concerns provoke checking to be sure that things look "just right" and remain in their expected places. These symptoms are most frequently present during childhood, when an infant or toddler first explores the home environment and forms elaborate daily rituals and routines. Other examples of such concerns occur during early family life, when there may be a heightened attention to details in the human equivalent of 'nest-building.' New parents also often need to check on their newborns and the security of their environment even though they know that they are comfortable and safe.

Obsessions and compulsions in the *environmental cleanliness* threat domain involve anxiety due to misgivings about personal hygiene and cleanliness. The fear of being dirty or causing others to contract illness may plague the individual, provoking a sense of responsibility—checking the house to ensure cleanliness, never sharing items or touching objects seen as repulsive, or excessively washing one's hands. These patterns occur in toddlers as they select preferences for food and drink, in parents as they feel a need to protect children from infection, and in individuals whose loved ones are in danger, as they become obsessed with their loved ones' hygiene to keep them "safe."

Finally, obsessions and compulsions in the *privation* threat domain cause concern about essential resources and compulsive checking to ensure that sufficient supplies are available. In this domain, individuals may be preoccupied with intrusive images in which they or their loved ones suffer adversity and feel responsible for preventing such tragedies. These behaviors dominate childhood and early family life. Children may collect and hoard their favorite objects and develop ritualistic behaviors such as not stepping on cracks on the sidewalk; parents may collect various personal items to ensure safety and adequate supplies for their newborn.

In all of these cases, the compulsion may not seem like a logical way of relieving the obsession. It seems rational to check the stove if one is worried that it is on and will cause a fire; it seems rational to wipe the surface of all one's kitchen appliances after entertaining visitors. It is quite a different thing to relieve the fear of not getting home safely on the walk from school or work by stepping exactly once in every sidewalk square. This "magical thinking" convinces the individual that an illogical ritual will prevent the obsessive thought from being realized, providing subjective relief and reinforcing the behavior.

It is important to acknowledge that the evolutionary accounts proposed above are speculative and untestable. Yet these stories offer a useful framework with which to integrate knowledge across disciplines and improve clinicians' ability to empathize with their clients. OCD risk increases at specific time periods in the course of development, particularly during times of vulnerability and change. The evidence supports an increase in the frequency and intensity of risk scenarios and harm avoidance rituals at biologically critical times, particularly childbirth, puberty, and early parenthood. Gender differences would also be expected, concomitant with the different life challenges males and females face. Indeed, pregnancy and childbirth correspond with significantly increased risk of OCD for women (Buttolph et al., 1998); 95% of mothers and 80% of fathers experienced OCD-like intrusive thoughts in the weeks preceding birth (Leckman et al., 1999).

Many of the intrusive worries caused by OCD are not as bizarre in content as popular stereotypes imply—in fact, they seem quite similar to the experiences of the non-affected population. The idea of checking that one's door is locked before leaving the house and the urge to wipe the kitchen spotlessly clean before expecting guests are both acceptable, rational worries within the appropriate context. Only when these worries provoke excessive measures—checking the door no less than 15 times every morning or confining oneself to the home for fear of exposure to dirt—do they become clinical symptoms. The content of the intrusive thought does not seem to determine the line between OCD and normal behavior as much as the degree to which that thought occupies one's daily life and the context of the behavior performed to control its realization.

That similar symptoms occur in normally functioning individuals may provide indirect support for the theory of OCD as a dysregulation of an evolutionarily conserved mechanism. To illumine these connections, we proceed to examine three specific time points in the normal life cycle at which OCD-like symptoms occur.

## 5. Evidence from ontogeny

### *5.1. Early childhood rituals*

Evans and colleagues (1999) tested 61 children between 13 and 86 months on the Childhood Routines Inventory (CRI), a "19-item parent-report measure that assesses children's repetitive, ritualistic, perfectionistic behaviors." Measuring repetitive behavior in their children, the parents reported whether their child "prefers the same household activities every day," "acts out the same thing in pretend play," "engages in elaborate bedtime rituals," "repeats certain actions over and over," and has "strong preferences for certain foods." They also assessed the presence of "Just Right" behavior, including whether the child "prefers to have things done in a particular order or certain way," "arranges objects or performs certain behaviors until they are 'Just Right,'" "lines up objects in straight lines or symmetrical patterns," "insists on having certain belongings around the house 'in their place,'" and "seems very aware of how certain clothes feel." Expert ratings of each child's behavior were incorporated into the analysis.

Next, parents inventoried their children's fears on a 69-item survey, using a 5-point scale to report the intensity of each fear. Clustered on the basis of shared characteristics, these categories included "fear of strangers (fears of adult males, adult females, and of peers); bedtime fears (fears of the dark, ghosts and monsters, nightmares, and going to sleep); separation (going to sleep, staying with a babysitter, going to school or daycare, spending the night out, death of parents); death fears (fears of something happening to parent, of something happening to self, death of parent, own death, graveyards); city fears (burglars and kidnappers, being alone at home, fires, guns, knives); contamination (fears of diseases, fears of dirt)"; and "fears of animals (dogs, cats, snakes, birds, rodents, horses and cows, insects)."

Children below the age of 4 exhibited significant correlations between bedtime fears and hoarding behavior, between contamination fears and the "Just Right" item of being "very aware of, or sensitive to, how certain clothes feel," between fears of death and close attachment to a favorite object, and between fears of animals and bedtime routines.

Children in the older age group showed peculiar correlations between fears and the practice of rituals. Fears of animals correlated to "strong preferences for certain foods" and concern with "dirt, cleanliness, and neatness." Bedtime fears correlated with the repetition of "certain actions over and over," "strong preferences for certain foods," collecting and storing objects, and having "persistent habits." Fears of urban environments related to the collecting and storing of objects. Fears of contamination were related to the repetition of "certain actions over and over," the attuned awareness of "imperfections in toys and clothes," "persistent habits," "bedtime routines," preferring "to stick to one game/activity," and insisting on having certain belongings "in their place." Fears of death correlated with repeating "certain actions over and over," eating "food in a particular way," and "arranging objects or perform[ing] certain behaviors until they are 'Just Right.'" Fears of separation correlated with the repetition of "certain actions over and over," "strong preferences for certain foods," liking "to eat food in a particular way," and having "persistent habits." Finally, fears of strangers correlated with repeating "certain actions over and over," being "very aware of certain details," and insisting that belongings go "in their place."

These results support older data (Gesell, 1928; Gesell et al., 1974) that children begin to develop elaborate, rigid routines at around 2.5 years old. Routines crystallize by the age of 4. Many of these childhood fears are similar to the obsessions of OCD, such as the fear of contamination, death, separation, and strangers. Older children demonstrated fear–behavior dyads of a more "magical" nature, such as the connection between their fear of death and their commitment to eating food in a particular way.

Behaviors like hoarding, repetitive cleaning, insistence on exact arrangement and placement of certain objects, and rigid preferences for certain foods closely resemble the compulsions

that plague afflicted individuals. Just as in OCD, certain fears may be paired with a specific compulsion in a logical manner. For instance, the fear of death may cause a child to develop a close attachment to a comfortable favorite object.

Gesell (1928) postulated that childhood rituals developed as a way for children to master major developmental tasks such as toilet training, feeding, and dressing. Rules help children master tasks by providing a rigid rubric before they can understand cognitive rationales; thinkers since Aristotle (350 BC) have appreciated the value of this habituation into virtuous behavior.

Piaget (1962) also noted the importance of repetitive, circular motor reactions in early development. As children hone their reflexes into voluntary actions by ritualistic habituation, they adapt to their environment and learn to handle potential threats. As in OCD, such habits may persist even when they cause errors in functioning. Despite exposure to information suggesting that their previous actions will be ineffective in meeting a challenge, children may repeat an inappropriate habit. For instance, children will look for an object in a location where it was previously hidden even though they have watched it being moved to a different location.

Freud (1919) proposed that these rituals result from children's desire to be the exclusive focus of their parents' attention, which creates unconscious sexual impulses toward the caregiver. The child's desire to suppress the realization of these anxiety-provoking impulses manifests itself in compulsive, neurotic behavior. Winnicott (1956) interpreted bedtime routines and other childhood habits as a way for the child to weave the parent into a "transitional web." During formative or stressful periods, the child attaches to transitional objects, such as favorite teddy bears or blankets, which mirror the comfort of parents' presence and help sustain the emotional closeness of the relationship.

Likening childhood rituals to religious behaviors, Erikson (1968) noted that both give the individual an affirmation of self and a sense of belonging to the surrounding world. A series of unbending, reliable rules clarifies difficult and often ambiguous situations in the development of interpersonal relationships, helping the child to establish a sense of self and a concept of relationships.

Werner (1957) recognized that the ritualistic compulsions of childhood represent a rigid, magical connectedness between the organism and the environment, causing the child to feel a sense of "completion" upon performing the ritual. He noted that such completion was contingent on the "unbroken totality" of the ritual, so that any disruption of its performance could undermine the magical function it performs. The reliance on rules and structure accords children comfort in times of anxiety, providing unchanging modes of behavior for them to follow even in the most unpredictable of times.

Empirical and theoretical data support the notion that childhood rituals emerge normally in early development. These rituals may resemble pathology when taken to an extreme, but within their appropriate ontogenetic context, they are crucial in teaching children to manage their anxiety about the outside world.

### 5.2. Romantic love

As Table 1 demonstrates, striking parallels between the thoughts and behaviors associated with romantic love, religious ritual, and parental love have been long been observed (James, 1902; Leckman and Mayes, 1999). Romantic love shares many of OCD's time consuming thoughts and images directed at the "other." Tennov (1979) coined the term *limerence* to describe the cognitive obsessions of being in love: obsession about the

Table 1
Comparison of prominent features of religious experience with early parental love and romantic love

| Feature | Early parental love | Religious experience | Romantic love |
|---|---|---|---|
| Potential for a transformation of hedonic homeostasis | ++++ | ++++ | ++++ |
| Altered emotional state | ++++ | ++++ | ++++ |
| Positive intrusive thoughts and images (preoccupations): | | | |
| –Idealization of the "other" as being perfect | ++++ | ++++ | ++++ |
| –Longing for reciprocity "oneness" with the "other" (monism) | ++++ | ++++ | +++ |
| –Nearly ineffable feelings of completeness, buoyancy, and assurance at times of perceived reciprocity | ++++ | ++++ | +++ |
| –Heightened sensory awareness of the other, involving visual, auditory, and olfactory cues | ++++ | ++++ | +++ |
| –Positive images of the future | ++++ | +++ | +++ |
| Anxious–intrusive thoughts and images (preoccupations): | | | |
| –Worries of not being adequate or worthy | +++ | ++++ | +++ |
| –Heightened sense of responsibility for the welfare of the other | ++++ | + | ++++ |
| –Separation distress | ++++ | +++ | +++ |
| –Worries about the safety and well-being of the other | ++++ | + | +++ |
| –Upsetting aggressive thoughts focused on the self or the other | ++ | + | +++ |
| Exclusivity of focus | ++++ | ++++ | +++ |
| Repetitive behaviors: | | | |
| –Proximity seeking | ++++ | ++++ | ++++ |
| –Emotionally charged caring — talking, singing, feeding and grooming with clear rhythmic/musical elements | ++++ | +++ | ++++ |
| –Need to check to make sure the "other" is safe and secure | ++++ | + | +++ |
| Clear onset | ++++ | ++++ | +++ |
| Time limited duration | ++ | ++ | +++ |
| Dichotomous resolution, either: | | | |
| –Establishment of intimate, mutually satisfying reciprocal patterns of interaction based on a transformation of hedonic homeostasis (habitual center of personal energy) usually marked by a culturally defined ritual, or | ++++ | ++++ | ++++ |
| –Rejection | + | + | +++ |

This tabulation based on information in a variety of sources, including Beyle (1975), Dulaney and Fiske (1994), Fisher (1992), Hazan and Shaver (1994), James (1902), Leckman and Mayes (1999), Tennov (1979), and Winnicott (1956).

object of one's desire (the *limerent object* or *LO*), yearning for reciprocation, determination of one's mood by the actions of the LO, inability to react limerently to more than one person at a time, fantasies of passionate encounters with the LO, fear of rejection, acute sensitivity to the LO's thoughts and behaviors, desire for explanations that interpret the neutrality of the disinterested observer as a sign of hidden passion, aching of the "heart," buoyancy in response to reciprocation of love, and general intensity of feeling to the exclusion of other concerns and needs, such as sleep or food.

Emphasizing the obsessive nature of romantic love, Tesser and Paulhus (1976) found that the sheer time those in love devoted to thoughts about the object of their affections is a telltale feature of limerence. In a study of 656 college students, Shea and Adams (1984) bolstered the importance of preoccupation with the LO in characterizing romantic love. This preoccupation mirrors the recurrent, persistent nature of pathological obsessions and compulsions.

Biological and neurochemical investigations of the anecdotal parallels between romantic love and OCD have yielded empirical substantiation. Marazziti et al. (1999) compared 20 subjects who had "fallen in love" within the last 6 months with 20 unmedicated OCD patients and 20 control individuals. They evaluated the serotonin (5-HT) transporter, which has been linked to both neuroticism and sexual behavior (Lesch et al., 1996), in the specific binding of $^{3}$Hparoxetine ($^{3}$H-Par) to platelet membranes. The density of $^{3}$H-Par binding sites was significantly lower both in individuals who had recently fallen in love and in individuals with OCD than in controls. The authors concluded that the early phases of a romantic relationship operate similarly to OCD on a neurochemical level, a finding supported by the psychological dimensions of obsession and idealization common to both. In the following year, Bartels and Zeki (2000) contributed evidence that viewing a picture of the object of one's romantic affection evoked a pattern of striatal, cingulate, and insular activity similar to that associated with OCD.

### 5.3. Early family life

More than any other time period in adult life, the time surrounding pregnancy and childbirth is characterized by "normal" OCD-like thoughts and behaviors (Table 1). Winnicott's concept of "primary maternal preoccupation" (1958) emphasized the mother's heightened attention to the needs of her infant and her focus on their relationship to the exclusion of all else. Following this theoretical background, Leckman et al. (1999) interviewed 82 parents at 2 weeks and 3 months postpartum, finding several behavioral patterns similar to the symptoms of pathological obsessions and compulsions. At 2 weeks, mothers reported spending 14 h per day focused solely on the infant; fathers reported an average of 7 h. In addition to thoughts of idealization and harmony with the infant, parents were also plagued by anxious–intrusive thoughts about their ability to protect the infant from harm. Cleaning and renovation projects seemed to satisfy a concern for the safety and cleanliness of the child's environment. In most cases, the preparation of the baby's room relieved the need for circumstances to be "just right" for the baby. As each child matured, parents often "child-proofed" their homes by eliminating potentially dangerous products and physical structures.

In the immediate postpartum period, more than 80% of mothers and 70% of fathers worried about harm befalling their babies: an illness threatening their health, a developmental hardship, or a defect in their appearance. Many parents reported the persistence of graphic images in which they failed as parents or harm befell their child. Several imagined dropping or throwing the baby, scratching the baby with too-long fingernails, hurting the baby in a car accident, and watching pets injure the baby—even though they would never actually act on these thoughts. Others worried about the possibility of child molestation and Sudden Infant Death Syndrome. Many parents reported that these disturbing images prompted them to make the environment even safer for their infant.

Though these fears were persistent, only 10% of normal mothers and fathers reported that such thoughts interfered with their lives, and only 15% reported experiencing moderate emotional distress as a consequence. Demonstrating compulsive behavior in response to these worries, 59% of mothers and 42% of fathers allayed their fears by checking on the baby, talking to others, and otherwise distracting themselves.

Even when they were sure "everything was OK," 75% of parents still felt driven to check on the infant. Moreover, 83% of mothers and 69% of fathers predicted that they would be "severely" or at least "moderately" distraught if prevented from checking on the child. This pattern is reminiscent of individuals with OCD who persist in the rigid performance of their compulsions despite "knowing it is crazy"; the temporary relief they gain from these actions reinforces the behavior.

As children grow older, family rituals help stabilize and enrich relationships between family members. Fiese and colleagues (1993) examined the formation of rituals within the family, interviewing 115 married couples with children of either infant or preschool age. Families with a preschool-age oldest child reported more rituals around dinner time and annual celebrations. Older children participated more actively in religious and cultural celebrations, suggesting that family rituals change and intensify as family members' roles shift over the course of development. The authors also found that meaningful family rituals correlated with greater marital satisfaction regardless of the children's ages, concluding that these rituals served to bring the couple closer through participation in regular activities. This finding bears out Goffman's (1971) proposal that the practice of supportive rituals can help reinvigorate relationships grown weak due to neglect, quarreling, boredom, or separation.

The similarity between parental preoccupations and behaviors persistent through evolution and OCD suggests that such behavior is necessary to the survival of the human species.

## 6. Evidence from transformative experience and religious rituals

William James (1902) theorized that religious beliefs follow a two-part model. An uneasiness about humans as they

"naturally stand" leads to a search for a solution that saves humans through proper connection with "higher powers." Early representations in infanthood reinforce the idea of a defenseless infant reliant on his parents for protection from the threatening outside world. Some have proposed that our memories preserve these representations in later life as ineffable idealizations that figure prominently in interpersonal relations and religious experience (Table 1; Leckman, personal communication, 2002).

A growing body of evolutionary thinking connects features of religious experience, experimental evidence for underlying cognitive systems, clues about the genetic basis of these systems, and precise hypotheses about the reproductive advantage of such capacities (Boyer, 2001, 2003; Atran, 2002). Religious experiences frequently provide a sense of comfort in times of adversity, a supportive network, a culturally acceptable way of asking for help, and a prescribed set of behaviors for coping with threats and vulnerabilities.

Ritualistic behaviors similar to OCD figure centrally in religious observance. These include stereotyped physical activity that conveys information (Turbott, 1997) and thought patterns that promote survival-oriented behaviors (Leckman and Mayes, 1999). As Malinowski (1948) has argued, magical rituals may function to help people cope with unpleasant emotion by reducing anxiety. Rituals also arouse strong feelings in their participants, reinforcing socially approved attitudes about their underlying themes and facilitating organized action. Religious rituals provide an adaptive mechanism to control disorder and maintain social unity (Rappaport, 1999).

Concerning the link to OCD, Rachman (1997) proposed that "people who are taught, or learn, that all their value laden thoughts are of significance will be more prone to obsessions—as in particular types of religious beliefs and instructions" (p. 798). Indeed, Catholics with a high or moderate degree of religiosity scored higher on measures of OCD-related cognitions than did less religious Catholics (Sica et al., 2002a). Of 45 outpatients with OCD, 42% of patients had religious obsessions (Tek and Ulug, 2001); religion seems to be a common domain for the expression of obsessive–compulsive-like traits.

Religious influences have also been shown to affect the presentation of OCD (Sica et al., 2002b). Rasmussen and Tsuang (1986) observed that strictly religious patients demonstrated religiously themed obsessions and compulsions. For instance, Hindus with OCD tended to have symptoms related to contamination and washing, which was unsurprising in light of Indian culture's emphasis on purity and cleanliness (Khanna and Channabasavanna, 1988). Similar relationships between OCD symptoms and religious practices have been found in Orthodox Jews (Greenberg, 1984) and Muslims (Okasha et al., 1984), underscoring the influence of particular religious affiliation on the specific themes of an individual's obsessions and compulsions.

## 7. Evidence from ethology

The use of rituals to meet life's challenges extends across numerous species. Maternal behavior among mammals manifests complex repertoires, such as nest-building among mice and dirt-scratching among dogs preparing to give birth. After birth, mammals develop fixed action patterns, such as removing and cleaning the amniotic sack, discarding the placenta, cutting off the umbilical cord, and bathing the newborn. Some rodents and dogs collect pups in their nest, huddle over them for suckling, and repetitively lick and groom them, while primates eat the placenta, groom the baby with their hands, inspect it, and lick it clean. These patterns reliably emerge as postpartum rituals, measures to shield the infant from filth or physical harm.

Studies of animal models in OCD behavior (Greer and Capecchi, 2002) examined the behavior of mice whose *Hoxb8* gene, which is associated with important developmental functions, was manipulated in the lab. These mice showed extreme grooming patterns to the extent of hair removal and lesions on both themselves and their cage-mates. Human compulsions such as grooming, washing, and hoarding may function similarly: as dysregulations of normal developmental mechanisms.

Turner (1988) distinguished between animal and human rituals by noting that animal rituals transmit signals for sexual or social bonding, while human rituals also transmit rich linguistic and cultural meaning. Rituals allow us to maintain cognitive control of our environment, obtain knowledge through rigid classification, and resolve conflicts in culturally acceptable ways. Yet Turner also distinguished cultural rituals from pathological compulsions: while the former recur at regular intervals (often annually), pathological compulsions persist on a daily basis. Cultural rituals enjoy social legitimacy, while compulsions are perceived as senseless or irrational. Indeed, as Heinz (1999) has noted, the cultural ritual in its proper context may carry religious or humanitarian meaning, but these implications would be lost if the behavior were permanently repeated. If we were to celebrate Independence Day with a parade on every day of the calendar year, not just on the 4th of July, a meaningful celebration would swiftly deteriorate into little more than a private obsession.

Examining the adaptive nature of rituals across cultures, Fiske and Haslam (1997) proposed that the ego-dystonic actions and thoughts of OCD become *ego-syntonic*, i.e., seen as valuable, in the context of culturally legitimated rituals. They coded 52 cultures' descriptions of rituals, work, and a control activity. Rituals demonstrated more features of OCD and other psychopathologies than did work or the control activity, suggesting that a psychological mechanism expressed in normal rituals can, when hyperactivated, lead to OCD. Chwe (2001) has also postulated that the power of public ceremonies lies in their capacity to transmit meaning from a central source to individual audience members, giving audiences a framework of *common*, not just *mutual*, knowledge. This common knowledge not only gives individuals shared information, but provides them knowledge of each other's knowledge—the knowledge that others know it, that others know that others know it, and so on. As any game theorist can attest, this common knowledge is essential to the coordination of social activities.

## 8. Evidence from genetics and neurobiology

### 8.1. Genetic studies

Studies of twins and families with repeated instances of OCD suggest that genetic factors play a role in the expression of OCD. Earlier studies have indicated that the transmission of OCD among family generations is consistent with the effects of a single major gene (Hanna et al., 2005b; Nestadt et al., 2000), but there are likely to be a number of heritable genes involved. There is even a suggestion that one of the genes may reside on chromosome 9p24 (Hanna et al., 2002; Willour et al., 2004). Relatives of individuals with OCD who had high scores for either aggressive obsessions and checking compulsions or obsessions of symmetry and exactness and ordering compulsions seem to be at greater risk for OCD than the relatives of individuals who had low scores on those factors (Alsobrook et al., 1999; Hanna et al., 2005a). Leckman et al. (2003) also found that both aggressive obsessions and checking compulsions as well as obsessions of symmetry, ordering, and exactness significantly correlated in sibling-pairs concordant for Tourette syndrome. Mother–child correlations—but not father–child correlations—were significant for these two factors. Using the same data set as Leckman et al. (2003), Zhang et al. (2002) observed significant allele sharing in the hoarding factor for chromosomal loci at 4q34, 5q35.2, and 17q25.

Measuring qualitative traits with quantitative instruments seems to be a powerful way to discover the loci of genetic susceptibility to OCD. Thus far, this approach has provided three especially promising leads with regard to the phenotypes of symmetry/ordering and hoarding. First, tracking these symptoms in large, multigenerational families will help refine the initial results for the genetic linkage of the hoarding phenotype. Second, genome scans using the other phenotypes of OCD will likely reveal other loci. Given the high mother–child correlations in the study by Leckman et al. (2003), it may be valuable to examine the linkage results for alleles that are identical by descent from the mother. Third, twin and cross-fostering studies would help evaluate the heritability of OCD within the general population, examining the different heritability of distinct symptom clusters (such as hoarding, symmetry, or checking) in relatives. If successful, we anticipate that some genetic loci will be specific for a particular obsessive–compulsive symptom dimension, while others will be general vulnerability genes that confer increased risk for OCD as a whole or as a larger subset, e.g., tic-related OCD, or across disorders within the obsessive–compulsive spectrum (Lochner et al., 2005; Miguel et al., 2005).

### 8.2. Neuroimaging studies

Functional neuroimaging studies have greatly increased our understanding of the neural mechanisms underlying OCD. Although the replicability among these studies has been imperfect, they strongly link obsessive–compulsive symptoms with activation of the orbitofrontal cortex, with less consistent involvement of the anterior cingulate gyrus, the striatum (particularly the caudate nucleus), the thalamus, the lateral frontal and temporal cortices, the amygdala, and the insula (Saxena et al., 2001; Stein, 2000). Most studies lumped together patients with mixed symptoms. Only a limited number of studies used patients with one predominant type of symptom or compared mutually exclusive groups of patients. In one PET study, Rauch et al. (1998) reported that checking symptoms correlated with increased—and symmetry/ordering with reduced—regional cerebral blood flow in the striatum, whereas washing symptoms correlated with increased blood flow in the bilateral anterior cingulate and the left orbitofrontal cortex. Phillips et al. (2000) compared OCD patients with predominantly washing symptoms with OCD patients with predominantly checking symptoms while viewing pictures of either normally disgusting scenes or washing-relevant pictures using functional magnetic resonance imaging (fMRI). When viewing washing-related pictures, only washers demonstrated activations in regions implicated in emotion and disgust perception (i.e., visual regions and the insular cortex), whereas checkers demonstrated activations in frontostriatal regions and the thalamus. In a similar study, OCD patients with predominantly washing symptoms demonstrated greater activation when viewing disgust-inducing pictures than comparison subjects in the right insula, the ventrolateral prefrontal cortex, and the parahippocampal gyrus (Shapira et al., 2003). Saxena et al. (2004) found that 12 patients with predominant hoarding symptoms showed reduced glucose metabolism in the posterior cingulate gyrus (versus comparison subjects) and the dorsolateral prefrontal cortex (versus nonhoarding OCD subjects) and that the severity of hoarding in the whole patient group ($N=45$) correlated negatively with metabolism in the latter region.

A recent fMRI study (Mataix-Cols et al., 2003, 2004) examined the neural correlates of washing, checking, and hoarding symptom dimensions of OCD. Using symptom provocation with pictures and narratives, both patients and control subjects experienced increased subjective anxiety and activated neural regions previously linked to OCD. Analyses of covariance, controlling for depression, showed a distinct pattern of brain activation associated with each symptom dimension. Although both patients and comparison subjects activated similar brain regions in response to symptom provocation, the patients showed greater activation in bilateral ventromedial prefrontal regions (the washing experiment); the putamen/globus pallidus, the thalamus, and dorsal cortical areas (the checking experiment), and the left precentral gyrus and the right orbitofrontal cortex (the hoarding experiment). These results were further supported by correlation analyses within the patient group, which revealed highly specific positive associations between subjective anxiety, questionnaire scores, and neural response in each experiment (Mataix-Cols et al., 2004). The findings suggest that different obsessive–compulsive symptom

dimensions are mediated by relatively distinct components of frontostriatothalamic circuits implicated in cognitive and emotion processing involving threat detection and harm avoidance.

In vivo brain imaging studies of normal subjects during periods of OC-like behavioral and mental states offer additional support for a common neurobiological substrate. Lorberbaum et al. (2002) found increased levels of activity in a number of brain areas in response to hearing standard baby cries. Several other groups are working in this area, using different experimental paradigms and populations (Bartels and Zeki, 2000, 2004; Nitschke et al., 2004; Ranote et al., 2004; Seifritz et al., 2003; Swain et al., 2003). These imaging studies hold the promise of identifying brain regions associated with parent–infant attachment and romantic love, which may share function in OCD thoughts and behaviors. For example, Nitschke and colleagues (2004) found that mothers of newborn children exhibited bilateral activation of the orbitofrontal cortex while viewing pictures of their own versus unfamiliar infants. The most detailed imaging study to date of early parenting comes from the work of Swain et al. (2005) in which over 25 mothers and 25 new fathers were imaged twice (when their newborn was 2–4 weeks and again at 3–4 months of age). Brain activity was monitored in response to own versus other infant cries and pictures, using the same stimuli at both time points. They found that first-time parents responding to their infant's cries (versus the cries of other infants) at 2 weeks postpartum activated the amygdala bilaterally as well as the insula. At 3 to 4 months, the activity pattern had shifted so that areas in the hypothalamus and the ventral tegmental area were activated. The response in the "veteran" parents at 2 weeks, however, more closely resembled what was seen at 3 to 4 months in the first-time parents. For all parents studied, activation of the right amygdala was correlated with measures of OCD symptom-like anxious–intrusive thoughts and harm-avoidant behaviors. More research is needed on the common and distinct neural correlates of various obsessive–compulsive symptom dimensions with symptom-provocation paradigms, as well as combining neuropsychological tasks and neuroimaging techniques particularly within "normal" subjects.

It is also intriguing to note that CSF levels of oxytocin, otherwise known as the affiliative neuropeptide (Carter, 1998, 2003; Numan and Insel, 2003) are elevated in some individuals with OCD (Leckman et al., 1994a,b). Indeed it was this observation that first led to the hypotheses: 1) that some forms of OCD are at the extreme end of a range of normal behaviors that are mediated by oxytocin and related systems; and 2) that some normal cognitive, affiliative, and sexual behaviors are evolutionarily conserved and contain elements that are similar to features of OCD.

In sum, the brain circuitry and neurochemical systems implicated in OCD likely identifies neural networks involved in threat detection and harm avoidance, including the orbital frontal cortex, the anterior cingulate cortex, the insula, the caudate nucleus, the nucleus accumbens, and the thalamus. The involvement of these areas in executive functions—self-monitoring, error detection, and selection among competing responses—suggests that OCD functions along the same neural pathways as behavior in everyday challenges.

## 9. Conclusions

How can Darwin's theory of natural selection (Darwin, 1859 [1993]) explain the persistence of psychopathology that places individuals at a reproductive disadvantage? Perhaps evolution is not a perfect editor: the developmental mechanisms honed by survival-based advantage have generated a sophisticated human organism well suited for our environment, but it has also generated vulnerability to certain diseases. In the struggle for life, certain traits have come to predominate.

Natural selection is likely to have shaped not only the internal biology of our brains but, indirectly, our mental processes and behavior. Elements in our mental and behavioral repertoire that were certainly the focus of the greatest selective pressures are those related to successful reproduction and survival in the face of external threats.

Evidence across a variety of scientific disciplines suggests that some cases of OCD become manifest when evolutionarily conserved neural systems go astray (Leckman and Mayes, 1998). Each of the obsessive–compulsive symptom dimensions identified thus far can be seen in a distinctive and plausible (albeit untestable) relationship to successful aspects of our capacity to reproduce and survive as a species. Patterns in normal development suggest that the thematic content of OCD resembles that of normal mental states and behavior. When these normal thoughts and behaviors come to dominate one's mental life, the individual is seen to be afflicted with what we call OCD.

In normal life, precipitating factors trigger reliance on ritual to cope with vulnerability and change. In the vulnerable individual, these factors can lead to a pathological, persistent dysregulation of our threat detecting and harm avoiding neural systems. The persistence of OCD in a small segment of the population may be a necessary price to pay for mechanisms without which humans could not have survived. It may also be that these same systems have also left us richly blessed (and at times cursed) by aspects of religious experience and ritual as well as the wonders of romantic and early parental love.

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