

FACTOR STRUCTURE OF OCD: TOWARD AN EVOLUTIONARY NEURO-  
COGNITIVE MODEL OF OBSESSIVE-COMPULSIVE DISORDER

A THESIS

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By

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## ABSTRACT

Obsessive-Compulsive Disorder (OCD) is a disorder characterized by its clinical heterogeneity, but also a commonality of symptom clusters that are known as “symptom dimensions.” Previous research among clinical samples using factor analysis has shown that the symptom-structure of OCD falls into four or five of these dimensions. The symptom dimensions can be conceptualized as representing impairment in several discrete brain systems which may meet the criteria for evolved mental “modules.” The current study uses confirmatory factor analysis in a community sample to test several competing models of OCD-like symptoms. These symptoms are discussed from the perspective of adaptive mental modules, and normal functions of OCD-like thoughts and behaviors are discussed. The four-factor model of OCD symptoms proposed in previous research was supported relative to competing one and five-factor models, and a positive correlation between OCD-like symptoms and mating success is demonstrated. Implications are discussed for the understanding and treatment of OCD, as well as our understanding of the brain’s evolved cognitive structure and organization during normal functioning.

## INTRODUCTION

Obsessive-compulsive disorder (OCD) is a chronic psychiatric disorder characterized by persistent, distressing obsessive thoughts and compulsions. Lifetime prevalence of the disorder is 1-3% and tends to be cross-culturally robust (Staley & Wand, 1995). While the mechanisms of OCD have been studied in great depth, much mystery still surrounds the etiology of the condition. The symptoms which occur in any individual case of the disorder are so seemingly unrelated that it appears that many disparate but somehow related cognitive processes are being affected. For instance, some OCD sufferers have recurring unpleasant intrusive thoughts, self-doubt in their own efficacy to turn off the stove, and altered, “magical” notions of causality that cause them to believe that if they do not, for example, read aloud each sign they come across, their loved ones will die (Bloch, Landeros-Weisenberger, Rosario, Pittenger, & Leckman, 2008). While researchers and clinicians accept from experience that these symptoms co-occur in OCD, it is far from obvious that they must necessarily do so, given how disparate in nature they are from one another.

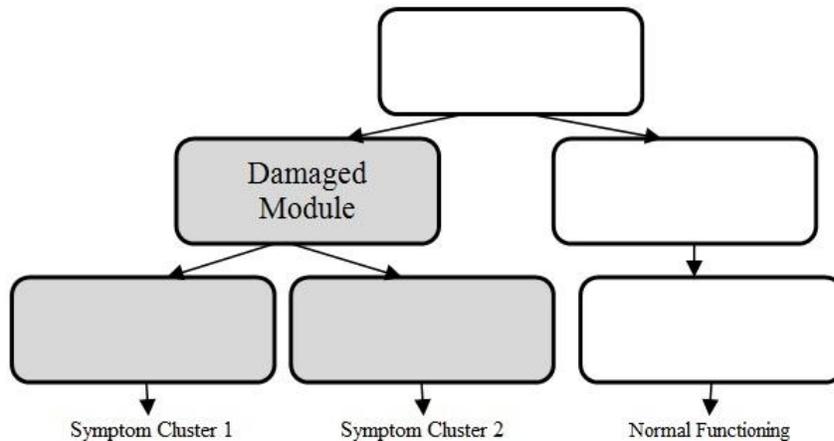
Research on the etiology of Obsessive-Compulsive Disorder, in which a number of seemingly disparate systems can be affected within the same patient, may benefit from a theory of cognition and behavior that views the brain as a system of interconnected data processing streams (which ultimately use the outside world as input and produce behavior and cognition as output). The modular theory of mind, as initially proposed by Jerry Fodor (1983) and refined by subsequent researchers (Pylyshyn, 1999; Ermer, Cosmides, & Tooby, 2007), posits that the brain works in exactly this way, and is composed of a series of functional modules which take in data from the sensory world or other modules

and output them as behavior or to successive modules. This theory, which likens the brain to an organic computer, underlies the domains of cognitive and evolutionary psychology and is considered by its advocates to be the only way that any system, organic or artificial, could produce behavior and cognition (Pinker, 2000). According to this theory, the theoretical modules and processing streams of the brain, which are underlied in reality by complex systems of interconnected neurons, electrochemical impulses, and neurotransmitters, can produce aberrant behavior when their functioning is impaired through aberrant input or physical or chemical insult (Murphy & Stich, 1998).

This theory is implicit in the field of cognitive neuropsychology, in which the impairment of particular cognitive or behavioral faculties in a single patient can be used to create and inform potential models of how the cognitive system underlying that set of behaviors might be laid out and how it might operate in a normally-functioning brain (Coltheart, 1985). For example, the incidence of both patients who experience prosopagnosia (the inability to recognize even familiar faces) and others who experience Capgras syndrome (in which a familiar person is recognized normally but believed to be an imposter) have led researchers to posit two processing streams involved in face recognition. One pathway, impaired in prosopagnosics, encodes the features of the face and associates them with its bearer; the other, which is one of the affected systems in the Capgras delusion, assigns an emotional valence to the face (Hirstein & Ramachandran, 1997). Impairment in this latter system, accompanied by other impairments in reasoning, prompt Capgras patients to assume that their loved ones, whose faces they recognize but do not associate emotional meaning with, must have been replaced by a clone or robotic doppelganger. OCD may be similarly well-suited for this type of neurocognitive analysis

because of its odd and disparate symptom range, which has been so poorly understood with traditional approaches.

Simply observing that a patient has impairments in a number of separate domains does not allow us to infer that the neural structures underlying all these domains are damaged. Murphy and Stich (2000) describe the information in our mental processing systems as flowing in a stream, with the output from one module serving as the input for others; therefore, a damage or insult to only one module can impair the functioning of those “downstream” from it simply by passing “corrupted” information to the downstream modules. This model may be appropriate for obsessive-compulsive disorder; perhaps the numerous domains of impaired cognition and behavior seen in OCD patients are the result of an irregularity in one or more “upstream” modules which in turn send “bad” input to the others, with the end result of abnormalities in all of these processes (see Figure 1).



**Figure 1.** Information-processing model of brain, showing network of “modules.” Gray shading indicates problematic processing. Note how the two modules giving rise to symptoms are undamaged, but lie downstream from a damaged module, resulting in problematic processing.

The extent to which such a proposed model holds up in any mental disorder depends on the degree to which clinical phenotypes feature symptoms predictably and reliably co-occurring with other specific symptoms. While OCD appears at first glance to be a massively heterogeneous disorder, with as many types of OCD as there are OCD patients, researchers have found that symptoms tend to group into one of several discrete “dimensions.” Factor analyses by various researchers have found anywhere from 2 to 5 different groupings of OCD symptoms (for example, Baer, 1994; Amir, Foa, & Coles, 1997; Cavallini, Di Bella, Siliprandi, Malchiodi, & Bellodi, 2002; Cullen et al., 2007), but a 2008 meta-analysis (Bloch et al., 2008) involving 21 previous studies found four factor groupings. They named the four factors “symmetry” (involving obsessions with symmetry and compulsions to repeat, order, and count), “forbidden thoughts” (involving violent, sexual, religious, and somatic obsessions and checking compulsions), “cleaning” (consisting of cleaning and contamination obsessions and compulsions), and “hoarding” (consisting of hoarding obsessions and compulsions).

The research of Bloch et al. (2008) and most of the other studies of OCD symptom dimensions used the Yale-Brown Obsessive Compulsive Scale Checklist (YBOCS-CL) as the assessment tool and ran factor analyses at the category level (YBOCS-CL contains 15 categories such as “aggressive obsessions,” “contamination obsessions,” and “checking compulsions,” most of which contain a number of individual items); in contrast, Katerberg et al. (2010) used an item-level factor analysis and found a five-factor solution. The factors were analogous to Bloch et al.’s (2008), except “forbidden thoughts” broke down further into three factors—“taboo,” “doubts,” and “rituals/superstition”—and hoarding and symmetry were contained in a single factor.

Katerberg et al. (2010) suggested that item-level (rather than category-level) factor analysis—and thus the five-factor solution—was more likely to represent the clinical reality of the disorder, both because categorical analysis omits the miscellaneous symptoms of the Y-BOCS Checklist and because it relies on an unwarranted and unsupported assumption that all items in the predefined categories would cluster together if analyzed separately (Katerberg et al., 2010). In addition to the discrepant findings in the number of symptom dimensions from various factor analyses, different types of analysis such as latent class modeling have even suggested one-factor solutions (i.e., no distinct symptom subgroups; Leckman et al., 2010).

These symptom dimensions should not be considered pure “sub-types” of OCD (Rauch et al., 1998). Rather, individual OCD patients are conceptualized as having varying levels of symptoms on each of the four or five dimensions; while “pure” patients exist who have symptoms from only one dimension, they are the exception rather than the rule (Mataix-Cols, Rosario-Campos, & Leckman, 2005). This multidimensional model of OCD may cut across some of the confusion resulting from the clinical heterogeneity of the disorder (Mataix-Cols et al., 2005) and suggests the possibility of each symptom dimension having its own underlying disorder structure in the cognitive processing machinery of the brain. Since OCD represents the impairment or aberrant functioning of a certain set of cognitive domains rather than a general impairment of brain functioning as a whole (Bloch, et al. 2008), a neurocognitive perspective would suggest that the disorder affects particular discrete systems of the mind’s processing apparatus; in fact, it has been demonstrated that the different symptom dimensions seem to have distinct neural substrates (Mataix-Cols, Wooderson, Lawrence, Brammer,

Speckens, & Phillips, 2004). It has been further suggested that the particular systems affected in OCD might meet the criteria of adaptive functional “modules” (as opposed to simply being by-products of our brain’s evolutionary history), each of which evolved for a particular function (Evans & Leckman, 2006; Feygin, Swain, & Leckman, 2006). Using the four-factor solution (Bloch et al., 2008) as their version of the OCD symptom dimensions, Evans and Leckman (2006) suggest a different putative adaptive benefit underlying each dimension (for example, hoarding behavior may be related to functional resource acquisition). Importantly, clinical OCD is viewed as a dysfunction or disinhibition in these proposed modules; Evans and Leckman (2006) are not suggesting that OCD itself was naturally selected for.

Thus, the individual systems which malfunction in OCD may be evolved systems of the normally functioning brain which work individually and in tandem with other modules to give rise to adaptive behaviors and cognitive processes. In this case, not only should the pattern of symptoms in OCD patients give clues to the underlying processing streams, but the functioning of unimpaired minds should as well. There have been many studies of OCD-like symptoms in nonclinical populations (Gibbs, 1996), often in family members of the OCD patients themselves (Pauls, Alsobrook, Goodman, Rasmussen, & Leckman, 1995) but other times in general populations to assess incidence of “sub-clinical OCD” (Degonda, Wyss, & Angst, 1993). Incidence of OCD-like obsessions and compulsions in nonclinical samples has been shown to be as high as 99%, depending on the population sampled and the criteria assessed (Gibbs, 1996).

To the extent that OCD-like thoughts and behaviors are pervasive and possibly adaptive at subclinical levels, individuals with moderate levels of these symptoms should

have higher *mating success* (the ability to attract sexual partners; see Landolt, Lalumière, & Quinsey, 1995) than individuals low on these traits; a certain level of cleanliness, order, and caution are generally considered positive and useful traits. On the other hand, symptoms of major mental disorders have been conceptualized as signals of high levels of genetic mutations (Keller & Miller, 2006) and thus as undesirable signals which should be unattractive to potential mates (Shaner, Miller, & Zintz, 2007). Therefore, high levels of OCD symptoms should also harm individuals' mating prospects and therefore their genetic fitness (defined as the relative ability of an organism to pass on its genes in its current environment). This prediction is congruous with the widely acknowledged perspective that severe mental disorders such as OCD significantly interfere with the ability to successfully pass on one's genes, making common, heritable mental disorders something of a paradox from an evolutionary perspective (Keller & Miller, 2006).

### The Current Study

The current study was designed to assess OCD-like symptoms in a community sample to determine whether these symptoms show the discrete factor groupings found in previous studies (as opposed to a one-factor solution), and if so, whether they fall in line with the four-factor structure found by Bloch et al.'s meta-analysis (2008) or the five-factor structure found by Katerberg et al. (2010). If the symptom dimensions of OCD are indeed due to discrete underlying information-processing pathways, it is crucial to reliably ascertain which symptom dimensions exist. A questionnaire derived from the Yale-Brown Obsessive Compulsive Scale (Y-BOCS) Checklist was administered to a general sample of men and women using the website Amazon Mechanical Turk (MTurk for short; see below). A confirmatory factor analysis was then run to compare the one,

four, and five-factor models. It was hypothesized that the symptoms of the sample as a whole would fall into the four-factor structure of Bloch et al. (2008): *symmetry, forbidden thoughts, cleaning, and hoarding*. Such a finding would imply that there are (at least) four different, discrete processing streams involved in the etiology of OCD and, perhaps, specialized “modules” in the human brain dedicated to these domains of cognition.

Measures of mating success, mating intelligence, and life history strategy were also collected to assess the extent to which OCD-like symptoms might affect genetic fitness. As the modern world places limits on the unrestrained spreading of genes, mating success is often used as a proxy to estimate genetic fitness in contemporary society (Geher & Kaufman, 2011). *Mating intelligence* is a measure of the differential cognitive ability to achieve adaptive mating-relevant outcomes (Geher & Kaufman, 2011), while *life history strategy* refers to the extent to which an individual emphasizes a risky lifestyle with many mating opportunities versus a more cautious lifestyle with greater emphasis on childcare (Figueredo et al., 2006). Mating intelligence and life history strategy were assessed in the current study as possible covariates which could affect mating success in addition to the effects of OCD-like symptoms. It is hypothesized that moderate levels of OCD-like thoughts and behaviors will be associated with higher mating success than either relatively low or high levels of these behaviors.

## METHOD

### Participants

536 male and female (36.7% female, 60.2% male, 1.2% preferred not to respond) adults responded to the survey, but only 518 completed all survey items; the subjects with incomplete surveys were dropped. Participants ranged in age from 18 (the minimum

required to participate in the study) to 72 ( $M = 28.14$ ,  $SD = 8.82$ ). Each participant was compensated \$0.10 (ten cents) for taking the survey, a sum which is comparable to that paid by other requesters on MTurk for tasks of similar length (around 20 minutes). No identifying information about the participants was available, beyond the demographic questions collected as part of the survey, ensuring the anonymity and security of the participants' data. However, geographical region is automatically collected by SurveyMonkey, showing the majority of participants to be located in South Asia, especially India.

### Measures

The Yale-Brown Obsessive Compulsive Scale Symptom Checklist (Y-BOCS CL) is normally used as part of a larger clinical assessment for OCD which is generally administered in interview format by a clinician (Goodman et al., 1989). The Y-BOCS CL contains 44 obsession symptoms grouped into categories of aggressive, contamination, somatic, sexual, hoarding/saving, religious, symmetry, or miscellaneous, and 29 compulsion symptoms, grouped into the categories of cleaning/washing, checking, repeating rituals, counting, ordering/arranging, hoarding/collecting, and miscellaneous. The current study used a version of the Y-BOCS CL with modified wording so it could be administered as a self-report measure (see Appendix A). The open-ended "Other" obsessions within 5 of the obsession categories and 5 of the compulsion categories were omitted; further, the miscellaneous compulsions "Excessive listmaking" and "Rituals involving blinking or staring" were accidentally omitted from the questionnaire, resulting in a total of 39 obsession items and 22 compulsion items assessed. For each item, participants rated the combined frequency/severity of its

occurrence, presently or in the past, on a 5-point Likert-type scale from 1 (Never) to 5 (Constantly/Very Severe). In this way, both severity *and* variety of symptoms were assessed, which would not have been possible with the nominal scale usually associated with the Y-BOCS CL (Never experienced, In the past, or Currently). Subjects were also asked their age, sex, and whether they had ever received a diagnosis of Obsessive-Compulsive Disorder (they were told to exclude diagnoses of Obsessive-Compulsive *Personality* Disorder, a distinct disorder).

Finally, subjects were given the Mating Success scale, an 8-item Likert-type questionnaire assessing participants' success with potential sexual partners (Landolt, Lalumière, & Quinsey, 1995; sample item: "I receive sexual invitations from potential partners." See Appendix B for full scale); the Mini-K scale, a 20-item Likert-type questionnaire assessing participants' life history strategy (Figueredo et al., 2006; sample item: "I would rather have one than several sexual relationships at a time." See Appendix C for full scale); and the Mating Intelligence scale, a 24-item true-false questionnaire assessing participants' skills in mating relevant domains (Geher & Kaufman, 2007; sample item "I'm good at saying the right things to people I flirt with." See Appendix D for full scale). Participants who did not indicate their sex were not given the latter scale, as the Mating Intelligence scale contains a different set of questions for males than for females; in this study, both versions of the Mating Intelligence scale used wording which was neutral with respect to the participants' sexual orientation (e.g., "I've dated many intelligent people" rather than "I've dated many intelligent women" for the male version).

## Procedures

Participants were recruited using the web-based software Amazon Mechanical Turk, also known as MTurk (<http://www.mturk.com>), which respondents accessed from their personal computers. On this website, participants answer surveys or perform other small, quick tasks (e.g., categorizing photographs or transcribing audio clips) in exchange for small sums of money (usually on the order of several cents per task). These tasks are generally posted by individuals or organizations, which pay the participants for their work through the Amazon.com website. In this way, the posting entities get quick, cheap labor and the participants can get paid while working from their computers, simply by completing many of the small tasks. The use of MTurk in social science research has been validated in a number of studies (for a review, see Mason & Suri, 2010).

To avoid the possibility of Amazon's employees having access to participants' potentially sensitive personal information, MTurk users who elected to participate were instructed to follow an external link to the web service SurveyMonkey, through which the actual survey was conducted. Participants were assured confidentiality and anonymity. The obsession questions were asked first, followed by the compulsion questions (the order of items within each section was randomized). The Mating Success scale, Mini-K scale, demographic information, and Mating Intelligence scale were then assessed, in that order. Finally, subjects were asked to make up a six-character passcode, which they entered on both SurveyMonkey and MTurk, so their completion of the survey could be verified. However, all MTurk respondents who elected to take the survey were awarded the ten cents, whether or not they fully completed it.

## RESULTS

Of the 518 respondents, 78 (15.3%) reported having received an OCD diagnosis in the past and 53 (10.2%) did not answer this question or marked “prefer not to say.” Females were almost twice as likely (odds ratio = 1.98) as males to report having had an OCD diagnosis,  $\chi^2(1) = 6.19, p < .05$ . The mean total Y-BOCS CL score (calculated by summing the responses for all items) was 158.25 ( $SD = 49.45$ ). The mean for males only was 163.24 ( $SD = 48.44$ ) and the mean for females only was 150.21 ( $SD = 50.32$ ); this difference was significant,  $t(500) = 2.88, p = .004, d = .26$ . The distribution of total Y-BOCS score was bimodal and positively skewed (see Figure 2).

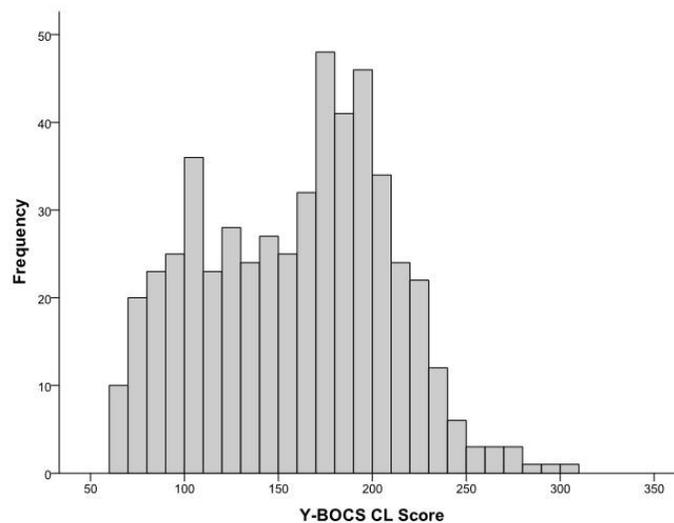


Figure 2. Histogram showing distribution of Y-BOCS CL scores.

The mean mating success of the sample was 32.39 ( $SD = 7.4$ ) out of a range of 8 to 56 wherein higher scores equal higher mating success. The mean life history strategy (Mini-K) score of the sample was 17.61 ( $SD = 17.19$ ) out of a possible range of -60 to 60, wherein more negative scores equal faster life history strategy (marked by more sexual partners and younger age of reproduction) and more positive scores equal slower life history strategy (marked by fewer sexual partners and later age of reproduction). The

mean mating intelligence score was 12.02 ( $SD = 3.22$ ), out of a possible 24 points (higher scores indicate higher mating intelligence). No significant differences between males and females were found for mating intelligence, mating success, or life history strategy scores.

A point-biserial correlation showed no relationship between OCD diagnosis status and mating success, ( $r = .06, p = .188$ ), even when controlling for the effects of mating intelligence and life history strategy ( $r = .07, p = .099$ ). However, there was a significant positive relationship between Y-BOCS CL Total Score and mating success ( $r = .21, p < .001$ ; see Figure 3), and controlling for mating intelligence and life history strategy in a partial correlation strengthened this relationship ( $r = .23, p < .001$ ). This relationship was similar across sexes, in both the bivariate correlation (males,  $r = .20, p < .001$ ; females,  $r = .20, p < .01$ ) and the partial correlation (males,  $r = .21, p < .001$ ; females,  $r = .21, p < .01$ ).

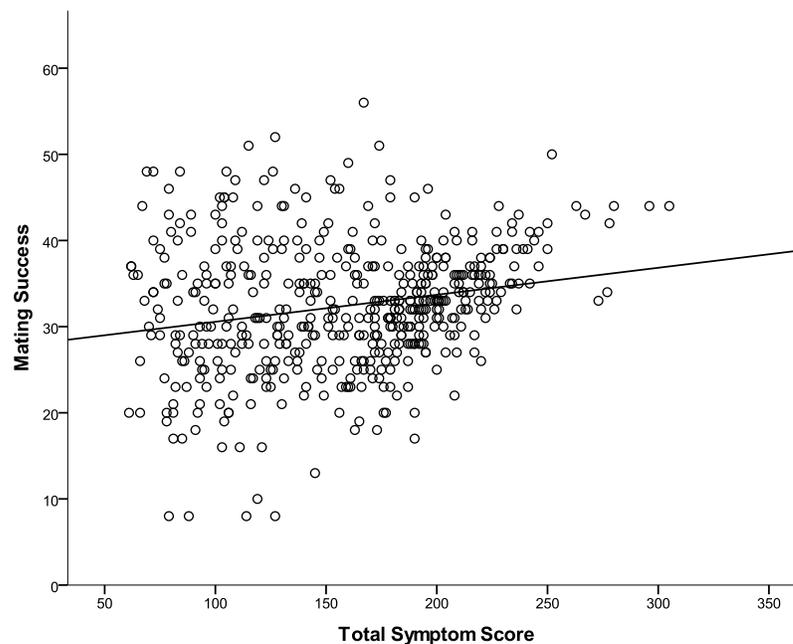
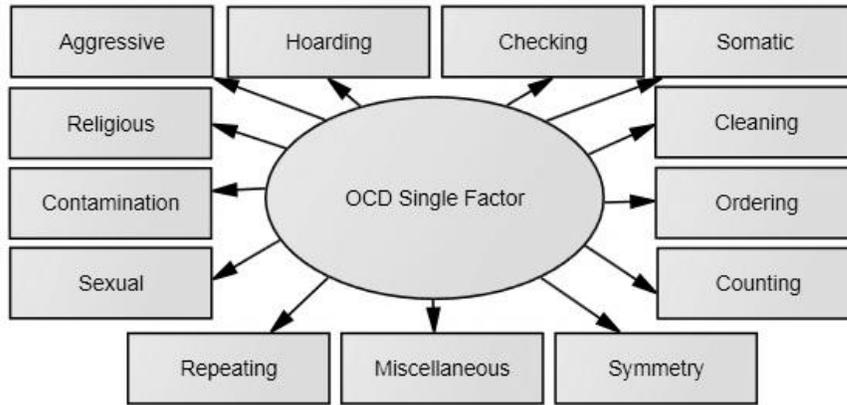


Figure 3. Scatterplot showing relationship between OCD-like symptom score and mating success.

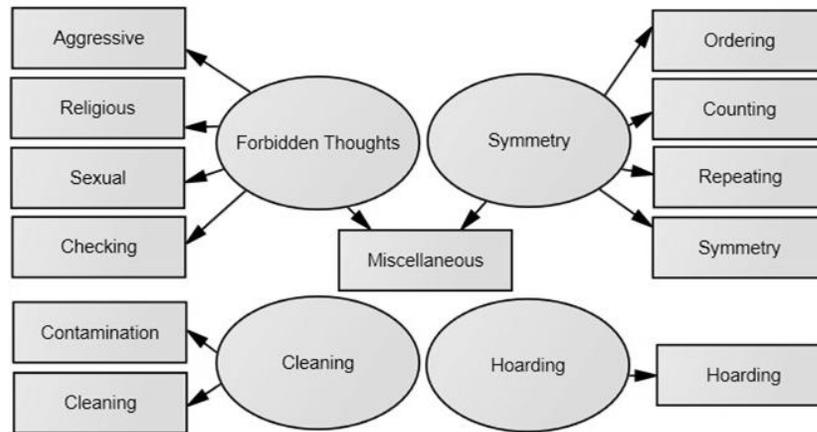
Item-level partial correlations between mating success and each of the Y-BOCS CL items (controlling for mating intelligence and life history strategy) were run to test the possibility that certain OCD-like behaviors might be associated with greater mating success (such as cleanliness) while others with reduced mating success (such as trichotillomania). All items were found to be significantly positively correlated with mating success ( $r$  ranging from .10 to .25) except for symmetry-related obsessions, fear of not saying the right thing, and ordering/arranging compulsions (which approached significance;  $p = .052$ ). The item most strongly correlated with mating success was obsessions about inappropriate sexual behavior toward others ( $r = .25, p < .001$ ). No meaningful patterns emerged when these correlation analyses were broken apart by sex.

A confirmatory factor analysis was run using IBM<sup>®</sup> SPSS<sup>®</sup> AMOS Version 20 to compare the fits of the one, four, and five-factor solutions, respectively. The one-factor model assumed one underlying latent variable which contributed to all the OCD-like behaviors from the Y-BOCS CL (Figure 4a). The four-factor model assumed a separate latent variable underlying each of the four domains of forbidden thoughts, cleaning/contamination, order/patterns/symmetry, and hoarding (Figure 4b). The five-factor model assumed a separate latent variable underlying each of the five domains of taboo thoughts, superstition/rituals, doubt, symmetry/hoarding, and cleaning/contamination (see Figure 4c). To ensure consistency, only the miscellaneous obsessions and compulsions (i.e., those that did not belong to a Y-BOCS CL category) which were part of Katerberg et al.'s (2010) five-factor model were included in the one-factor and four-factor models; the rest of the miscellaneous symptoms were omitted from analysis.

A.



B.



C.

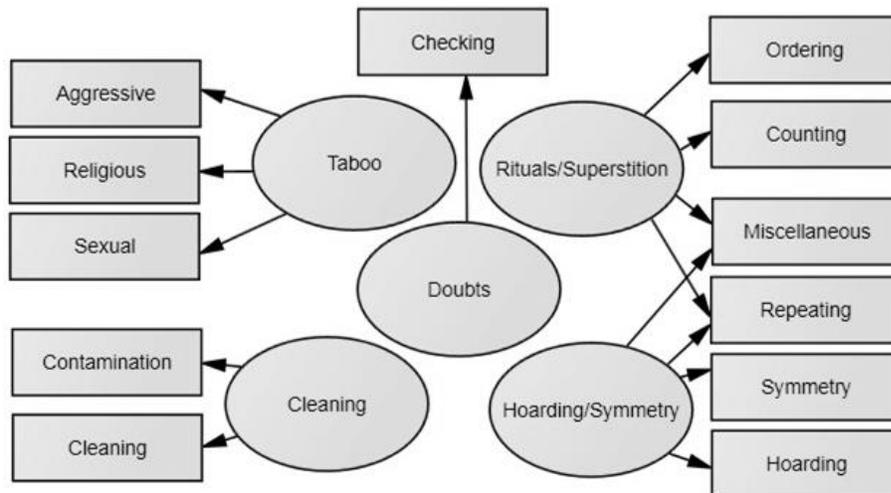


Figure 4. The one (A), four (B), and five (C) factor models, respectively. Covariance arrows between factors have been omitted and individual items have been lumped together into categories for readability.

Table 1 shows the fit indices of the three models. The chi-square divided by degrees of freedom index should be below 3 to indicate good fit, and numbers closer to zero indicate better fit. The root mean square error of approximation (RMSEA) should be less than .050 to indicate good fit, and numbers closer to zero indicate better fit. The normed fit index (NFI), the Tucker-Lewis Index (TLI), and Comparative Fit Index (CFI) are additional goodness-of-fit indicators; .95 or greater indicates a good fit, while below .90 indicates a poor fit. As shown in Table 1, the four-factor model fares the best, with the chi-square divided by degrees of freedom, RMSEA, and CFI all indicating a fair fit to the data.

Table 1. Goodness-of-Fit Indices for Three Models of OCD Symptom Dimensions

<b>Factors</b>	$\chi^2$	<i>df</i>	$\chi^2/df$	<b>RMSEA</b>	<b>NFI</b>	<b>TLI</b>	<b>CFI</b>
<b>1</b>	2820.53	1175	2.4	.052	.821	.882	.887
<b>4</b>	2596.33	1169	2.22	.049	.835	.897	.902
<b>5</b>	4109.87	1476	2.78	.059	.773	.834	.841

## DISCUSSION

This study was designed to address the question of whether the symptom dimensions of OCD might exist due to a number of discrete informational-processing systems in the brain which were naturally selected over our evolutionary history to solve particular adaptive problems. A community sample was given an OCD symptom checklist and the resulting data was analyzed with confirmatory factor analyses to adjudicate between three competing models of the symptom structure of OCD. While none of the three models was a perfect fit for the data, the four-factor model advocated by Bloch et al. (2008) was a fair fit and better than the one or five-factor models. These findings suggest that OCD-like behaviors indeed tend to cluster into “dimensions” rather

than a single, general “OCD propensity” factor. Therefore, rather than resulting from a unitary pathophysiological process, OCD cases from patient to patient seem to vary as a function of impairment or disinhibition in a number of discrete brain systems.

It was hypothesized that clinical OCD would be associated with lower levels of mating success, while the OCD-like behaviors themselves, at moderate levels, would be associated with higher mating success than these behaviors at very low or clinically high levels. This hypothesis was partially supported. No relationship was found between reported OCD diagnosis status and mating success, although this could have been due to a problem with the wording or participants’ construal of the OCD diagnosis question (see below). Further, it would not be surprising if a formal OCD diagnosis was less informative of symptom severity than overall Y-BOCS CL symptom score, since many undiagnosed individuals nevertheless have high levels of symptoms.

Nevertheless, even high scores on the symptom checklist did not seem to confer a mating success disadvantage in this sample. As predicted, low levels of OCD-like behaviors were associated with lower mating success, suggesting that minimal levels of these conscientious thoughts and behaviors are either directly helpful for attracting mates or associated with some other phenotype which is. However, instead of the predicted inverted U-shaped graph, the relationship between OCD-like symptoms and mating success was linear. In fact, no participant with high levels of OCD-like symptoms appeared to have low mating success. This finding, if replicated, could suggest that, contrary to prevailing wisdom, OCD-like symptoms could be naturally selected for by providing mating success to their bearers, even while taking a debilitating personal toll. Individuals with OCD-like symptoms may have other compensatory traits which are

attractive, such as higher levels of creativity and it may be these traits, rather than the OCD-like symptoms per se, which lead to higher mating success. An alternate possibility is that individuals high in OCD-like symptoms may tend to overestimate their own mating success, although there is no existing theoretical reason to believe that this is so. Finally, the mating success scale itself—which assesses the respondent’s self-reported ability to attract potential partners—may be insensitive to the actual selection pressures that an ancestral environment may have exerted on individuals with debilitating OCD, such as starvation, predation, and ostracism.

It is therefore suggested that the discrete information-processing systems differentially affected in OCD, which underlie the domains of functioning from Bloch et al.’s (2008) four-factor model of the symptom dimensions, may meet the criteria for evolved mental “modules.” Obsessive violent or other forbidden thoughts, accompanied by precautionary checking measures, may represent a dysfunction in systems evolved to identify and prevent threatening situations before they occur (Abed & DePauw, 1998; Brüne, 2006). Contamination worry and cleaning obsessions may be the disinhibition of modules which normally function to avoid pathogens (Evans & Leckman, 2006), and this hypothesis may dovetail with the existing evolutionary psychology literature on evolved mechanisms of core disgust (Curtis & Biran, 2001). Hoarding behaviors may be a result of dysfunction in an evolved resource-acquisition mechanism (Leckman & Bloch, 2008) which is normally involved in identifying and collecting objects from the world which may be useful (e.g., as tools). Symmetry, patterns, and order obsessions are harder to explain from this adaptationist perspective. Evans and Leckman (2006) speculate that these behaviors may function to keep one’s home environment in an orderly state, but it

is not clear that this type of ordering would provide fitness benefits. It is possible that symmetry/order obsessions may simply be a disinhibited form of the natural human preference for patterns, which may exist as a by-product of our organized brains.

Alternately, these symptoms may be related to our intuitive mathematical abilities or a mechanism which assesses symmetry in potential mates (Thornhill, Gangestad, & Comer, 1995).

A remaining question is why these domains are the ones affected in OCD, and why impairment in one of these domains is, more often than not, accompanied by impairment in one or more of the others. One possibility is that OCD confers only a general propensity for obsessions and compulsions, and environmental context dictates the particular content thereof for each individual. While this may be true to a degree, this hypothesis cannot account for the universality and discreteness of the symptom dimensions; if OCD content were infinitely malleable based on particular experiences, one would expect to see a continuous spectrum of all possible obsessions and compulsions across patients, rather than thoughts and behaviors which cross-culturally, robustly, and reliably, fall into one of four or five particular domains.

Another way to account for the pattern of symptom dimensions is to posit that each dimension represents its own particular discrete “disorder,” and thus to reject the existing unitary nosological entity of OCD in favor of four separate disorders. This view is consistent with a modular approach to the mind, suggesting that each of the systems associated with the OCD symptom dimensions can individually be “disordered,” and sometimes these disorders can co-occur. Under this formulation, for example, an OCD patient with severe hoarding and cleaning symptoms would be described as suffering

from comorbid hoarding and cleaning disorders. However, this “separate disorders” model is unlikely to be correct, for several reasons. To begin with, OCD patients displaying only a single symptom dimension are rare (Mataix-Cols et al., 2005) rather than ubiquitous as one would expect if the symptom dimensions each represented an orthogonal disorder. Also, single-factor models of OCD have been suggested so frequently (see Leckman et al., 2010) that it is clear that there is a general tendency for individuals high in one symptom dimension to be high on others.

Thus, a neurocognitive model of the type shown in Figure 5 may be the best explanation for the existence of these symptom dimensions in OCD. It is suggested that the four (or possibly more) systems which can be affected in OCD may be connected by an “upstream” module or series of modules. A model of this type is a parsimonious way of explaining how seemingly disparate systems can be regularly associated in a disorder like OCD. The organization of these brain systems results in a predictable grouping of symptoms, depending on the position and extent of the initial abnormality or lesion.

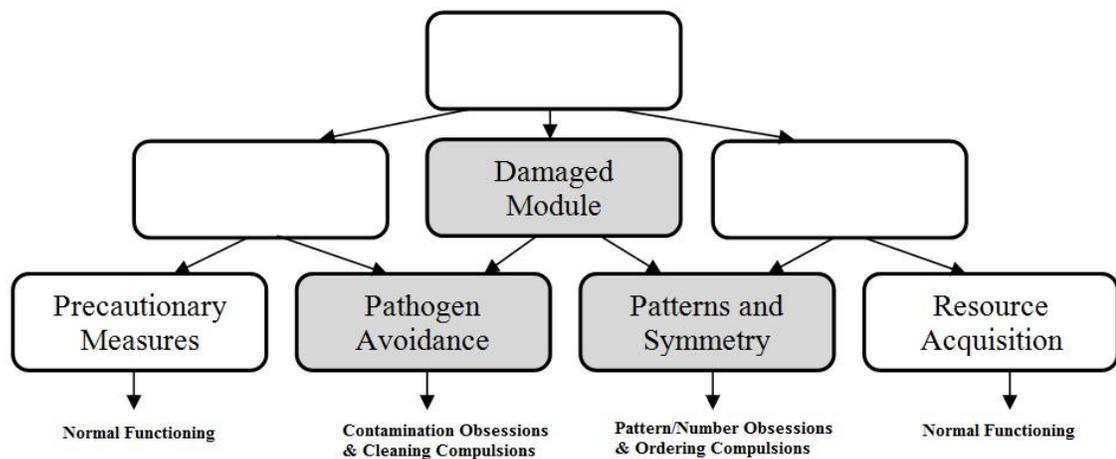


Figure 5. One possible model explaining the existence of symptom dimensions in OCD. Gray shading indicates problematic processing. In this figure, Cleaning and Symmetry type symptoms have been elicited by a lesion or other insult to an upstream module.

In this model, depending on which upstream module is affected, different combinations of symptoms may be elicited. The model allows for both single-domain impairment (via direct lesion to the modules) as well as impairment (or disinhibition) of all four domains (via insult to the uppermost module). Importantly, this model does not specify that impairment be all or none; symptom severity can change depending on the extent of the insult.

Figure 5 represents only the *type* of model that can be created and tested, rather than a firm model created with regard to specific data. Future research can adjudicate between different models by observing if certain symptom dimensions are more or less likely to occur with other dimensions, and if some combinations never manifest. In theory, this type of model may be useful for understanding the disorder patterns of other mental illnesses as well.

Viewing mental illness in this way may eventually yield a number of benefits to clinical researchers and practitioners. A modular view of disorder may offer solutions to many of the questions of classification which trouble the Diagnostic and Statistical Manual of Mental Disorders (DSM) and in turn illuminate treatment options. If a hierarchical neurocognitive model is correct, identifying and treating potential upstream modules or processes which underlie the domains affected in OCD may be more effective than attempting to treat the symptom themselves. Perspectives from neuroscience can inform the search for the neurolocalization of these modules, and future generations of drug treatments may be able to target specific symptom dimensions or modules.

Several results unrelated to the hypotheses bear mentioning. Firstly, the reported frequency of OCD diagnosis from this dataset was higher than the 1-3% lifetime

prevalence rate normally associated with OCD. There are several possible explanations for this finding. While “English-speaking” was a requirement for participation, some respondents—especially those from whom English was a second language—may have misinterpreted the question “Have you ever received a diagnosis of obsessive-compulsive disorder?” and endorsed “yes” even if they had not received a professional diagnosis. Additionally, there may have been a self-selection bias for respondents who chose to complete this survey; although the terms “OCD” or “psychology” did not appear in the description, potential participants were told the survey was about “some feeling or behaviors you may have experienced.” Another intriguing possibility, not mutually exclusive with the others, is that MTurk may have a higher rate of OCD sufferers than the normal population; perhaps the precise nature of the type of work on MTurk appeals to individuals with OCD, some of whom may have trouble maintaining steady jobs as a result of their disorder. It is also conceivable that there are higher rates of OCD in the geographical or socioeconomic population that tends to use MTurk (i.e., South Asia), although there is no existing theoretical or empirical evidence which would support this possibility. Finally, there may have been a large number of participants who rushed through the survey without answering the items truthfully. Future analyses can examine the time each participant spent on the survey and exclude such possible cases.

It is also noteworthy that more females than males reported an OCD diagnosis, while males display significantly higher levels of symptoms than women do; this discrepancy may reflect a sex difference in willingness to seek psychiatric help and/or to admit to having a psychiatric diagnosis.

The bimodality of the Y-BOCS CL total score is also interesting, as it could suggest that the current sample is actually drawing from two different populations, with qualitative differences in their propensity for severe OCD-like symptoms. This may speak against the conception of OCD as a continuum disorder, with clinical OCD patients simply existing on the extreme end of a normal symptom distribution, although more research is needed to answer this question.

This study had several limitations. This particular self-report version of the Y-BOCS CL has not been validated, nor has the Likert-type scoring used. While the number of participants was fairly high, there were still not enough cases to run confirmatory factor analyses on subsets of the sample (such as only those with high symptom scores) to see if the factor structure was being driven by any particular subset. The anonymous online survey method of MTurk may be especially vulnerable to abuse by participants who may respond at random to surveys to collect as much compensation as possible, leading to invalid data. Additionally, language comprehension may have been an issue in the large Asian population who uses MTurk. Finally, confirmatory factor analysis is only as good as the models used as input; while the four-factor model fit the data better than the alternatives used, it may still not be the best possible model to describe the symptoms of OCD. Future research will test more competing models of OCD, including other proposed five-factor models.

While community samples may not provide the cleanest models for OCD symptom dimensions, the fact that OCD-like thoughts and behaviors can be observed in the general population suggests that OCD may represent the disinhibition or dysfunction of naturally selected mental modules. Through further analysis of clinical cases, it may be

possible to create an evolutionary neurocognitive model of OCD symptoms and the relationships between the underlying processes, and advance one more step toward understanding and treating this mysterious disorder.

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## Appendix A: Modified Y-BOCS Symptom Checklist

Rate the frequency/severity with which you currently have (or have had in the past) obsessive thoughts about the following:

(1 = Never, 2 = Rarely/Mild, 3 = Occasionally/Moderate, 4 = Frequently/Severe, 5 = Constantly/Very Severe)

1. Fear that you might harm yourself; e.g., fear of eating with a knife or fork, fear of handling sharp objects, or fear of walking near glass windows.
2. Fear that you might harm others; e.g., fear of poisoning other people's food, fear of harming babies, fear of pushing someone in front of a train, fear of hurting someone's feelings, fear of being responsible by not providing assistance for some imagined catastrophe, or fear of causing harm by bad advice.
3. Violent or horrific images; e.g., images of murders, dismembered bodies, or other disgusting scenes.
4. Fear of blurting out obscenities or insults; e.g., fear of shouting obscenities in public situations like church, or fear of writing obscenities.
5. Fear of doing something else embarrassing; fear of appearing foolish in social situations.
6. Fear you'll act on unwanted impulses; e.g., fear of driving a car into a tree, fear of running someone over, fear of stabbing a friend.
7. Fear you'll steal things; e.g., fear of "cheating" a cashier, fear of shoplifting inexpensive items.
8. Fear you'll harm others because you weren't careful enough; e.g., fear of causing an accident without being aware of it (such as a hit-and-run automobile accident).
9. Fear you'll be responsible for something else terrible; e.g., fear of causing a fire or burglary because of not being careful enough in checking the house before leaving.
10. Concerns or disgust with bodily waste or secretions; e.g., fear of contracting AIDS, cancer, or other diseases from public rest rooms; fears of your own saliva, urine, feces, semen, or vaginal secretions.
11. Concern with dirt or germs; e.g., fear of picking up germs from sitting in certain chairs, shaking hands, or touching door handles.
12. Excessive concern with environmental contaminants; e.g., fear of being contaminated by asbestos or radon, fear of radioactive substances, fear of things associated with towns containing toxic waste signs.

13. Excessive concern with household items; e.g., fear of poisonous kitchen or bathroom cleansers, solvents, insect spray, or turpentine.
14. Excessive concern with animals; e.g., fear of being contaminated by touching an insect, dog, cat, or other animal.
15. Bothered by sticky substances or residues; e.g., fear of adhesive tape, sticky spots on tables, or other sticky substances that may trap contaminants.
16. Concern you'll get ill because of contaminants
17. Concern you'll make others ill by spreading some contaminant; e.g., fear of touching other people or preparing their food after you touch poisonous substances (like gasoline) or after you touch your own body.
18. Thoughts of how being contaminated might feel without concern over the consequences
19. Forbidden or perverse sexual thoughts, images, or impulses; e.g., unwanted sexual thoughts about strangers, family, or friends.
20. Sexual thoughts involving children or incest; e.g., unwanted thoughts about sexually molesting either your own children or other children.
21. Sexual thoughts involving homosexuality; e.g., worries like "Am I a homosexual?" or "What if I suddenly become gay?" when there is no basis for these thoughts.
22. Sexual behavior toward others; e.g., unwanted images of violent sexual behavior toward adult strangers, friends, or family members.
23. Obsession with saving or hoarding items that most people would think are of no use, e.g., worries about throwing away seemingly unimportant things that you might need in the future, urges to pick up and collect useless things. Please exclude collections or hobbies and items of monetary or sentimental worth.
24. Concerned with sacrilege and religious blasphemy; e.g., worries about having blasphemous thoughts, saying blasphemous things, or being punished for such things.
25. Excess concern with right and wrong/morality; e.g., worries about always doing "the right thing," having told a lie, or having cheated someone.
26. Obsessions with the need for things to be symmetric or "just exactly so," or else something unrelated and bad might happen; e.g., being concerned that another will have an accident unless things are in the right place, such as papers and books being properly aligned, calculations or handwriting being perfect.

27. Have you had obsessions with the need for things to be symmetric or “just exactly so” that are *not* accompanied by the fear that something unrelated and bad might happen?
28. Concern with illness or disease; e.g., worries that you have an illness like cancer, heart disease or AIDS, despite reassurance from doctors that you do not.
29. Excessive concern with one of your body parts or another aspect of your appearance; e.g., worries that your face, ears, nose, eyes, or another part of your body is hideous, ugly, despite reassurances to the contrary.
30. The need to know or remember certain things; e.g., believing that you need to remember insignificant things like license plate numbers, old telephone numbers, bumper sticker or t-shirt slogans
31. Fear of saying certain things; e.g., fear of saying certain words (such as “thirteen”), because of superstitions, fear of saying something that might be disrespectful to a dead person, fear of using words with an apostrophe (because this denotes possession).
32. Fear of not saying just the right thing; fear of having said the wrong thing, fear of not using the “perfect” word.
33. Fear of losing things; e.g., excessive worry about losing a wallet or unimportant objects like a scrap of paper
34. Intrusive (non-violent) images; random, unwanted images in your mind.
35. Intrusive nonsense sounds, words, or music; words, songs, or music in your mind that you can't stop
36. Being excessively bothered by certain sounds or noises; e.g., worries about the sounds of clocks ticking loudly or voices in another room.
37. Lucky/unlucky numbers; worries about common numbers (like thirteen) that may cause you to perform activities a certain number of times or to postpone an action until a certain lucky hour of the day.
38. Colors with special significance; fear of using certain colors, e.g., black may be associated with death, red with blood and injury.
39. Superstitious fears; e.g., fear of passing a cemetery, hearse or black cat or fear of omens associated with death.

Rate the frequency/severity with which you currently have (or have had in the past) extreme urges to do the following:

(1 = Never, 2 = Rarely/Mild, 3 = Occasionally/Moderate, 4 = Frequently/Severe, 5 = Constantly/Very Severe)

40. Excessive or ritualized handwashing; e.g., washing your hands many times a day or for long periods of time after touching, or thinking that you have touched, a contaminated object. This may include washing the entire length of your arms.

41. Excessive or ritualized showering, bathing, tooth brushing, grooming, or toilet routine; e.g., taking showers or baths or performing other bathroom routines that may last for several hours. If the sequence is interrupted the entire process may have to be restarted.

42. Excessive cleaning of household items or other inanimate objects; e.g., excessive cleaning of faucets, toilets, floors, kitchen counters, or kitchen utensils.

43. Other measures to prevent or remove contact with contaminants; e.g., asking family members to handle or remove insecticides, garbage, gasoline cans, raw meat, paints, varnish, drugs in the medicine cabinet, or kitty litter. If you can't avoid these things, you may wear gloves to handle them, such as when using a self-service gasoline pump.

44. Repeatedly checking locks, stoves, appliances, etc. to make sure they're locked, off, or safe; e.g., repeated checking of door locks, stoves, electrical outlets, before leaving home.

45. Repeatedly checking to make sure you have not or will not harm others; e.g., checking that you haven't hurt someone without knowing it. You may ask other for reassurance or telephone to make sure that everything is all right.

46. Repeatedly checking to make sure you have not or will not harm yourself; e.g., looking for injuries or bleeding after handling sharp or breakable objects. You may frequently go to doctors to ask for reassurance that you haven't hurt yourself.

47. Repeatedly checking that nothing terrible did or will happen; e.g., searching the newspaper or listening to the radio or television for news about some catastrophe that you believe you caused. You may also ask people for reassurance that you didn't cause an accident.

48. Repeatedly checking that you haven't made a mistake; e.g., repeated checking while reading, writing, or doing simple calculations to make sure that you didn't make a mistake (and you can't be certain that you didn't).

49. Repeatedly checking that you're not ill or diseased, or repeatedly checking some part of your body or aspect of your appearance, e.g., seeking reassurance from friends or doctors that you aren't having a heart attack or getting cancer; repeatedly taking your pulse, blood pressure, or temperature; checking yourself for body odors; checking your appearance in a mirror, looking for ugly features.

50. The need to reread or rewrite something a certain number of times, or until it "feels right," e.g., taking hours to read a few pages in a book or to write a short letter because you get caught in a cycle of reading and rereading; worrying that you didn't understand something you just read; searching for a "perfect" word or phrase; having obsessive thoughts about the shape of certain printed letters in a book.

51. The need to repeat a routine activity like walking in and out of a door, or standing up and sitting down in a chair, a certain number of times, or until it "feels right"; repeating activities like turning appliances on and off, combing your hair, or looking in a particular direction; not feeling comfortable unless you do these things the "right" number of times.

52. Feeling compelled to count to a certain number, or count until it "feels right," e.g., counting objects like ceiling or floor tiles, books in a bookcase, nails in a wall, or even grains of sand on a beach; counting when you repeat certain activities, like washing.

53. Feeling compelled to order or arrange things for no apparent reason, until it "feels" like they are in the right place, e.g., straightening paper and pens on a desktop or books, in a bookcase; spending hours arranging things in your house in "order" and then becoming very upset if this order is disturbed.

54. Feeling compelled to hoard or save items that most people would think are of no use? For example, saving and carefully reading junk mail, piling up of old newspapers, collecting useless objects for no particular reason or for fear that if you throw them away you may one day need them; picking up useless objects from the street or from the garbage can. Please exclude collections or hobbies and items of monetary or sentimental worth.

55. Performing rituals in your head, like saying certain phrases or thinking a "good" thought to undo a "bad" thought. These are different from obsessions because you perform them intentionally to reduce anxiety or to feel better. Do not include counting or checking things.

56. Asking other people to reassure you, confessing to wrong behaviors you never even did, believing that you have to tell other people certain words to feel better.

57. Giving in to the urge to touch, tap, or rub surfaces, like wood, or hot surfaces, like a stove top; giving in to the urge to lightly touch other people; believing you need to touch an object like a telephone to prevent an illness in your family.

58. Taking measures besides repeatedly checking things to prevent harm or terrible consequences to yourself or others; e.g., staying away from sharp or breakable objects, avoiding tools

59. Ritualized eating behaviors, e.g., arranging your food, knife, and fork in a particular order before being able to eat, eating according to a strict ritual, not being able to eat until the hands of a clock point exactly to a certain time.

60. Superstitious behaviors, e.g., not taking a bus or train if its number contains an “unlucky” number (like thirteen), staying in your house on the thirteenth of the month, throwing away clothes you wore while passing a funeral home or cemetery.

61. Pulling hair from your scalp, eyelids, eyelashes, or pubic areas, using your fingers or tweezers. You may produce bald spot that require you to wear a wig, or you may pluck your eyebrows or eyelids smooth.

## Appendix B: Mating Success Scale

For each question, please rate your answer on a scale of 1-7. (1 = “strongly disagree” and 7 = “strongly agree”)

1. Potential partners that I like tend to like me back.
2. Potential partners notice me.
3. I receive many compliments from potential partners.
4. Potential partners are not very attracted to me.
5. I receive sexual invitations from potential partners.
6. Potential partners are attracted to me.
7. I can have as many sexual partners as I choose.
8. I do not receive many compliments from potential partners.

### Appendix C: Mini-K Life History Strategy Scale

Please indicate how strongly you agree or disagree with the following statements. (-3=strongly disagree, +3=strongly agree). For any statement that does not apply to you, please choose "0."

1. I can often tell how things will turn out.
2. I try to understand how I got into a situation to figure out how to handle it.
3. I often find the bright side to a bad situation.
4. I don't give up until I solve my problems.
5. I often make plans in advance.
6. I avoid taking risks.
7. While growing up, I had a close and warm relationship with my biological mother.
8. While growing up, I had a close and warm relationship with my biological father.
9. I have a close and warm relationship with my own children.
10. I have a close and warm romantic relationship with my sexual partner.
11. I would rather have one than several sexual relationships at a time.
12. I have to be closely attached to someone before I am comfortable having sex with them.
13. I am often in social contact with my blood relatives.
14. I often get emotional support and practical help from my blood relatives.
15. I often give emotional support and practical help to my blood relatives.
16. I am often in social contact with my friends.
17. I often get emotional support and practical help from my friends.
18. I often give emotional support and practical help to my friends.
19. I am closely connected to and involved in my community.
20. I am closely connected to and involved in my religion.

## Appendix D: Mating Intelligence Scale

### Male Version

1. I think most potential partners just like me as a friend.
2. I have slept with many beautiful people.
3. I'm pretty good at knowing if a potential partner is attracted to me.
4. I'm definitely not the best at taking care of kids.
5. I'm good at saying the right things to people I flirt with.
6. I haven't had as many sexual partners compared with other guys I know (who are my age).
7. I have a difficult time expressing complex ideas to others.
8. I am good at picking up signals of interest from potential partners.
9. I'm definitely near the top of the status totem pole in my social circles.
10. I doubt that I'll ever be a huge financial success.
11. If I wanted to, I could convince a potential partner that I'm really royalty from some little-known country.
12. Honestly, I don't understand the minds of potential partners at all!
13. People tend to flirt with me pretty regularly.
14. If a person doesn't seem interested in me, I figure s/he doesn't know what s/he's missing!
15. Potential partners definitely find me attractive.
16. I've dated many intelligent people.
17. People tell me that I have a great sense of humor.
18. When I lie to potential partners, I always get caught!
19. I am usually wrong about who is interested in me romantically.
20. It's hard for me to get potential partners to see my virtues.

21. At parties, I tend to tell stories that catch the attention of potential partners.
22. I'm not very talented in the arts.
23. I can attract potential partners, but they rarely end up interested in me sexually.
24. When a potential partner smiles at me, I assume s/he's just being friendly.

#### Female Version

1. I can tell when a partner is being genuine and sincere in his/her affections toward me.
2. I doubt I could ever pull off cheating on my partner.
3. I look younger than most women my age.
4. When a potential partner doesn't seem interested in me, I take it personally and assume something is wrong with me.
5. Good looking people never seem into me.
6. I have a sense of style and wear clothes that make me look sexy.
7. I attract many wealthy, successful partners.
8. Honestly, I don't understand the minds of potential partners at all!
9. With me, a partner gets what s/he sees—no pretenses here.
10. If I wanted to make my current partner jealous, I could easily get the attention of other people.
11. Potential partners don't tend to be interested in my mind.
12. I'm definitely more creative than most people.
13. I hardly ever know when a potential partner likes me romantically.
14. I laugh a lot at potential partners' jokes.
15. If a potential partner doesn't want to date me, I figure s/he doesn't know what s/he's missing!
16. I am not very artistic.
17. My current partner spends a lot of money on material items for me (such as jewelry).

18. I am usually right on the money about a potential partner's intentions toward me.
19. I really don't have a great body compared with other women I know.
20. Intelligent people never seem interested in dating me.
21. I believe that most potential partners are actually more interested in long-term relationships than they're given credit for.
22. Most potential partners who are nice to me are just trying to get into my pants.
23. When it comes down to it, I think most potential partners want to get married and have children.
24. If I have sex with a partner too soon, I know s/he will leave me.