

OCD as a Dynamical Disease and the Familial Context of Ritual Rigidity: A Nonlinear Dynamics Perspective

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OCD AS A DYNAMICAL DISEASE AND THE FAMILIAL
CONTEXT OF RITUAL RIGIDITY: A NONLINEAR
DYNAMICS PERSPECTIVE

by

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ABSTRACT
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Marquette University, 2011

Comparatively few studies of obsessive-compulsive disorder (OCD) have addressed the interpersonal dynamical patterns within families that could exacerbate or quell symptom severity in the ill relatives or hypothesize other roles for familial variables. Furthermore, the extant studies have relied primarily upon linear models. Methodological limitations of linear models, such as assuming that change occurs as the result of unidirectional influences and that the scores obtained for each variable are independent of each other are at variance with temporal, dynamic phenomena and have restricted the empirical investigations of the dynamics of OCD.

The current study investigated whether OCD could be considered a dynamical disease such that the complex rhythmic processes that are the norm for living things would be replaced by relatively constant dynamics or by periodic dynamics. Determining whether OCD could be a dynamical disease could improve our current treatment strategies or lead to the development of new treatment strategies, by finding ways to best control or alter the dynamics of the family system and determining when the best time for change could take place. To accomplish this, this study analyzed both the occurrence of rituals as they transpired over time and the influence the family may have had upon the spatiotemporal structure of symptoms.

This information was obtained by using the time-diary method and comparing the time-series of 17 clinical cases with 16 matched controls. Comparisons of nonlinear regression parameters and Lyapunov exponents revealed that OCD exhibited a low-dimensional deterministic structure. The average nonlinear model ($R^2 = 0.32$) explained more than 10 times the variance of its linear counterpart ($R^2 = 0.03$). Family reactions and emotional responses accounted for only a very modest increase in the variance explained by the nonlinear regression model or in the amount of turbulence.

Family reactions and emotional responses do little to make the rituals go away, but instead may strengthen the dynamics. Finally, significant rank order correlations were found between the R^2 for each logbook and Lyapunov exponents with symptom severity and family reactions. Theoretical and practical implications of the results are discussed, including implications for treatment.

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OCD as a Dynamical Disease and the Familial Context of Ritual Rigidity:
A Nonlinear Dynamics Perspective

Obsessive-compulsive disorder (OCD) has been described as a sickness of ritual and doubt that has run wild (Rapoport, 1989). People with OCD have persistent, upsetting thoughts and use rituals to control the anxiety that these thoughts produce. The phenomenological features of OCD have long fascinated the psychological sciences (see Berrios, 1989). Over the years, numerous theories have been proffered to explicate the iterative thoughts and behaviors that compose the core features of OCD; from Freud's (1909/1973) psychoanalytic theory of psychosexual development, to the behavioral theories of acquired fear (e.g., Meyer, 1966), through the cognitive theories of thought appraisals (e.g., Salkovskis, 1985), and onward to the identification of neuropsychological deficits (see Tallis, 1995) and neuro- biological (e.g., Boone, Ananth, Philpott, Kaur, & Djenderedjian, 1991) and -chemical irregularities (e.g., Pigott et al., 1990). Yet, despite advances in our understanding of OCD, especially its treatment, the study of OCD has not produced any psychological theory that satisfactorily explains the complexities of OCD; for instance, cognitive and behavioral models do not adequately consider the systemic interactions nor the interpersonal dynamics that exist and the neuropsychological and biological models ignore them all together.

When considering the totality of OCD studies, comparatively fewer studies exist that attempt to explicate the interpersonal dynamical patterns that may occur within families to exacerbate symptom severity in the ill relatives. Likewise, fewer psychological models of OCD exist that hypothesize mediating or moderating familial

variables – this, despite psychology’s rich history of theorizing and empirically testing interpersonal dynamics (e.g., Malmö, Boag, & Smith, 1957).

Furthermore, those studies that have hitherto investigated the familial context of OCD have relied primarily upon linear mathematics – a mathematics that assumes that change occurs as the result of unidirectional influences (Lasser & Bathory, 1997).

Although complex dynamical systems like the family may resemble linear systems when in a steady state, they can also produce unpredictable behavior (Ward, 1995); in this way, studies that have investigated the family variables of OCD have at best only scratched the surface of the dynamics involved in OCD. The complexity of systemic interactions necessitates researchers to develop dynamical models of pathology that employ more complex mathematical concepts and techniques that would better illuminate the family’s effect on pathology; namely, nonlinear dynamics.

Of late, efforts have been made to investigate the dynamics of compulsive checking rituals in rats using nonlinear dynamics. Szechtman, Sulis, and Eilam (1998) injected rats with quinpirole, a dopamine agonist, or saline and observed the behavior of the rats across time. Compared to the saline-injected rats, they found a trend toward periodicity in the ritual-like behavior of rats that were injected with quinpirole. Although their study suggests that chaos may be present in the data, their findings are limited in their generalizability to humans. Therefore, it is not certain that the characteristics measured in Szechtman et al.’s study were indeed characteristics of human OCD rituals.

The goal of this study is to build upon the work of Szechtman et al. (1998) by studying the dynamical nature of OCD by means of analyzing both the occurrence of rituals as they transpire over time in a human population and the influence the family

environment may have upon the spatiotemporal structure of symptom periodicity using questionnaire and daily log methods and comparing clinical cases with control cases.

Obsessive-Compulsive Disorder Background

Many individuals have experienced unwanted cognitive intrusions (Steketee, 1993a) or may even hold superstitious beliefs. Also, many have probably engaged to some extent in the performance of benign repetitive behaviors or superstitious habits (Rapoport, 1989). Yet, for all intents and purposes these are normal experiences and generally under the control of the individual; and although they are normal experiences, they too are at the heart of OCD – arguably one of the more debilitating psychological disorders. For persons with OCD, intrusive thoughts and repetitive habits lack benignity. They go beyond what is considered normal and control over these compulsions is diminished (Tallis, 1995). The rituals (repetitive behaviors) are intense and disabling and can dominate each day (Rapoport, 1989). A person's entire quality of life deteriorates; many suffer embarrassment, low self-esteem, despair, unemployment, substance abuse, and a disintegration of the home and social life (Koran, 2000; Lochner et al., 2003; Rapoport, 1989). In short, the repetitive thoughts and rituals have run amok.

Definition

The essential features, according to the American Psychiatric Association's *Diagnostic and Statistical Manual of Mental Disorders* (DSM-IV-TR; 2000), are obsessions and compulsions. Obsessions are unwanted and intrusive persistent ideas, thoughts, images, or impulses (urges) that go beyond everyday worry about real-life problems and cause anxiety or distress (APA, 2000). They are experienced as senseless, repugnant, unacceptable, and difficult to dismiss (Salkovskis & Kirk, 1989). Obsessional content can be varied. For some, the content of the obsessions may be meaningless (e.g.,

numbers); for others, obsessions can be emotionally charged and intense (e.g., “I have just killed someone”), and in severe cases, these ruminations can be bizarre and irrational (Rapoport, 1989). Rasmussen and Tsuang (1986) found that the most common obsessions are: contamination fears (55%), aggressive thoughts or fear of harming others (50%), the need for exactness (36%), somatic fears (34%), and sexual thoughts (32%).

Compulsions, on the other hand, are repetitive, purposeful, and intentional physical behaviors or mental acts that are performed in response to the obsessions and usually carried out according to a set of rules or performed in a stereotyped fashion (Jenike, Baer, & Minichiello, 1998). The goal of rituals is not to bring the individual gratification or pleasure, but rather to reduce distress and anxiety or prevent calamity (APA, 2000). Like obsessions, there is a broad range of compulsions (Calamari, Wiegartz, & Janeck, 1999). Rasmussen and Eisen (1988) found that the most prevalent compulsive behaviors are: checking (63%), washing (50%), symmetry (28%), and hoarding (18%). Obsessional slowness and mental compulsions only accounted for 4% of those treated for OCD (Ball, Baer, & Otto, 1996). Along with compulsive rituals, persons with OCD may also develop avoidance behaviors and avoid situations that could trigger the obsessions (Salkovskis & Kirk, 1989).

Epidemiology of OCD

In the past, OCD was thought to be an uncommon psychiatric disorder. Early surveys estimated the prevalence of OCD in the general population to be approximately 0.05 percent (Steketee, 1993a). Contrarily, the Epidemiologic Catchment Area (ECA) study of the 1980s found instead that OCD was 50 to 100 times more common than previously believed (Rasmussen & Eisen, 1998); in the general population, it has been

found to have a lifetime prevalence rate of 2-3% (Crino, Slade, & Andrews, 2005; Horwath & Weissman, 2000; Karno, Golding, Sorenson, & Burnam, 1988; Robins et al., 1984). It has been estimated that OCD affects about 2.2 million American adults (Kessler, Chiu, Demler, & Walters, 2005), making OCD the fourth most common psychiatric disorder in the United States (Abramowitz, 2006; Steketee, 1993a).

The disorder affects men and women equally (Abramowitz, 2006), with most affected persons having a childhood onset (Samuels & Nestadt, 1997); however, among children affected with OCD, boys have a higher prevalence rate than girls (Abramowitz, 2006). It is not surprising, then, when one considers the number of persons suffering with OCD and its debilitating nature, that much of the focus on OCD has emphasized treatment.

Models and Treatments of OCD

Learning Theory and Learning-Based Treatment

Over the decades, a number of strategies have been used to treat OCD.

Psychodynamic treatment strategies, which derived from Freud's psychoanalytic theory, dominated the psychological sciences for much of the early- to mid- 20th century (Baer & Minichiello, 1998; Steketee, 1993a). Despite the early dominance, psychodynamic treatment techniques have not met with much success (Steketee, 1993a) and many in the past regarded OCD as treatment refractory (Swinson, Antony, Rachman, & Richter, 1998). It was not until the arrival of behavioral therapy in the 1950s and its eventual use with OCD that a change in the conceptualization and treatment outlook of OCD came about (Jenike et al., 1998). Thenceforth, it began to be seen by many as largely a learned problem.

The Two-Factor Theory

Learning theorists adopted Mowrer's two-factor model of the acquisition of fear and avoidance behavior to account for the development of anxiety disorders (Abramowitz, 2006; Foa, Steketee, & Ozarow, 1985). Mowrer (1960) proposed that learning takes place in two stages, which he labeled sign and solution learning. According to Mowrer, the first stage of learning involves sign learning and describes the process by which a fear response may be acquired. In this stage, fear becomes conditioned to a formerly neutral stimulus, which then serves as a signal of what is to come. The second stage of learning involves solution learning. According to Mowrer, fear is experienced by the individual as aversive and thus possesses motivational

properties. The emotional experience of fear results in individuals seeking behavioral solutions to reduce the aversive effects of fear (e.g., avoidance behavior). These responses become negatively reinforced by their ability to remove anxiety (Foa et al., 1985).

Concerning OCD, the learning theorist regards obsessional fears to be classically conditioned fear responses that result in subsequent feelings of discomfort (Steketee, 1993a). Since classically conditioned responses are not voluntary, individuals cannot stop experiencing fear when the conditioned stimulus is encountered (Holmes, 1994). This experience of fear causes individuals with OCD to seek out behavioral solutions to eliminate or reduce their discomfort. Thus, OCD sufferers engage in ritualistic behaviors or avoidance behaviors (Foa et al., 1985), which immediately reduce anxiety (Steketee, 1993a). By removing the anxiety, the compulsive behavior becomes negatively reinforced, which then increases the probability that the compulsive behavior will be used again (Holmes, 1994).

The more an individual engages in a ritual, the more likely they will become convinced that the compulsive behavior can reduce their anxiety (Foa et al., 1985), as the fear is maintained by behaviors that prevent the natural extinction of the fear (Abramowitz, 2006). As such, obsessional fears and compulsive behaviors are maintained by operant conditioning (Salkovskis, Richards, & Forrester, 2000). From this perspective, OCD ceases to be a problem of unconscious conflict and instead is regarded as learned. Accordingly, behavioral treatment seeks to break the conditioned fear response and eliminate the reinforcing compulsive and/or avoidance behavior (Meyer, 1966; Steketee, 1993a).

Exposure and Response Prevention and Treatment Efficacy

The main behavioral treatment of OCD that derived from the two-factor theory is a combination of exposure therapy with response prevention or ERP (Salkovskis, 1998). In brief, exposure therapy involves deliberately evoking anxiety by bringing individuals into direct contact with feared stimuli – including thoughts (Abramowitz, 1996), in so doing, demonstrating that the feared outcome does not occur (Salkovskis & Kirk, 1989). Exposure is typically done incrementally by way of systematic desensitization with the evocative medium of exposure typically being in-vivo (exposure that occurs in real-life settings), imaginal (exposure by imagining the feared situation), or a combination. Response prevention, on the other hand, purports to eliminate rituals by purposely prolonging exposure and anxiety by requiring individuals to refrain from compulsive or neutralizing behaviors (Abramowitz, 1996; Salkovskis & Kirk, 1989).

Exposure therapy and response prevention when used in tandem has been shown to be an effective treatment strategy for OCD. Over the decades, its efficacy at ameliorating OCD symptoms has been demonstrated in numerous randomized control trials (see De Haan, Hoogduin, Buitelaar, & Keijsers, 1998; Fisher & Wells, 2005; Hodgson, Rachman, & Marks, 1972; Kozak, Liebowitz, & Foa, 2000; Marks, Hodgson, & Rachman, 1975; Rachman et al., 1979; Rachman, Hodgson, & Marks, 1971), in studies utilizing meta-analytic techniques (see Abramowitz, 1996; Kobak, Greist, Jefferson, Katzelnick, & Henk, 1998), and in studies using nonrandomized samples (see Franklin, Abramowitz, Kozak, Levitt, & Foa, 2000; Rothbaum & Shahar, 2000). Of equal importance, the therapeutic gains of ERP have been shown to be maintained at one-year

(Wetzel, Bents, & Florin, 1999), at 18-month (Cottraux, Mollard, Bouvard, & Marks, 1993), and at two-year (Marks et al., 1975) follow-up.

Cognitive Theory and Treatment

Although the introduction of learning theory and behavioral treatment revolutionized how mental health professionals viewed and treated OCD, they are not without their limitations. First, many patients refuse or prematurely discontinue ERP treatment because of the prospect of having to confront their obsessional fears (Stanley & Turner, 1995). Second, the effectiveness of ERP may be less significant for patients who present with obsessions and no overt ritualizing (Rachman, 1997). Third, behavioral theory does not adequately account for some of the phenomenological features observed in OCD. For instance, obsessions are cognitive phenomena. As well, individuals with OCD have been shown to exhibit over-valued ideas of threat (Steketee, Frost, Rhéaume, & Wilhelm, 1998), perfectionism (Coles, Frost, Heimberg, & Rhéaume, 2003), excessive feelings of responsibility (Rachman, 1993; Tolin, Woods, & Abramowitz, 2003), indecisiveness (Summerfeldt, Huta, & Swinson, 1998), and uncertainty (Overton & Menzies, 2002). Considering these limitations, researchers recognized a need for models that address these cognitive phenomena.

Although numerous cognitive-behavioral models have been postulated (e.g., Purdon & Clark, 1999; Rachman, 1997, 2002; Salkovskis, 1985, 1989, 1999), they diverge more in emphasis and are more similar than different, in that the fundamental premise of each is that obsessional fear results from the appraisal of normal intrusive thoughts. Appraisals are the key cognitive process that leads to an escalation in the frequency and intensity of obsessive intrusive thoughts (Clark, Purdon, & Wang, 2003).

Of the cognitive-behavioral models of OCD, scholars regard Salkovskis' model as particularly important, in particular, because it had a significant effect on directing current thinking, research, and cognitive treatment strategies (Barrett & Healy, 2003; Steketee et al., 1998). Moreover, it was from Salkovskis that the interpretations of intrusive thoughts was brought to the forefront of cognitive theory and treatment (Thordarson & Shafran, 2002).

Salkovskis' Cognitive Appraisal Model of OCD

In 1985, Salkovskis argued that any conceptualization of obsessions in cognitive terms must be done within the framework of Beck's cognitive theory of emotional disorders. He postulated that unwanted intrusive thoughts are normal and occur frequently in individuals without leading to serious disturbance. Indeed, 80% to 90% of the general population report having unwanted intrusive thoughts, ideas, images, and impulses that are contrary to their belief system and are similar to the content of obsessional thoughts (Abramowitz, 2006; Shafran, 2005; Steketee, 1993a). As such, the interpretation of the intrusive thoughts for persons with OCD seems to be the distinctive feature that differentiates normal intrusive thoughts from obsessional thoughts (Barrett & Healy, 2003).

According to the cognitive theory of OCD, intrusions only produce distress when the intrusive thought, image, or impulse is an indication that harm to themselves or others is a serious risk and that they may be responsible for the harm (Salkovskis, 1985, 1999; Salkovskis & McGuire, 2003). That is, the intrusive thoughts turn into clinical obsessions if the individuals have faulty or dysfunctional beliefs involving blame or responsibility (Salkovskis, 1996). According to Salkovskis, the interpretation of

obsessional intrusions as indicating increased responsibility has a number of interlinked effects that can maintain the negative interpretations: (a) increased discomfort, anxiety, and depression, (b) increased focus on the intrusions, (c) greater accessibility to the intrusions, and (d) active attempts to reduce the thoughts and decrease the responsibility perceived to be associated with them (Salkovskis, 1999). However, these neutralizing behaviors - whether overt or covert - actually strengthen and increase the frequency of the intrusions and compulsions and subsequently prevent the natural extinction of the anxiety and disconfirmation of the appraisal of the intrusion (Abramowitz, 2006; Salkovskis & McGuire, 2003).

Dysfunctional Beliefs

For Salkovskis (1985, 1996, 1999), the overestimation of responsibility for preventing harm, as well as the overestimation of harm probability (belief related to the likelihood of aversive events occurring) and harm severity (beliefs about the personal cost that would result from the aversive event) are strongly linked to the etiology and maintenance of OCD. To extend the work of Salkovskis and others, the Obsessive Compulsive Cognitions Working Group (OCCWG) formed to develop a consensus regarding the most important beliefs in OCD (Taylor, 2002). They identified several belief domains significant to OCD: inflated responsibility, over-importance of thoughts, perfectionism, overestimation of threat, and intolerance for uncertainty (OCCWG, 1997).

Inflated responsibility. According to the OCCWG (1997), inflated responsibility refers to the belief that one is especially powerful in producing and preventing personally important negative outcomes. That is, there is a belief that one has power to bring about or prevent negative outcomes, which they perceive as essential to prevent (Abramowitz,

2006; Salkovskis & Forrester, 2002). Unfortunately, individuals with OCD tend to feel responsible for their intrusive thoughts, as well as for their obsessional impulses to harm others (Rachman & Shafran, 1998). They hold themselves responsible for causing harm or for failing to prevent harm to others (Tolin et al., 2003a). Interestingly, although individuals with OCD exhibit elevated sense of responsibility for negative events, this inflated sense of responsibility does not generalize to positive events, as their sense of responsibility for positive events is normal or even lower than normal (Rachman & Shafran, 1998).

Even though the sense of responsibility can be extensive, it is typically limited to an individual's psychological territory. For instance, inpatients with OCD displayed a reduction in their sense of responsibility during hospitalization as marked by an initial decrease in compulsive behaviors (Rachman, 1993). However, ritualizing increased as they acclimated to the hospital ward and incorporated it into their personal psychological territory.

Studies have been generally supportive of the hypothesis that an inflated sense of responsibility is a predominant feature of OCD beliefs. For instance, inflated responsibility was found to be significantly correlated with self-reports of OCD symptoms in student volunteers (Rhéaume, Freeston, Dugas, Letarte, & Ladouceur, 1995). Similarly, both guilt and responsibility were significant predictors of compulsive behaviors in a non-clinical sample of university students (Freeston, Ladouceur, Thibodeau, & Gagnon, 1992).

Regarding OCD, although an inflated sense of responsibility is a common obsessional characteristic in all individuals with OCD (Foa, Sacks, Tolin, Prezworski, &

Amir, 2002), it has been suggested that an exaggerated sense of responsibility is a characteristic more common among individuals with checking compulsions (Rachman, 1993). Individuals with checking compulsions were found to report greater distress and urges to check under conditions of high responsibility (i.e., when the experimenter was not present) than when responsibility was low (Shafran, 1997). Yet, when experimenters assumed full responsibility, checkers reported a greater reduction in their perceived responsibility, which in turn resulted in a decrease in the urge to check (Lopatka & Rachman, 1995).

Lastly, when compared to controls and individuals with generalized social phobia, OC checkers reported greater urges to check, increased distress, and an increase in perceived responsibility in low- and medium-risk harm situations (Foa, Amir, Bogert, Molnar, & Przeworski, 2001). This finding was also observed when OC checkers were compared to individuals without checking compulsions (Foa et al., 2002a). Taken together, responsibility assumptions make it more likely that the person will react to the intrusions and seek out things that they believe will diminish the perceived risk of causing harm (Salkovskis & Forrester, 2002).

Over-importance of thoughts and thought-action fusion. The importance of thoughts domain comprises beliefs and interpretations involving excessive importance attached to negative intrusive thoughts (OCCWG, 1997). Importance of thoughts refers to general beliefs and specific interpretations in one of three themes: (a) negative intrusive thoughts indicate something significant about oneself; (b) having negative intrusive thoughts increases the risk of bad things happening; and (c) negative intrusive

thoughts must be important merely because they have happened. These interpretations have also been described as thought-action fusion (Thordarson & Shafran, 2002).

Thought-action fusion (TAF) is not limited exclusively to OCD; however, TAF exhibits a greater temporal stability in OCD than in other anxiety disorders (Rassin, Diepstraten, Merckelbach, & Muris, 2001). Of TAF, Rachman (1993) writes that there is a tendency for individuals with OCD to fuse thoughts and actions, especially in instances of blasphemous, sexual, or aggressive thoughts, images, or impulses. Thought-action fusion is considered an internal source of the inflation of responsibility (Shafran, Thordarson, & Rachman, 1996). In other words, TAF is the internal trigger for feelings of responsibility and is believed to have two components: likelihood TAF and moral TAF (Rachman, Thordarson, Shafran, & Woody, 1995; Shafran et al., 1996). Likelihood TAF refers to the belief that thinking about an unpleasant or disturbing event increases the probability that the negative event will occur; moral TAF is characterized by the belief that having an immoral thought is as bad as the immoral behavior (the moral TAF). Thus, TAF can be seen as two special cases in which negative intrusive thoughts are interpreted as being excessively important (Thordarson & Shafran, 2002).

Because of this tendency to fuse thoughts and actions, persons with OCD are more likely to fear that a catastrophe would occur if a ritual was not performed (Tolin, Abramowitz, Kozak, & Foa, 2001). Interestingly, not only do individuals with OCD believe at higher rates than others that a negative event will occur as a result of their negative thoughts, they also are more likely to believe that they can prevent harm by their positive thoughts (Amir, Freshman, Ramsey, Neary, & Brigidi, 2001).

Overestimation of threat. Cognitive processes and content related to threat or danger have been hypothesized to be a central characteristic of anxiety disorders (Sookman & Pinard, 2002). It has been observed that many individuals with OCD overestimate the risk of negative consequences for a variety of actions and presume worse outcomes (Steketee et al., 1998), and tend to overestimate that bad things are more likely to happen (Overton & Menzies, 2002). Not only do they overestimate that bad things will happen, they tend to perceive that bad things are more likely to happen to them (Woods, Frost, & Steketee, 2002) and they are more likely to believe that a situation is dangerous until proven safe (Steketee, 1993a). Because of this, persons with OCD are risk-averse and prefer to avoid even normal risks like leaving a car door unlocked (Steketee et al., 1998). Moreover, individuals with OCD attempt to control thoughts that signify potential harm to avert harm and the sense that one may be responsible for harm (Purdon & Clark, 2002).

It also appears that the overestimation of threat exhibited by persons with OCD may be symptom reliant. For instance, individuals with contamination fears may be more likely to overestimate the threat in situations in which contamination concerns would be more likely (Woods et al., 2002). Indeed, persons with OCD pay more attention to anxiety-related threatening stimuli than to neutral words (Van Oppen & Emmelkamp, 2000). Moreover, the overestimation of threat may be greater for individuals with more severe symptoms, in that as symptoms increase so too does estimations of threat, whereas perceived coping ability decreases (Woods et al., 2002).

Intolerance of uncertainty and doubt. Interrelated with an overestimation of threat is an intolerance of uncertainty (Sookman & Pinard, 2002). Persons with OCD

have been found to exhibit elevated cognitive self-consciousness (i.e., directing attention toward one's own thoughts; Janeck, Calamari, Riemann, & Heffelfinger, 2003). This tendency to reflect upon one's own thoughts is believed to increase the potential for negative appraisal of intrusive thoughts and increase the likelihood of obsessional symptoms. As well, it has been suggested that excessive focus on one's thoughts may encourage the development of various dysfunctional cognitions (Janeck et al., 2003). An unnecessarily active self-consciousness may result in exaggerated indecisiveness, uncertainty, and doubt in individuals with OCD.

Clinical observations have noted that individuals with OCD tend to exhibit indecisiveness characterized by meticulousness, prolonged decision making, and attentiveness to detail (Summerfeldt et al., 1998). It is as if persons with OCD have a pathological need for certainty (Rasmussen & Eisen, 1992) combined with a belief that there is ultimately a correct solution to their search for certainty (Steketee, 1993a) and the belief that the absence of complete reassurance of safety implies a high risk of harm (Abramowitz, 2006). As such, persons with OCD request repetition of information and more time before making decisions and paradoxically doubt the decisions they have made (Steketee, 1993a).

Although all individuals experience doubt and uncertainty, what distinguishes individuals with OCD from others is their relative intolerance for the uncertainty, which is often perceived by the OCD individuals as more aversive than the actual occurrence of the negative outcome (Tallis, 1995). It is this intolerance for uncertainty that underlies obsessional fears of events that might occur (Abramowitz, 2006). Since OCD sufferers cannot tolerate uncertainty, they engage in compulsive behaviors and often continue to

engage in these rituals until they are performed “just right” (Coles, Frost, Heimberg, & Rhéaume, 2003; Tolin et al., 2003a). Thus, intolerance for doubt leads to repetitive actions and repeating rituals (Tolin, Abramowitz, Brigidi, & Foa, 2003). Even though pathological doubt is observed across all OCD subtypes, checkers show greater intolerance for uncertainty (Overton & Menzies, 2002; Tolin et al., 2003b). Interestingly, indecisiveness was also found to be correlated to hoarding (Frost & Shows, 1993). It has been suggested that hoarding represents an attempt to delay decision-making, which allows them to avoid experiencing tormenting doubt once a decision is made (Summerfeldt et al., 1998).

Perfectionism. Perfectionism has been linked to OCD for nearly a century (Frost, Novara, & Rhéaume, 2002). It may be defined as a striving to achieve high standards while adopting stringent self-evaluations (Summerfeldt et al., 1998). It is a belief that there is a perfect solution to every problem; that doing something perfectly is possible and necessary; and that even minor mistakes have serious consequences (OCCWG, 1997). Perfectionistic actions in OCD tend to be manifest by way of excess of control behavior (Steketee, 1993a). Individuals with OCD may feel the need to complete forms without making mistakes or repeat routines until it feels like they got it just right and experience discomfort when things do not feel right (Coles et al., 2003). It can emerge as a need to walk through a doorway exactly in the middle, a need to have shoelaces tied exactly the same, or saying one’s prayers perfectly (Rasmussen & Eisen, 1992).

The “just right” experiences are common occurrences in OCD. For instance, among patients with primary OCD, 73% endorsed just right perceptions (Leckman et al., 2000). Furthermore, this awareness was associated more with visual and tactile cues of

the compulsive action (Leckman et al., 2000). That is, things need to look right or need to look and feel right. As such, there appears to be a need for individuals with OCD to match sensations precisely with subjective criteria (Coles et al., 2003). Though perfectionism has been described as a core feature of OCD, studies specifically exploring perfectionism among individuals with OCD suggest that perfectionism may be associated more strongly with some symptoms types than others. For instance, empirical investigations have found that perfectionism was associated with ordering, checking, washing, and hoarding (Coles et al., 2003).

Cognitive and Cognitive Behavior Treatment Efficacy

Researchers and treatment specialists have long recognized the importance of obsessions in OCD; however in the past, treating the obsessions focused on understanding the internal psychological conflicts. These treatments were largely ineffective at improving obsessional symptoms. As stated earlier behavioral treatment specifically has as its target the overt behaviors; as such, its affect on obsessions is modest. Thus, researchers recognized the one-sidedness of the behavioral approach to treating OCD and argued for a need to have additional treatments that specifically address the cognitive features of OCD (see Salkovskis, 1985). Salkovskis effectively conceptualized OCD from within the framework of Beck's cognitive theory of emotional disorders.

Cognitive therapy (CT) seeks to produce change in an individual's thinking and belief system by challenging dysfunctional thoughts, generating alternative thoughts, and restructuring dysfunctional thoughts. It helps persons with OCD identify ways in which they misinterpret situations and thoughts, as well as raise awareness about how thoughts

can lead to obsessional fear (Abramowitz, 2006). Empirical investigations have provided evidence that CT is a viable treatment option for OCD (Van Balkom et al., 1998; Van Oppen et al., 1995), with especial improvement in irrational beliefs (Emmelkamp & Beens, 1997; Emmelkamp, Visser & Hoekstra, 1988; Van Oppen et al., 1995) and inflated responsibility (Ladouceur, Leger, Rhéaume, & Dube, 1996). However, cognitive techniques alone have limited efficacy in reducing OCD symptoms (Abramowitz, 2006).

It is argued that an approach that focuses on both thoughts and behaviors will result in a more complete and thorough change, as well as create a therapeutic environment that may be less distressing than when ERP is used alone (Salkovskis et al., 2000). Cognitive therapy used in conjunction with ERP can play a useful role in helping prevent premature discontinuation and maximizing adherence to ERP (Kozak & Coles, 2005). Furthermore, it may prove to be an effective means of treating clients who do not have overt compulsive behaviors (Freeston et al., 1997). Combining cognitive therapy with behavioral approaches is referred to as cognitive-behavioral therapy or CBT. Numerous studies evaluating the efficacy of exposure-based CBT for OCD have consistently shown that patients who complete this treatment achieve clinically significant improvements (Abramowitz, Franklin, & Foa, 2002; Abramowitz, Franklin, Schwartz, & Furr, 2003; Fals-Stewart, Marks, & Schafer, 1993; Foa et al., 2005; Franklin, Abramowitz, Bux, Zoellner, & Feeny, 2002; Freeston et al., 1997; Lindsay, Crino, & Andrews, 1997; O'Connor, Todorov, Robillard, Borgeat, & Brault, 1999; Sofronoff, 2001; Storch et al., 2010c; Warren & Thomas, 2001).

Cognitive Deficit Models

Besides the dysfunctional thoughts, persons with OCD also often state that they are unable to recall whether a behavior was executed successfully and that their inability to remember completed actions increases their desire to repeat behaviors (Constans, Foa, Franklin, & Mathews, 1995; Radomsky, Rachman, & Hammond, 2001). Moreover, persons with OCD evidence abnormalities on a range of cognitive tasks such as executive function, cognitive inhibition, and some forms of memory (Abramowitz, 2006). Because clinical observations suggest that OCD patients often have doubts about their memory for their actions and surroundings (Amir & Kozak, 2002), scholars have proposed that the source of doubt in OCD stems from a general memory deficit (e.g., Reed, 1977). In other words, faulty memory may play a role in OCD. Thus, neuropsychological models have attempted to account for the doubt-related phenomena observed in OCD by proposing that OCD may result from memory deficits.

General Memory Deficits

Relevant to the memory deficit hypothesis, neuropsychological studies indicated that individuals with OCD show deficits in nonverbal memory (Boone, Ananth, Philpott, Kaur, & Djenderedjian, 1991; Deckersbach, Otto, Savage, Baer, & Jenike, 2000; Hartl et al., 2004; Savage et al., 1996; Tallis, Pratt, & Jamani, 1999; Savage et al., 2000; Segalàs et al., 2008; Zitterl et al., 2001) and verbal memory recall and recognition (Sawamura, Nakashima, Inoue, & Kurita, 2005; Segalàs et al., 2008). Furthermore, individuals with subclinical checking concerns have been found to have poorer recall for previously completed actions (Rubenstein, Peynircioglu, Chambless, and Pigott, 1993; Sher, Frost,

Kushner, Crews, & Alexander, 1989; Sher, Frost, & Otto, 1983; Sher, Mann, & Frost, 1984), which was also found to be true for OCD checkers (Ecker & Engelkamp, 1995).

Contrary to the above results, research has not consistently found support for cognitive deficit hypotheses (e.g., Constans et al., 1995; Hermans, Martens, De Cort, Pieters, & Eelen, 2003; MacDonald, Antony, MacLeod, & Richter, 1997; McNally & Kohlbeck, 1993). For instance, problems with nonverbal memory recall may be more likely explained by poor organization strategies. For example, investigations found that persons with OCD used less systematic organizational strategies during encoding (Deckersbach et al., 2000; Savage et al., 2000). As such, persons with OCD are disadvantaged when they attempt to retrieve nonverbal information, because, in the first place, they did not encode the information effectively (Deckersbach et al., 2000).

Moreover, when anxiety was elicited, OCD washers were able to recall more contaminated objects than clean objects (Radomsky & Rachman, 1999) and more accurately remember which objects were touched by a contaminated object (Ceschi, Van der Linden, Dunker, Perroud, & Brédart, 2003). Moreover, OCD checkers were more accurate than controls at recalling objects left in unsafe positions (Constans et al., 1995). Furthermore, OCD checkers showed a positive memory bias for threat-relevant information, which was amplified when responsibility increased (Radomsky et al., 2001); interestingly, OCD checkers reported being less satisfied with the vividness of their memories (Constans et al., 1995).

Memory Confidence

Supportive of Constans and colleagues' (1995) reports was a finding that nonclinical checkers have reduced recollection of vividness, whereas memory accuracy

was unaffected (van den Hout & Kindt, 2003a, 2003b). Therefore, doubting may reflect a lack of confidence in memory rather than a true memory deficit. For example, studies have found that doubt about whether specific behaviors were performed does not arise because one does not remember performing the action, but rather because one distrusts or lacks confidence in the memory for this action (Foa, Amir, Gershuny, Molnar, & Kozak, 1997; Hartl et al., 2004; Hermans, Martens, De Cort, Pieters, & Eelen, 2003; MacDonald et al., 1997; McNally & Kohlbeck, 1993; Radomsky et al., 2001; van den Hout & Kindt, 2003b). Ironically, evidence suggests that repeated checking breeds doubt and not certainty (van den Hout & Kindt, 2003a; van den Hout & Kindt, 2003b). The more individuals with OCD check, the more they doubt their memory (Tolin et al., 2001).

Taken together, people with OCD evidence abnormalities in some forms of memory; however, not in memory per se, since people with OCD have been shown to exhibit memory bias and lack of confidence in memory. At times, poor encoding strategies may better explain memory deficits. Furthermore, the cognitive deficit models are limited in that they do not account for the heterogeneity of OCD symptoms, nor do they explain why these deficits may cause OCD instead of other disorders in which mild cognitive deficits are also present (Abramowitz, 2006). Lastly, individuals with OCD tend to assign different attributions to their thoughts and actions (Amir & Kozak, 2002). That is, individuals with OCD do not always blame memory for their symptoms. For instance, as discussed earlier, individuals with OCD may exhibit an interpretation bias for threat, responsibility, exaggerated importance of negative thoughts, etc.

A Dynamical View of OCD

Modern psychological inquiries have advanced our understanding of how to treat OCD, especially in identifying cognitive biases that have led to better understanding and treatment of OCD symptoms. However, they may have also resulted in a somewhat circumscribed view of OCD, arguably constraining our understanding of OCD by underscoring or wholly ignoring the influence psychosocial factors may have on maintaining, causing, or co-causing OCD symptoms. Indeed, the psychosocial dynamics have been largely overlooked, as shown by the dearth of research that exists investigating the role of the family environment in OCD when compared to other OCD research areas. This is the case, despite the reality that psychoanalytic psychotherapy was the most common treatment as recently as the late 1960s (Baer, 2000) and dominated psychological thought for half of the 20th century (Baer & Minichiello, 1998).

Although there is philosophical richness to the dynamical models of the past – which is arguably not found in the prosaic, modern models of OCD – they have largely fallen out of favor with many researchers and practitioners. In large part, this may be due to any number of factors, not excluding the psychodynamic models themselves. First, whereas cognitive-behavioral techniques have proven effective in treating OCD and other psychological disorders, psychodynamic treatments have failed to produce significant changes in individuals with OCD (Rapoport, 1989). Indeed, modern psychoanalysts have conceded that OCD continues to be refractory to their efforts (see Munford, Hand, & Liberman, 1994).

Second, psychodynamic explanations were difficult to test empirically, offering few hypotheses that could be verified or rejected through the scientific method (Myers,

1989). Third, psychodynamic explanations tended to blame patients or family members for the disorder without truly considering the validity of the symptom experiences themselves (Dolnick, 1998). Further endangering dynamical explanations of OCD is the wholesale rejection of these theories by influential experts like Judith Rapoport, who argued in an interview that mental woes are not the source of the problem in OCD and that attempted psychological explanations of OCD are mistaken efforts (see Dolnick, 1998).

Consequently, the pendulum has swung – arguably too far – away from a dynamic view and toward a medical view of mental illness, currently dominating clinical psychology (see Albee, 1998). The medical viewpoint perceives mental illness to be more or less static (Sulis & Gupta, 2001) and does not account for symptom variation across time. That is, individuals have an illness or they do not, they are always ill or they are always healthy (Sulis & Gupta, 2001). Regarding OCD, the medical view would seem to suggest that individuals either have OCD or they do not, without regard to the course of the disorder.

Although a static view of OCD would allow researchers to investigate two seemingly independent variables and demonstrate linear causality, the course of OCD has been found to typically follow a chronic and deteriorating course with occasional periods of partial remission (Steketee, 1993a). As well, symptom presentation changes in content, form, and severity over time (Rettew, Swedo, Leonard, Lenane, & Rapoport, 1992). It could be argued that the waxing and waning course of OCD symptoms and their change over time in content and form suggests that a variety of variables could well be mutually influencing OCD symptoms in ways that have yet to be understood or

explored and should be considered. Thus one might not need to look much further than the family environment for one possible answer.

One could argue that fewer psychological models exist that hypothesize mediating or moderating familial variables regarding OCD. Yet, why look toward the psychosocial environment? First, despite improvement in therapeutic gains, at follow-up assessments relapses have been shown to occur in a significant portion of those treated. For instance, Foa et al. (1984) found that 10% to 30% of individuals who received ERP experienced a relapse of obsessive and compulsive symptoms, respectively. In other words, when patients return to their psychosocial environment, relapses may occur. Although it may be true that factors other than the psychosocial environment may contribute to the relapse, for example, not continuing to apply thought challenging and response prevention techniques, it could also be probable that the family environment may also be contributing to symptom relapse. Thus it is probable that the family environment generates dysfunctional relationships that could influence symptom severity and symptom relapse, maintain or exacerbate OCD symptoms, or inhibit psychological treatment effects.

The Family and OCD

Speculation concerning the family's role in the development of pathology is not new. Indeed, researchers have long speculated about the role of childrearing or parenting behaviors in the development of OCD (Waters & Barrett, 2000). Psychoanalytic writers have focused on possible early family experiences that might influence OCD symptom formation (Merkel, Pollard, Wiener, & Staebler, 1993). Freud, for example, postulated

that a relationship between strict or lax parental toilet training practices during the anal stage of psychosexual development forms the basis of OCD (Ehiobuche, 1988).

Others have suggested that parents exhibit traits associated with OCD (e.g., perfectionism), which they then transmit to their child. For instance, through interviews and observations of families of OCD patients, Hoover and Insel (1984) found that their OCD patients typically lived in a family culture of “supercleanliness, over-meticulousness, and the like” (p. 209); in other words, parents had habits, attitudes, and perfectionistic standards of cleanliness and performance not ordinary to most families.

Additionally, behaviorists have speculated that parents may unwittingly transmit OCD to their children by modeling avoidance behavior or by modeling fear responses to stimuli (Pollock & Carter, 1999). Regardless of the context of the postulation regarding the psychogenesis of OCD, the premise that parents can transmit OCD to their children is one commonality among these different theories.

Because of the impact family members have on each other, it is probably not surprising to learn that family members find it stressful to live with members who have OCD. Financial problems, marital discord, emotional distress and disruption of the lives of family members are some of the ways in which OCD can devastate a family (Cooper, 1996). For instance, Cooper (1993) surveyed 225 family members of adults with OCD and reported that 75% experienced disruption of their lives due to OCD, which included losses of personal relationships, loss of leisure time and financial problems. It should also be noted that the dynamics within OCD families are often conflictual. For instance, Emmelkamp, de Haan, and Hoogduin (1990) and Riggs, Hiss, and Foa (1992) found that about half of their participants reported experiencing marital distress; and Hoover and

Insel (1984) observed that the relationships between parents of OCD children were strained or distant and “furiously argumentative” (p. 210).

More recently, empirical studies have demonstrated that the interactions between family members and relatives with OCD are more emotionally distressed (Amir, Frashman, & Foa, 2000), and the family often directs anger and frustration toward the OCD member (Black et al., 1998). Therefore, it is not surprising that individuals with OCD are more likely to be divorced or separated compared to individuals who do not suffer with OCD (Karno, Golding, Sorenson, & Burnam, 1988). Furthermore, decreased cohesion in the family appears to be associated with an increased prevalence of OCD (Valleni-Basile et al., 1995).

Considering the information above, one could surmise that OCD significantly interferes with healthy family functioning by increasing the negative affect and decreasing positive affect within a family, thereby, creating emotional distance within the family. For example, adolescents with OCD reported perceiving less emotional support, warmth, and closeness in their family (Barrett, Shortt, & Healy, 2002). Among the opinions regarding the influence of childrearing patterns on the development of OCD, it has been suggested that overly controlling, overly critical, as well as less emotionally warm, rejecting, and anxious parenting styles may foster the development of OCD (Rapee, 1997). Not only might OCD contribute to a lack of cohesion in a family, but for some families the opposite may also be true; for instance, recollections of adults with OCD suggest that their parents may have been overly protective (Turgeon, O’Connor, Marchand, & Freeston, 2002), which may suggest that parents of children with OCD may believe that their children are incapable of coping, and take over in some situations,

thereby fostering dependency and reducing the affected child's autonomy within the family.

Furthermore, two of the most frequently recorded problems in OCD are: (a) the need of persons with OCD to be reassured and (b) family members being drawn into the ritualizing behavior. A survey, for instance, found that 63% of family members reported being drawn into the ritualizing behavior (Black et al., 1998). Additionally, relatives of individuals with OCD have reported participating in washing rituals, allowing their homes to be cluttered with hoarded items, and providing repeated reassurances to abate fears associated with obsessive thoughts (Calvocoressi et al., 1999). Others have observed that the demands of the individual with OCD break down the boundaries between parents and children, such that the child, by way of OCD, acquires unchallenged power in the family, which often leads parents into supporting elaborate symptoms (Hoover & Insel, 1984). Yet, although persons with OCD clearly cause distress and negatively affect family functioning, a dynamical approach suggests that interaction patterns or communication styles may also contribute to OCD as well.

Family Systems Theory

From a systems point of view, most of our relations with others in society are based on and regulated by communication, which defines, maintains, or changes the nature of relationships (Bavelas & Segal, 1982). Unlike the previous theories discussed, family systems theories does not isolate any individual from the system. It is argued that families (and consequently, individuals) are only intelligible by understanding them as an integrated and interdependent whole (Cox & Paley, 1997). Individual members that make up the family are seen only in context of the whole. However, perceiving the

family as a whole also means considering the personal dimensions of all the members' experiences (Nichols & Schwartz, 2001). The systems approach is interested in the interrelations among the family members, how individual behavior relates to the family unit, and how the family structure organizes the way in which family members interact than it is in the individual members of the family (Minuchin, 1974).

According to Systems theory, the family can be best imagined as a circle that operates by way of transactional patterns and develops a preferred pattern of functioning (Minuchin, 1974). The interaction patterns that develop become the essence of the family dynamic. These patterns can be either functional or dysfunctional. In healthy families, the interactions among the family members function without interference. The contrary would be true of dysfunctional families.

Systems theory argues that demands that are contrary to the preferred pattern of functioning are normally followed by a response from the family that returns it to balance, its normal state of functioning (Laszlo, 1972). That is, the interactive behavior of the members or individual elements serves a regulatory function to maintain structural integrity and orient the system toward equilibrium (Koopmans, 1998). However, as the demands for change increase in magnitude, the family enters a period of crisis brought about by external and internal demands. After which, the family adopts a different interaction pattern to cope (Minuchin & Franklin, 1981). In other words, the family re-organizes and creates a new homeostasis (Laszlo, 1972). Yet, the family will attempt to maintain the preferred pattern of functioning for as long as possible, before eventually re-organizing (Minuchin, 1974). The family, therefore, is very heavily influenced by cause-effect relationships that occur from within.

Within the family structure, however, the cause-effect relationship in a family is not conceived of in the traditional linear sequence; instead it is circular, having neither a beginning nor an end (Laszlo, 1972). That is, not only can behaviors lead to other behaviors, but these behaviors can also lead back to the originating behaviors. The systems approach observes what circles are occurring within the family (Bavelas & Segal, 1982), and what, if any, problems within the family are sustained by these ongoing circular actions and reactions (Nichols & Schwartz, 2001).

Social roles. One such component affecting the *circles* occurring within the family is the roles played by each member. Essentially, roles describe the status of an individual within a family, as well as the pattern of behavior expected of them (Nichols & Schwartz, 2001). In order for the family to function well, the roles must be clear so that individuals may function in their respective roles. Additionally, it is necessary for members of the family to balance their roles with the roles of others in the family and be flexible. Inflexibility within a family may result in a pathological disturbance, which in turn may result in the eventual reorganization of the family around a symptomatic member (Nichols & Schwartz, 2001).

Relationships. Another component affecting the circular, cause-effect patterns within a family is relationships. Relationships may be defined as the product of two or more family members interacting from their perspective roles (Pincus, 2001). When the roles become pathological, the relationships become adversely affected as well. These pathological relationships are referred to as: enmeshed, disengaged, or triangulated. Enmeshment refers to a transactional style or a type of interaction in which the boundaries between family members are diffuse, intrusive, and too emotionally close

(Minuchin, 1974). Disengagement, on the other hand, refers to relationships within families where boundaries are too rigid and members are emotionally distant.

Triangulated relationships describe relationships in which an emotionally significant relationship between two people is shadowed by a third party. Triangulated relationships are sometimes characterized by a coalition between two members often to the detriment of a third (Minuchin & Franklin, 1981). When problems occur, there is typically a breakdown in the roles, relationships, and interaction patterns of the family.

In the past, attempts have been made to attribute the symptoms of mental illness to the dysfunctional communication patterns in families (Koopmans, 1998). One such attempt was the Double Bind theory that postulated that contradictions in the interaction patterns of family members predisposed its members to schizophrenia (Koopmans, 2001). It was hypothesized that families who have members with schizophrenia communicate more ambiguous and conflicting information that has pathogenic effects on the child.

Although the double-bind model has been discarded for its lack of empirical support, its notion of a feedback relationship by way of communication between the symptomatic individual and systemic dysfunction warrants a second look, particularly concerning elucidating how the family environment through dysfunctional communication play a role in the development or maintenance of OCD symptoms. A review of the literature on families and OCD consistently implicates a couple of interaction patterns of OCD families: Expressed emotion (EE) and family accommodation (FA).

Expressed Emotion

The idea of EE derived from studies of patients with schizophrenia and depression (Steketee & Pruyn, 1998). Expressed emotion is a psychological construct that attempts to identify emotions, feelings, and attitudes expressed by one individual toward another (Hibbs, Hamburger, Kruesi, & Lenane, 1993). More precisely, it refers to a family environment that is characterized by hostility, criticism, or emotional over-involvement (Chambless & Steketee, 1999). It should be stressed that EE is a characteristic of family members and not of patients (De Berardis et al., 2008). A family is deemed to be high in EE when at least one member of the family system possesses one or all of these characteristics (Waters & Barrett, 2000).

Studying children, adolescents, and their parents, Hibbs et al. (1991) concluded that family members of patients with OCD show high levels of EE. Eighty-two percent of families were rated high in EE compared to a control group in which only 41% were rated high in EE. Moreover, they found that 46% of the fathers and 73% of the mothers of children with OCD manifested high levels of expressed emotion (Hibbs et al., 1991). In another study examining adolescents, Valleni-Basile et al. (1995) found that decreased family cohesion and rigidity may be associated with an increase in the prevalence of OCD, which is consistent with earlier results of a retrospective study that found that adults with OCD perceived their families as more rejecting and less emotionally warm (Ehiobuche, 1988). Moreover, Hibbs et al. (1993) found that OCD families were less cohesive and were more critical and conflictual.

More recently, in a study examining relative-client dyads, Chambless, Rodebaugh, Floyd, and Steketee (2007) found that relatives defined as hostile were twice

as critical as non-hostile relatives. When a hostile relative interacts with an anxious patient about a significant problem in their relationship, the relative engages in criticism and blames the patient for negative events rather than focusing on problem solutions. In turn, patients who interacted with hostile relatives were found to be more likely respond by being negative toward the hostile relatives, by disagreeing with the hostile relative, justifying their behavior to the hostile relative, and offering negative problem solutions.

Expressed emotion may also affect symptom severity. Amir et al. (2000), for instance, found that increased rejection and hostile criticism by family members of individuals with OCD increased compulsive behaviors but not the obsessions. In other words, the more rejecting and critical family members were the worse the individual's compulsive symptoms were. More recently, studying the interactions of EE, specifically, criticism and hostility, Van Noppen and Steketee (2009) found although hostility and criticism performed similarly in their analyses, hostility proved to be a better determinant of symptom severity than criticism for relative-rated EE; however, for patient-rated EE, data suggested that patients who perceived their relatives to be critical or hostile were more likely to have more severe OCD symptoms.

Among the family variables examined as predictors of outcome in other mental disorders, EE is one of the most extensively researched constructs (Hibbs et al., 1993; Steketee & Van Noppen, 2003), with many studies showing EE to be a predictor of relapse among patients with schizophrenia, affective disorders and other psychiatric disorders (Butzlaff & Hooley, 1998; Hooley, Orley, & Teasdale, 1986). Regarding OCD, Steketee (1993b) examined family interactions and treatment outcomes nine months after therapy. She found poor social and familial functioning and patient-rated negative

household interactions predicted fewer gains at follow-up. That is, participants who received high criticism and anger from their spouse were more likely to relapse, whereas individuals who experienced positive feelings in their environment showed more therapeutic benefit or maintained treatment gains. Conversely, positive feelings in the household predicted more improvement. Also examining EE and relapse in OCD, Emmelkamp, Kloek, and Blaauw (1992) found that the combination of EE ratings, avoidance, and life stressors predicted relapse. They also found that high EE ratings at follow-up were observed in three of four relapses. Expressed emotion may also affect children and adolescents similarly.

In a study of children and adolescents with OCD, Leonard et al. (1993) found that parental EE scores predicted functioning at follow-up. Specifically, at follow-up assessments, children and adolescents living with parents high in EE manifested poorer functioning compared to children or adolescents living with families low in EE. Furthermore, they found that 43% of the 54 participants still met diagnostic criteria for OCD and 9% were more symptomatic at follow-up. Thus, the poor treatment outcome found may to some degree be attributable to parental EE; moreover, children and adolescents with OCD were more sensitive to parental criticism.

Research by Hibbs, Zahn, Hamburger, Kruesi, and Rapoport (1992) may be supportive of this notion. They found that children with OCD exhibited heightened physiological reactions to parental EE. Specifically, Hibbs et al. found that high parental EE was related to elevated autonomic nervous system activity in children. This finding was stronger when both parents were rated as having high EE and in particular when fathers were high in EE. More, the effects of EE were stronger (i.e., increased autonomic

activity) during the resting period than during the actual task performance for children with OCD (Hibbs et al., 1992), which may suggest that parental EE could trigger anxiety that is then reduced through ritualizing, as autonomic activity was less active during task performance.

Expressed emotion may also have an impact on the effectiveness of behavioral treatment. For instance, in a study examining the effects of EE on the behavioral treatment outcome of adults with OCD or panic disorder with agoraphobia, Chambless and Steketee (1999) found that higher emotional over-involvement and hostility by family members predicted higher rates of treatment termination. The patient's perception of more criticism was also a significant predictor of poorer treatment outcome at posttest (though not significant, findings at follow-up were in the same direction). Overall, hostility predicted less change in symptoms after treatment and was the most consistent predictor of poor treatment outcome. In fact, when family members were hostile, they found that participants were six times more likely to drop out of treatment. As well, participants who completed treatment while living within a hostile family environment changed less on measures of general functioning (Chambless & Steketee, 1999).

Contrary to the typical findings of EE, criticism per se may not be necessarily detrimental to treatment outcome. Rather, it is the nature of the criticism being communicated by the family system that may determine therapeutic effectiveness of behavioral treatments for OCD. Criticism characterized as unhostile, for example, was predictive of better treatment results, whereas the opposite effect was found when criticism was hostile (Chambless & Steketee, 1999). It would appear, therefore, that when family members expressed dissatisfaction with symptomatic behavior but did not

reject the person exhibiting the symptomatic behavior, critical comments might have motivated the clients undergoing treatment (Chambless & Steketee, 1999).

How an individual with OCD perceives the criticism also appears to impede treatment response. More recent research, for example, has shown that the more individuals perceive family members as being critical, the less likely they will respond to behavioral treatment (Renshaw, Chambless, & Steketee, 2003). Moreover, higher levels of perceived criticism predicted more severe OCD symptoms after behavioral treatment (Renshaw et al., 2003). Thus it would seem that hostile criticism by family members and the perception of the criticism received from family members detracts from an individual's ability to respond to treatment. Furthermore, the patients' perception of criticism and hostility is what matters most regardless of the relatives' perception of themselves. For instance, Van Noppen and Steketee (2009) found that even if relatives did not perceive themselves as critical or hostile, it was the patient's perception that mattered most regarding the effect criticism had on the severity of OCD symptoms; however, perceived criticism may be affected by the insight of the person, in that insight may worsen EE and OCD symptom severity. For instance, patients with poor or no insight not only had higher perceived EE and criticism scores, but also more severe OCD symptoms (De Berardis et al., 2008).

Taken together, it can be surmised that when family members respond with hostile criticism toward the symptomatic member, the individual with OCD will become distressed. This distress could make it more difficult for the individual with OCD to resist compulsive urges. The more unpleasant the hostile criticism is, the more likely it will be that rituals will be used to reduce the distress associated with the EE. As

individuals engage in rituals to reduce the triggered distress, the frustration and anger experienced by other family members may increase, which may then increase the hostile criticism directed at the individual with OCD. If EE increases the overall distress of individuals with OCD, the more likely it is that these individuals will not respond to behavioral treatment or be more vulnerable to relapse. Expressed emotion may thereby perpetuate OCD symptoms through its impact on family cohesion; especially, the impact on the family will be greater the more individuals with OCD receive hostile criticism or rejection from the family.

Family Accommodation

Another of the striking features of OCD is the degree to which family members are involved in the rituals or accommodate OCD behavior. Cooper (1996) writes: “what distinguishes OCD families from other families of the mentally ill is the inextricable way that they are brought into the illness...nearly all affected children involve their parents, and sometimes siblings, in their rituals, thus dominating family life” (p. 297). Others have observed that the demands of the individual with OCD break down the boundaries between parents and children, such that the child, by way of OCD, acquires unchallenged power in the family, which often leads parents into supporting elaborate symptoms (Hoover & Insel, 1984).

Becoming involved in the rituals is a common response to OCD by family members (Waters & Barrett, 2000). For instance, studies have found that 63% (Black et al., 1998) to almost 89% (Calvocoressi et al., 1995; Calvocoressi et al., 1999) of families reportedly accommodate OCD behavior to some degree. For instance, Calvocoressi et al. (1995) found that approximately one-third of family members reported providing

frequent reassurance. Moreover, about one-third of the family members they studied actively participated in compulsive behaviors. Unfortunately, family members are frequently manipulated into codependent, enabling behaviors (Cooper, 1996). Indeed, family members have experienced verbal and physical abuse for refusing to accommodate OCD symptoms (Calvocoressi et al., 1995). Consistent with the adult research, parents reported high rates of family accommodation, mostly by way of offering their children reassurance, facilitating avoidance, and participating in rituals (Merlo, Lehmkuhl, Geffken, & Storch, 2009; Peris et al., 2008; Storch et al., 2007b).

Active participation in the compulsive behavior is vast. Examples from the literature include: supplying provisions related to the compulsive behavior (for instance, one father reportedly drove 20 miles at night to purchase a specific bar of soap; Hoover & Insel, 1984); active physical participation in the rituals themselves (for instance, relatives reported participating in washing rituals and allowing their homes to be cluttered with hoarded items; Calvocoressi et al., 1999); refraining from physical contact with a specified “contaminated” family member; facilitating avoidance behavior; modifying family activities and routines (Calvocoressi et al., 1995); providing repeated reassurances to abate fears associated with obsessive thoughts (Calvocoressi et al., 1999); and taking over responsibilities (Steketee & Van Noppen, 2003). Family accommodation (FA), therefore, refers to actions taken by family members to facilitate rituals, provide reassurance related to symptoms, agree to demands, decrease day-to-day responsibility, or assist with or complete tasks (Waters & Barrett, 2000).

Interestingly, the majority of family members who do accommodate individuals with OCD believe that accommodating the OCD behavior had no real affect on the

disorder (Calvocoressi et al., 1999). Family members believe that accommodation provides repeated reassurances and will at least abate the fear associated with the obsessional situation (Calvocoressi et al., 1995) or decrease symptom-related impairment (Storch et al., 2007b). Relatives also reported that they participated in compulsive behaviors to reduce the amount of time the OCD member spent completing the rituals (Calvocoressi et al., 1995). Moreover, they often accommodated the OCD behavior, despite believing it to be unreasonable (Calvocoressi et al., 1999). Furthermore, parents with OCD have been shown to accommodate their child's OCD behavior more than parents without OCD and they perceived worse consequences for their children if they did not accommodate (Peris et al., 2008). Although these efforts are well-intentioned, they typically result in greater impairment and reinforce the symptoms (Steketee & Van Noppen, 2003; Storch et al., 2010a). One study may even suggest that adult patients experience their relatives who accommodate them as intrusive and critical (Van Noppen & Steketee, 2009).

It is clear from the number of studies exploring familial involvement in OCD that FA is a common occurrence. As such, it likely reflects a common, dysfunctional interaction pattern that perpetuates OCD. Indeed, studies indicate that increased accommodation of OCD symptoms was related to more family dysfunction, distress, and disharmony (Amir et al., 2000; Calvocoressi et al., 1995; Calvocoressi et al., 1999). As well, increased FA has been shown to be related to an increase in symptoms severity (Calvocoressi et al., 1999; de Abreu Ramos-Cerqueira et al., 2008; Stewart et al., 2008) in particular compulsive behavior (Amir et al., 2000). Moreover, symptom severity, contamination obsessions and cleaning compulsions were found to be predictors of increased FA (Stewart et al., 2008). Consistent with the adult literature, increased FA has

also been shown to be related to symptom severity, functional impairment, and externalizing and internalizing behavior problems in children (Merlo et al., 2009; Peris et al., 2008; Storch et al., 2007b; Storch et al., 2010a).

Acts of accommodation may not only perpetuate the distressing OCD symptoms, but may also be a source of distress for the family. For instance, Calvocoressi et al. (1999) reported that about 69% of family members surveyed indicated that they experienced mild to extreme distress when accommodating the family member with OCD. Similarly, Amir et al. (2000) found that family members were more distressed when they helped with rituals or modified their routines to accommodate OCD. Paradoxically, family members not only experience distress when they assist individuals with their rituals, but also experience distress when they do not assist and the individual with OCD becomes upset (Amir et al., 2000); and recently in children studies, FA was shown to be related increased parental distress (Storch et al., 2008; Storch et al., 2009).

As stated earlier, the effectiveness of behavioral treatment for OCD lies in its requirement that individuals directly confront a feared situation to extinguish the anxiety associated with the fear-evoking stimulus (Salkovskis & Kirk, 1989). By accommodating individuals with OCD by way of reassurance, supplying items needed for rituals (e.g., soap), active participation in the rituals, and facilitating avoidance behavior, the family temporarily removes the anxiety; however, this level of involvement actually rewards the anxiety and maintains the symptoms (Waters & Barrett, 2000); therefore, interactions that involve accommodation prevent the individual from confronting the feared situation, which then prevents extinction from occurring. As long as families accommodate the OCD, the symptoms will continue until families alter how they interact.

The interaction patterns of an accommodating family may hinder treatment effectiveness or increase the likelihood that individuals will relapse. One study observing the effects of FA on treatment found that behavioral treatment of OCD is more effective when family members resist the pattern of accommodating the OCD individual (Amir et al., 2000). Additionally, when FA was directly targeted for treatment through education, the degree of accommodation decreased, as did the symptomatology of the OCD child (Merlo et al., 2009; Waters, Barrett, & March, 2001). Moreover, FA has been shown to decrease after family-based CBT (Storch et al., 2007a; Storch et al., 2010b), which was shown to be predictive of treatment outcome (Merlo et al., 2009).

Taken together, these studies demonstrate that family behavior is critical during and after treatment. As well, they may even suggest that family dynamics play a role in the perpetuation of OCD; however, although they are instrumental in establishing the importance of EE and FA, the temporal relations among these variables (EE, FA, and OCD) cannot be determined but merely inferred from the data.

The Need for Nonlinear Dynamics

In what follows, it will be shown that the referenced studies addressed the question of OCD from a linear perspective. As such, they have not sufficiently addressed the dynamics involved in the development and maintenance (and possible treatment) of OCD. Indeed, the prevailing idea of change in psychology consists of only one form, linear change (Guastello & Liebovitch, 2009), especially in epidemiology studies of health and disease phenomena (Philippe & Mansi, 1998). Consequently, the traditional conceptual and experimental analysis applied to the study of psychological phenomena has been and continues to be linear modeling (Heath, 2000).

All things being equal, linear models have several conceptual characteristics or assumptions that are at variance with temporal, dynamic phenomena. First, linear models assume that change occurs as the result of unidirectional influences (Lasser & Bathory, 1997). Second, linear models assume that the scores obtained for each variable are independent of each other (Clark-Carter, 1997). Third, linear models assume that outcomes are proportional to inputs in a straightforward manner (Guastello & Liebovitch, 2009). Mathematically, this latter assumption states that the relation of X to Y is dependent on the force of their relationship signified by alpha; therefore, Y is proportional to X according to alpha (Philippe & Mansi, 1998). As such, small initial differences produce small differences in outcome. Finally, linear models assume that the error term is the aggregate error that reflects the discrepancy between the model equation and the observed values such that the discrepancy is attributed to errors made in measuring the independent variables (Philippe & Mansi, 1998).

Linear models therefore presume, perhaps explicitly but more likely implicitly (or obviously), that errors in estimating the response variable are equivalent to those made in measuring the independent variable regardless of the complexity of the relationships (Philippe & Mansi, 1998). Furthermore, when linearity does not hold, interaction terms are included to correct residual discrepancies, regardless of the sources of nonlinearity. Regarding interaction terms, regressions represent statistical adjustments that do not account for nonlinearity, rather they box the data in a linear relationship. Mathematically, linearity assumes that the probability of an outcome is always the sum of its component forces and that the outcome is predictable albeit subject to random errors (Philippe & Mansi, 1998).

Since linearity assumes that change occurs as the result of unidirectional influences, deductions from linear models concerning the temporal relationships among psychosocial variables and pathology can only be inferred. Indeed, “complex phenomenon such as mental disease can hardly fit into a linear model” (Nandrino, Leroy, & Pezard, 2005, p. 146). Although complex dynamical systems may resemble linear systems when in a steady state, they may also produce unpredictable behavior (Ward, 1995). The study of chaotic dynamics has shown that unpredictability and surprise are fundamental aspects of the world around us (McDaniel & Driebe, 2005). Moreover, nearly any activity involving human interaction is suffused with nonlinearity (Driebe & McDaniel, 2005).

If behavior is governed by nonlinear dynamics, then the residual discrepancies that are corrected without accounting for structural nonlinearity provide us with useful information for understanding what lies beneath psychological processes. Consequently, extrapolating the temporal dynamics of OCD from linear modeling may likely be failing to capture the dynamics accurately or completely. Even though linear models have allowed us to gain insight, the extent of their usefulness is intrinsically limited when dealing with complex systems (Philippe & Mansi, 1998). It is necessary, therefore, to deal with the phenomena of OCD in a different way.

Considering these points, this current investigation argues that if our knowledge of the temporal dynamics of OCD is to continue to develop, it may require conceptualizing OCD using nonlinear dynamical systems theory (NDS). Indeed, for as Tschacher and Junghan (2009) argue: the application of dynamical systems theory in psychology seems promising because virtually all disorders exhibit sudden or periodic

shifts in cognitive, emotional, or behavioral functioning that can be modeled using dynamical models. Moreover, NDS provides a rich array of constructs that describe many types of change and is concerned with the mutual relationships of cause and effect variables and the coherent patterns they create (Guastello & Liebovitch, 2009; Lasser & Bathory, 1997).

Furthermore, NDS produces a better explanation of phenomena that could not be described in any other way and accounts for more of the data than linear models (Guastello & Liebovitch, 2009). For instance, in studies comparing proportions of variance explained by an accepted nonlinear model and its alternative theoretical counterpart (usually linear), the NDS model outperformed the alternative by a ratio of 2:1 (Guastello, 1995, 2002). Therefore, new nonlinear dynamical models of OCD should be proposed to elucidate and enrich our capability of understanding the variables governing the temporal dynamics of OCD, while at the same time taking into account the legitimate concerns and criticisms aimed at earlier dynamic theories.

Introduction to Nonlinear Dynamical Systems Theory

Although NDS may seem new to many in the social sciences, its usage in psychology is not; however, it does lag behind other disciplines (Gregson & Guastello, 2011). Concerning NDS' use in psychology, it can be traced back to Thom's catastrophe theory of 1975 and the early efforts of Zeeman to apply nonlinear concepts (Guastello, 1997, 2001, 2009). A few decades later, Abraham, Abraham, and Shaw (1990) speculated on the application of NDS to most of psychology's content domains. Since then, NDS has gained momentum within the psychological sciences; however, for many in the psychological sciences, while linear modeling needs no explanation, NDS and

some of its key concepts may require brief explanations. Perhaps the easiest way to unlock what NDS is would be to define the key words that compose NDS separately.

Nonlinear simply means that change is not proportional. A nonlinear relationship, then, is one where an incremental change in one is not met with a proportional change in the other (Guastello, 1997); that is, large changes in a variable may produce small or negligible effects elsewhere in the system or a small change in one variable could produce disproportionately large effects on another. Moreover, nonlinearity permits reciprocal causality (Lasser & Bathory, 1997): events can influence themselves or each other.

“Dynamical” refers to changes over time that involves attractors, bifurcations, and the like (Guastello, 1997). As such, the dynamical models recursively generate time series and describe a variable’s current value as a function of its preceding state (van Geert, 2009). That is, the dynamical models take the result of one step in the process as the starting value that then generates the next step, and the next, and the next, etc.

System refers to the focus on interactions of multiple causal factors, rather than focus on isolating and categorizing variables as solitary causes and effects (Pincus, 2001). A system focus blurs the cause and effect such that variables may act as both causes and effects depending on when and where one looks at them. In essence, NDS theory is a means of describing how one state develops into another state over time (Weisstein, 1999) in disproportionate ways. It is a general systems theory for describing, modeling, and predicting change processes (Gregson & Guastello, 2011).

Essentials of Nonlinear Dynamical Systems Theory

Some of the central ideas of NDS are attractors, bifurcations, chaos, self-organization, and complex adaptive systems. Many of these ideas were introduced to the behavioral sciences in the late 1970s and have since become influential in psychological research (Gregson & Guastello, 2011). The basic concepts are described below briefly.

Attractors. NDS tends to speak of attractors rather than control mechanisms. Attractors are spatial structures that characterize the motion of points when they enter the space (Gregson & Guastello, 2011). They can be seen as a box of space in which movement could take place or not (Guastello & Liebovitch, 2009). In a sense, the attractor acts as a magnet that exerts a pull on the system such that when an object enters the space, it does not leave unless a force strong enough pulls it out. Three common varieties are the fixed-point, limit cycle, and chaotic attractors.

Fixed-point attractors are ones in which when an object enters the space it gravitates towards and remains at a fixed point (Guastello & Liebovitch, 2009). Limit cycle attractors are also known as periodic attractors and are oscillations (Gregson & Guastello, 2011). Its behavior is cyclic; in the same way the earth orbits the sun or the moon the earth (Guastello & Liebovitch, 2009). As with any attractor, once an object enters the range of its pull, it does not leave (remember an attractor is like a magnet); however, unlike objects gravitating toward a fixed-point attractor, objects drawn into the limit cycle attractor do not get pulled toward the epicenter but rather oscillate around it. Chaotic attractors, like the previous attractors discussed, are points that are pulled into and stay within a space; however, unlike the previous attractors, they are allowed to move

about within the space and their motion within the space is more complex; moreover, the typical chaotic attractor is operating in more than two dimensional space.

Additionally, a chaotic attractor exhibits two characteristics in a time series. First, there is a structurally stable attractor basin, which is the effective range in which attractors can draw in objects (Gregson & Guastello, 2011; Guastello & Liebovitch, 2009); as such, all trajectories within the attractor are performing to the same rules. Second, there is also a firm but permeable boundary to the basin; As such, objects may enter if they veer close enough; however, when they do enter, they follow the same chaotic regimen as the other objects inside the attractor.

Chaos. Chaos theory is perhaps the best-known concept in NDS. In order for something to be labeled chaotic, three main features must be present: unpredictability, boundedness, and sensitivity to initial conditions (Kaplan & Glass, 1995). First, behavior patterns of chaotic systems must be unpredictable; that is, they do not repeat (Guastello & Liebovitch, 2009). However, the property of non-repetition is a matter of degree (Gregson & Guastello, 2011). Second, behavior of chaotic systems is bounded. That is, despite all the unpredictability of motion, all points remain within certain boundaries. Third, chaotic systems display sensitivity to initial conditions. Essentially, two points that start off arbitrarily close together become exponentially farther away from each other, as the iteration process continues, which is the hallmark of chaos. Chaotic motion is characterized by both expansion and contraction; that is, if the object veers too close to an attractor it is pulled inside. If it gets too close to the center it steers outward.

Bifurcations. According to Nicolis and Prigogine (1989), a bifurcation is a pattern of instability in which a system gains greater complexity by accessing new

dynamical states; in other words, a bifurcation is a change from one type of dynamics to another (Gregson & Guastello, 2011). For instance, an attractor can change from a fixed point to a limit cycle attractor (Guastello & Liebovitch, 2009). When bifurcations occur, the analyst is looking for critical points where the dynamics change; that is, when the value of a control parameter is changed beyond a given threshold. The critical point can be as simple as a single point, or it could be a more complex pattern.

Self-organization. Living systems do not live in a state of chaos for very long; they self-organize (Guastello, 2009). According to Prigogine and Stengers (1984), self-organization is a process that occurs when a system is in a state of high disorder and takes on a structure that allows the system to operate more efficiently. Systems self-organize by building feedback loops among the subsystems and across the system to the environment in which they are nested (Gregson & Guastello, 2011). Feedback loops can be either positive or negative and control and stabilize the system. Positive feedback loops facilitate growth, development, or radical change in the extreme, whereas, negative feedback loops have the net effect of inhibiting change. Indeed, it is accepted among experts that all forms of self-organization rely on information flow (Haken, 1988). Over time, these systems can become more complex or less complex (Prigogine & Stengers, 1984).

According to Kauffman (1993, 1995), change in systems is most likely to occur, if the system exists at the edge of order and chaos, since it is at this point that systems allow for more efficient use of information. Systems at the edge of chaos are thought to be at the phase shift between the static region and chaotic region. A phase shift results from

the formation of new internal structures in the system and is similar in principle to the change of ice to water or water to vapor (Gregson & Guastello, 2011).

Systems in near static region are less likely to experience change, because they are typically unresponsive to information (Koopmans, 1998). In other words, they are frozen and little information is accepted from the environment and shared within the system. Systems in the chaotic region are very responsive to the environment, only they are too disordered to provide stability (Ward, 1995). At the edge of these two extremes, there is sufficient sharing of information necessary for change and sufficient structure to ensure stability and continuity (Kauffman, 1993, 1995). The self-organized, emerging system is more complex and adaptive than its previous state, and once a system has evolved to a more complex state, it is irreversible (Prigogine & Stengers, 1984); or as they write, once you scramble an egg, you cannot unscramble it.

Complex adaptive systems. A complex adaptive system (CAS) is a living system that maintains a readiness to adapt to new situations (Gregson & Guastello, 2011). Regardless of the reason a system might have self-organized, complex adaptive systems are characterized by the potential to undergo self-organization spontaneously (McDaniel & Driebe, 2005); that is, it is ready to adapt to the environment at a moment's notice. According to complexity theory, systems are often in a state far from equilibrium to be open to change and to be capable of restructuring without necessarily being turbulent nor even returning to stability (Koopmans, 2009); that is, at the edge of chaos (see Kauffman, 1993). When it adapts, it reorganizes its communication, feedback, or workflow patterns to respond to the new situation (Gregson & Guastello, 2011). In other words, CAS describes the adaptive behavior of living systems as self-organizing.

Complex adaptive systems focus on larger systemic outcomes of local interactions among agents (Koopmans, 2009). Complex adaptive systems are composed of a large number of agents that are essentially information processors (McDaniel & Driebe, 2005). These agents are diverse from each other and exchange information among themselves and with their environment to adjust their own behavior as a function of the information they receive (Holland, 1995; Kauffman, 1995). Relationships among agents in the CAS are nonlinear and the effect of any one agent's activity can inform itself as well as influence other agents (McDaniel & Driebe, 2005).

Often the focus of CAS is on how the actions of lower level agents within a system result in the emergence of order in the exchange of information and energy at a higher systemic level (Koopmans, 2009). Many actions of a living system harbor a modicum of variability in their execution (Gregson & Guastello, 2011). The variability is not error; rather, it serves the purpose of permitting adaptation when necessary. Greater levels of entropy in behavior would characterize a healthy CAS, whereas, less entropy, or more rigidity and stereotypic behavior would characterize a less functional system.

NDS Theory and Psychopathology

Over the decades, NDS has been applied to most domains of psychology: neurosciences (Freeman, 1979), learning theory (Skarda & Freeman, 1987), psychophysics (Gregson, 1992, 1995), perception (Stewart & Peregoy, 1983), cognition (Goertzel, 1993), memory (Clayton & Frey, 1996), and clinical psychology to name a few. However, NDS' use within psychopathology is a recent development (Tschacher & Junghan, 2009), despite that the framework of NDS appears to offer an efficient and theoretically sound analysis of adaptive and maladaptive interactions (Lunkenheimer &

Dishion, 2009). Much of the focus has been on developmental psychopathology and the dynamical disease concept.

Developmental psychopathology. According to the principles of developmental psychopathology, human behavior is determined by multiple influences that interact (Sameroff, 1995). A primary aim of developmental psychopathology has been the study of individual differences in children's maladaptive developments; as such, much of the research has observed negative interactions in family relationships (Lunkenheimer & Dishion, 2009). For instance, studies have illustrated the importance of negative parental influences on children's development of anxiety (Barrett et al., 2002; Hudson & Rapee, 2000; Siqueland, Kendall, & Steinberg, 1996); however, like all linear analyses, important properties of the relationship as an evolving and changing system are largely missed.

NDS theory, which frames development as being governed by the principles of self-organization, has been applied to the study of relationship influences on the development of psychopathology. For instance, Thelen and Smith (1994) argued that developmental changes are novel and that the novelty emerges from within the system itself by way of self-organization. Studies exploring group dynamics using NDS principles have indeed found that interpersonal relationships were characterized by the type of patterning observed in self-organizing systems (Guastello, 2000; Guastello, Hyde, & Odak, 1998; Pincus, 2001; Pincus & Guastello, 2005).

In particular, Thelen and Smith (1994) argued that all developmental acquisitions can be described as attractor patterns that emerge over time. As such, the attractor principle has been useful in the study of relationship influence on the development of

psychopathology, in which the attractors shapes the available range of behaviors (Lunkenheimer & Dishion, 2009). For instance, in relationships, an attractor is a tendency for a relationship to get stuck in exchange patterns that occur over time. That is, the attractor represents recurrent behavioral patterns that eventually stabilize and become increasingly predictable (Hollenstein, Granic, Stoolmiller, & Snyder, 2004). With repeated exposures, interactions become stronger attractors making it more difficult to induce change and causing systems to become more organized and predictable. Indeed, the relationship between the child and the environment is active and self-organizing and stability is found in the processes by which traits are upheld by transactions between the child and the environment, which has been demonstrated using state space grid methodology (Lunkenheimer & Dishion, 2009).

According to NDS, a state space is used to reflect the range of behaviors for a given system. Essentially, behavior moves along a trajectory in the state space in real time and is pulled toward certain attractors and away from others (Lunkenheimer & Dishion, 2009). A key feature of self-organizing, dynamic systems is that they have the potential to exhibit an enormous number of behavioral patterns. However, they tend to stabilize in a limited range of these possibilities, referred to as attractors. The extent to which the interaction is organized and predictable versus chaotic and unpredictable is captured through state space grid methodology computation of entropy (Lunkenheimer & Dishion, 2009).

A study by Granic and Dishion (2003) examining deviant talk as an attractor suggests that children who are spending more time engaging in deviant talk in childhood are also those who are most likely to be committing delinquent acts and associating with

deviant peers during these early years. Interestingly, the average duration of deviant talk did not provide information about who will be most at risk for developing future antisocial behaviors; rather, it was those for whom deviant talk was an attractor who were more likely to later engage in antisocial behaviors and develop problems with drug abuse. Similarly, in another study, if males were both organized (low entropy) and engaged in high levels of deviant talk, their continuing antisocial behavior into adulthood was particularly high (Dishion, Nelson, Winter & Bullock, 2004). Taken together, these studies suggest that negative interactions appear to have a distinct and powerful organizing function.

Dynamical disease. Physicians have long recognized the importance of investigating the temporal dimensions of an illness when diagnosing and creating treatment strategies (Bélair, Glass, an der Heiden, & Milton, 1995). To address the abnormal temporal patterns of illness, physiologists Glass and Mackey (1988) proposed the idea of a dynamical disease. The dynamical disease approach is a direct application of NDS to mental disorders (Tschacher & Junghan, 2009). A fundamental property of living systems is that their dynamics are sensitive to small changes. As such, dynamical disease refers to when normal organization breaks down and is replaced by abnormal dynamics or abnormal temporal organization.

The abnormal dynamics stem from modifications in the control parameters (Nandrino et al., 2005) and are associated with periodic behavior, which suggests that dynamic complexities may be the norm rather than the exception in living systems (Glass & Mackey, 1988). Moreover, pathological behaviors emerge out of healthy behavior by way of a phase transition between two dynamical regimes and is not a property of the

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According to Glass and Mackey (1988), three types of qualitative changes are possible. First, variables that are constant or undergoing relatively small-amplitude “random” fluctuations can develop large-amplitude oscillations that may be more regular or less regular. Thus, there may be the appearance of a regular oscillation in a physiological control system not normally characterized by rhythmic processes. Also,

new cycles can arise in an already recurring process. Finally, rhythmic processes can disappear and be replaced by relatively constant dynamics or by periodic dynamics. (Although all types have been observed and written about, the third type of qualitative change is the focus of this study; as such, it will be the focus of the discussion.)

Dynamical changes have been observed in diverse conditions such as cardiac and neurological disorders (Tschacher & Junghan, 2009). For instance, a healthy person with a structurally normal heart will display considerable amounts of fluctuations in heart rate, whereas a decrease in heart rate variability has been observed in patients at risk of sudden death after surviving an acute myocardial infarction (Kleiger, Miller, Bigger, & Moss, 1987), and in patients with left ventricular malfunction (Myers, Martin, Magin, Benett, Schaad, Weiss et al., 1986), congestive heart failure (Casolo, Balli, Fazi, Gori, Freni, & Gesini, 1991) and coronary artery disease (Casolo et al., 1991; Hayano et al., 1990). Indeed, Goldberger and colleagues (Goldberger, Bhargava, West, & Mandell, 1985; Goldberger, Rigney, Mietus, Antman, & Greenwald, 1988) have concluded that ventricular fibrillation and sudden death are not chaotic rhythmic patterns, but rather periodic such that symptoms or rhythmic patterns are predictable and recur regularly over time with little variability in the pattern; that is, unhealthy hearts operate very near equilibrium. More, this loss of variability in heart rate can be seen in patients anywhere from minutes to months before sudden death (Goldberger et al., 1988). Thus, healthy hearts are those that function far from equilibrium or in an adaptive state of instability; however, the role of greater complexity in Goldberger et al.'s research mean a loss of coherence rather than chaotic dynamics.

Mood disorders and schizophrenia have both been viewed from the dynamical disease perspective (Tschacher & Junghan, 2009). For instance, in a series of studies examining the dynamics of behavior sequences over time in schizophrenia patients using nonlinear dynamic systems methods, Paulus and colleagues (Paulus, Geyer, & Braff, 1994, 1996, 1999a; Paulus, Perry, & Braff, 1999b; Paulus, Rapaport, & Braff, 2001), using a simple choice task demonstrated by way of dynamic entropy that the response sequences generated by schizophrenia patients showed a higher degree of interdependency and at the same time were less consistent in the selection and ordering of responses compared to controls. In other words, they found that schizophrenia patients generate a sequence of choices that are both highly predictable and unpredictable during the same test session; however, compared to controls the response choices of schizophrenia patients were significantly more predictable. As such, healthy (flexible) behavior and unhealthy (fixed) behaviors coexist in schizophrenia patients at the same time.

In another study examining the dynamics of schizophrenia, Tschacher, Scheier, and Hashimoto (1997) investigated whether psychotic episodes could be considered as a dynamical disease. They classified time series data obtained by observers' daily ratings of psychotic symptoms over 200 or more consecutive days. Using a nonparametric algorithm, they found that eight of 14 participants showed a nonlinear time course in their symptoms. They reported intermittent changes in positive and negative symptom status that resulted in long-range temporal correlations of symptom profiles across time. The existence of long-range temporal correlations is consistent with the organization of temporal behavior found in complex adaptive systems.

Another type of study investigated the temporal organization of linguistic production in persons with schizophrenia using dynamical methods. Leroy, Pezard, Nandrino, and Beaune (2005) studied 10 participants with schizophrenia and matched control participants. Participants read a short story aloud and then were asked to recall its plot immediately. Speech production was encoded into sequences of discrete symbols, which were then studied using dynamical entropy methods. They did not find a difference between patients with schizophrenia and the control group in the global complexity of their recall. However, significant differences in organization of the transition between propositions were observed such that patients with schizophrenia connected more basic ideas within a sentence more often than control participants. As such, patients with schizophrenia display a dynamical trend to connect basic ideas within sentences one after the other, which may suggest impairment in the ability to inhibit nonessential responses and a deficit in maintaining rather than in generating a linguistic discourse plan.

Pezard et al. (1996) used nonlinear systems approach to the analysis of electroencephalograms (EEG) of depressed patients and attempted to relate these to symptoms. They identified different EEG dynamics in both first-episode depressed persons and participants with recurrent depression compared with control participants. In the first recording session, first-episode patients have a lower entropy. Moreover, within the first-episode group, a decrease of entropy and of stationarity in brain dynamics was observed during the depressive episode, suggesting that dynamical changes are unstable in first-episode patients. At day 21, however, predictability in brain dynamics for the first-episode depressed persons shifted toward normality (entropy increased) in that their

level of prediction could no longer be differentiated from control participants, whereas the predictability of participants with recurrent depression remained at its initial levels.

Consistent with Pezard et al.'s finding of decreased chaotic dynamics in the brains of depressed individuals, a time series study that employed Lyapanov exponential analyses of heart rate variability in depressed patients and controls found a general decrease in cardiac vagal function, which suggests that depressed persons exhibit a decrease in the normal, chaotic dynamics exhibited by healthy hearts (Yeragani et al., 2002).

Heiby et al. (2003) examined depressed mood over time in two participants. Two women recorded their mood every hour 10 times per day for six months. Spectral exponents were analyzed to determine the existence of deterministic or random processes. Their data showed the existence of pronounced periodicity in the depressed participant's mood, as well as a possible chaotic process operating, whereas the non-depressed control participant's results suggested that randomness was the dominant structural component of the time series. Their results suggest that people suffering from recurrent depression exhibit maladaptive determinism with possible chaotic components in their mood state fluctuations. Their results are similar to other studies that found supportive evidence of chaotic structure for bipolar disorder. However, like Goldberger et al.'s findings it may also suggest that increased complexity may mean a loss of coherence.

In an attempt to uncover evidence of an attractor in bipolar disorder, Gottschalk, Bauer, and Whybrow (1995) studied a time series of mood records in seven rapid-cycling bipolar patients and 28 control participants. Nonlinear analysis time series data

demonstrated that the mood variations observed in bipolar patients was distinct from the control participants, although not periodic. However, a greater degree of organization was present in the time series from the bipolar patients, which was indicated by the appearance of the raw time series, by the corresponding phase space reconstructions, and their power spectra. Moreover, the broadband nature of the spectra observed in both groups was consistent with chaotic behavior. Even though their data did not find true cyclicity, they found that self-rated mood in bipolar disorder is significantly more organized compared to control participants and can be characterized by the presence of a low-dimensional chaotic attractor.

To date the dynamical disease concept has predominantly focused on the field of schizophrenia and mood disorder research. A literature search did not find evidence of OCD having yet been studied as a dynamical disease; however, Szechtman et al.'s (1998) study of ritual-like behavior in rats may suggest that OCD could be characterized as a dynamical disease, since they found that rats injected with the dopamine agonist quinpirole engaged in ritual-like behavior and that this behavior over time trended toward periodicity. Even though their study suggests that OCD could possibly be regarded as exhibiting characteristics of a dynamical disease, their findings are limited in their generalizability to humans, since one cannot be certain that the ritual-like behaviors measured in their rats were truly characteristics of human checking. Moreover, true cyclicity was not present and their data only showed a trend toward low dimensional chaotic processes. One could speculate that were a study to examine ritual behavior in humans that occur without being chemically induced that the data could exhibit true cyclicity. Regardless, it does suggest that there is a need to study OCD using nonlinear

techniques to examine compulsions over time with human participants to uncover possible attractors of compulsive behavior and chaotic dynamics.

Such an undertaking might be difficult, since researchers would not be able to directly observe and record humans in their natural environment without being somewhat intrusive. Moreover, it has been observed that compulsive behavior is often limited to the home (Rapoport, 1989). As such, attempts to uncover predictability of behavior over time with OCD participants in a laboratory setting may prove challenging. Also, it is not sufficient to find or simply state that chaotic dynamics are present. Any nonlinear model of OCD that is developed must attempt to understand the meaning of the chaotic processes and how interactions within dynamical systems affect psychopathology.

The Current Study

One goal of this study is to investigate the chaotic processes of OCD in humans. Time series analyses of ritual behavior would show evidence of abnormal temporal organization across time such that the behavior of participants with OCD will be less complex (low entropy) and more predictable than the behavior of individual controls without OCD. Rather than simply finding whether chaotic processes are at play in OCD, this study also has as an overlapping goal to test the assumption that FA and EE likely play an important role in explaining some of the abnormal temporal patterns such that FA and EE may behave as attractors for OCD rituals.

By studying OCD as a dynamical disease, it is hoped that the temporal nature of the dysfunction can be better understood. Since rituals are often limited to the home, this study utilized creative ways to capture behavior as it occurs over time. Likewise, the Lyapunov exponent was computed to determine the level of chaos in the data.

Time-Diary Method

To capture rituals as they occur over time, the time-diary strategy was used in this study. In the time-diary method, participants are able to provide complete accounts of what they do on a particular day, exactly how much time was spent on particular activities, what activities were going on around them, and how they felt about these activities. There are advantages of the time-diary method (Robinson, 1999). First, it allows participants to structure their day as they normally would thereby avoiding the artificial manipulation of behavior in a research setting. Second, it provides responses by participants that are in their own words. Third, when data are recorded and accumulated

over time (e.g., one week), time-diaries can provide an impressive amount of data for measuring how people spend their time; for instance, several hundred data points could be collected for each participant depending on how many days data were collected. Finally, time-diaries are reliable in that they produce consistent results that can be corroborated by observational data (Robinson, 1999).

Despite these advantages, the time-diary method is not without limitations (Robinson, 1999). The time-diary only reflects what a participant is willing to share; that is, reports of behavior can be distorted or intimate behaviors can be omitted. This, however, is true of any psychological study relying on a participant's self-report. Also, there can be differences in the level of detail; for instance, some time-diary accounts may be very descriptive, whereas others may say almost nothing at all. Finally, time-diaries only capture a limited amount of time in a participant's life (Robinson, 1999). That is, it is not known what happened the day before the data collection began or what happens after the data collection ends.

Nonetheless, time-diary methods offer a unique opportunity to collect data easily with participants over longer periods of time. What is arguably more important, time-diaries have been used successfully in psychology and have been shown to provide valuable information. For instance, Larsen and Kasimatis (1991) had participants record over time the occurrence rate of symptoms, the duration of symptoms, and the covariation of symptoms and mood. By doing so, they were able to successfully model different aspects of the temporal course of illness, examining patterns of day-to-day fluctuations between health and illness and their relationship to personality.

Because of the temporal nature of the data collected through the time-diary method, it seems perfectly suited for use in NDS. Indeed, scholars interested in nonlinear dynamics have successfully uncovered the chaotic dynamics using a time-diary method. For instance, in an attempt to measure the dynamics of motivation, Guastello, Johnson, and Rieke (1999) used an activity log and found that intrinsic motivation to perform certain tasks exhibited chaotic dynamics of irregular periods of high and low intrinsic motivation. Additionally, Navarro and colleagues (Navarro & Arrieta, 2010; Navarro, Arrieta, & Ballén, 2007) also used the diary method to successfully uncover chaotic dynamics to work motivation. Indeed, they found that motivation was not a stable process and that it never seems to reach a state of equilibrium.

In a health care application, Burton, Heath, Weller, and Sharpe (2009) used a diary method to collect time series data of self-reported medically unexplained somatic symptoms. Using the diary method, they found that low entropy in physical symptoms, suggesting that loss of complexity is a characteristic of illness. That is, abnormal bodily sensations are not reactions to random, unpredictable external events; and even though patients typically report that their symptoms are unpredictable or even chaotic, their reported symptoms showed significantly reduced entropy compared to surrogate data. Besides finding support for the dynamical disease concept of physical illness, their study shows that the diary method is an especially promising and viable tool for potentially monitoring OCD symptoms over time to explicate any low dimensional chaotic processes in ritual behaviors and what attractors of ritual behavior may exist.

As such, the time-diary structure allows for a dynamical analysis of each activity history, as well as some second-level data on individual differences in dynamical

outcomes. Moreover, the time-series data collected through a time-diary allows for an expansion of the relationship between the ritual and the time spent on an activity. Moreover, by recording societal reactions to rituals, it may be possible to explicate some external forces that may help govern the amount of time spent ritualizing. Additionally, use of a time-series design rather than a subject-based and static design has the following advantages. First, it increases statistical power. Second, it allows one to capture information from nearly every dimension of a person's day. Third, the design allows for the identification of possible points of future intervention. Fourth, many psychological phenomena that occur over time are iterative; as such, the iterative function of a time series better allows for the forecasting of future behavioral patterns (Guastello & Liebovitch, 2009). Finally, time series data iterations can lead to the observance of chaotic dynamics, since iterations of linear functions likely never lead to the observance of any chaotic dynamics.

Lyapunov Exponents and Turbulence

Chaotic dynamics vary in complexity, and the Lyapunov exponent is one metric for quantifying this complexity. The Lyapunov exponent measures the amount of divergence present in the attractor dynamics (Kurz, Markopoulou, & Stergiou, 2010; Ruelle, 1991), and is based on the idea of turbulence or entropy (Guastello & Liebovitch, 2009; Guastello, Nathan, & Johnson, 2009). According to Shannon (1948), entropy (unpredictability) is the amount of change in a system over time that cannot be predicted by available information. It is the inverse of information, which means that with increasing entropy there is less information. The Lyapunov exponent reflects the rate at which information that allows a forecast of a variable is lost, with greater entropy

reflecting a faster loss of information (Guastello & Liebovitch, 2009), in other words, chaos.

Chaotic motion is characterized by both expansion and contraction; that is, when a point veers too close to the chaotic attractor, it is pulled inside, whereas, if it gets too close to the center it steers outward (Guastello & Liebovitch, 2009). Moreover, a pattern of folding and expanding takes place within the chaotic attractor itself and the folding and expanding movement forms the basis of the Lyapunov exponent that is used to assess the level of turbulence in the attractor (Gregson & Guastello, 2011).

A major turning point in the development of NDS theory was the discovery that the basins of chaotic attractors are fractal, which led to many attempts to calculate the fractal dimension as proof of chaos (Gregson & Guastello, 2011; Guastello, 2011). The presence of a fractal dimension in a time series, however, is only suggestive that chaos may be present, since a system can be fractal without necessarily being chaotic (Guastello et al., 2009). In other words, chaos could be present, but the determination requires the calculation of an indicator of the diverging and converging dynamics, like the Lyapunov exponent.

The strength of the Lyapunov exponent is that it can distinguish chaotic and non-chaotic time series and converts to a fractal dimension (Guastello et al., 2009); as such, the Lyapunov exponent is better suited for the determination of chaos (Guastello, 2011). If the Lyapunov exponent is positive, one has a better case for chaos. Larger values of the Lyapunov exponent reflect greater amounts of instability in the attractor dynamics (Kurz et al., 2010), whereas a Lyapunov exponent closer to zero suggests the presence of

an aperiodic attractor. If it is negative, dampened oscillations and fixed point attractors are denoted.

Hypotheses

The current study of the dynamic properties of OCD was conducted to evaluate the following hypotheses. (1) There will be a linear relationship between the amount of time the patient spends on a ritual task and the level of reported distress caused by the family reaction. Specifically, it is predicted that the more distress individuals experience in response to the family reaction the more rituals they would perform.

(2) There will be a linear relationship between the number of reported family reactions and OCD symptoms of OCD as measured by the Yale Brown Obsessive Compulsive Scale. It is predicted that the more instances of family reactions recorded would be related to greater severity in OCD symptoms.

(3) Expressed emotion exhibited by the family environment will have a stronger correlation with distress to the family reaction, whereas accommodation by the family environment will correlate with less reported distress.

(4) Expressed emotion will better predict the duration of time spent performing a ritual than will FA.

(5) The time series of all participants with OCD without considering the family reactions will manifest characteristics of chaotic dynamical disease, such that their time series will follow a lower-dimensional deterministic structure, denoting greater rigidity, when compared to controls; consequently, the exponential model will fit the OCD participants, but not the controls. To be specific, it is hypothesized that symptom severity, as measured by the Yale Brown Obsessive Compulsive Scale, will positively correlate with the nonlinear regression (NLR) parameters and Lyapunov exponents

calculated for all OCD participants without considering family reactions and for OCD participants when factoring in the effects of family reactions, such that greater symptom severity would moderate the regression parameter values and decrease turbulence.

In addition, it is hypothesized that the time-series data of individuals with OCD who have recorded family reactions would manifest characteristics of chaotic dynamical disease, such that their time series will also follow a lower-dimensional deterministic structure. It is further predicted, moreover, that the regression parameters and Lyapunov exponents calculated for OCD participants with family reactions would be greater, when compared to the regression parameters and Lyapunov exponents calculated for all OCD participants without considering family reactions.

(6) The overall accuracy of the nonlinear model would be greater than that of the linear model for all OCD participants' time series. Moreover, the nonlinear model will also be superior to the linear model when factoring in the family reactions recorded. In other words, the nonlinear model would explain more of the variance than would the linear model.

(7) Using a Spearman rank order correlation coefficient, the NLR parameters and Lyapunov exponents calculated for each participant would be correlated with reported family reactions and emotional responses to the family reaction. It is predicted that greater family reactions and emotional responses to family reactions will moderate the regression parameters and decrease the complexity of the data.

Method

Participants

OCD participants. A total of 18 participants (after initial screening) with OCD volunteered for this study. Of these, one withdrew. Of the total number of participants, 4 were male and 13 were female. Three participants were Hispanic and 14 were Caucasian. Two of the Hispanic participants were native Spanish speakers; however, both were bilingual. Considering that Spanish was the first and primary language of the home, when possible forms and measures were translated into Spanish. All OCD participants were individuals with a primary diagnosis of OCD according to the Structured Clinical Interview (SCID-I/P W/ PSCHOTIC SCREEN; First, Spitzer, Gibbon, & Williams, 2002) for the Diagnostic and Statistical manual for Mental Disorders (4th ed.; DSM-IV; American Psychiatric Association, 1994) and Yale Brown Obsessive Compulsive Scale (YBOCS) score greater than seven (Goodman et al., 1989a; Goodman et al., 1989b). (When necessary the assistance of a native Spanish speaker for translation purposes was used.)

They were referred to this study by local therapists who treat OCD in their private practice or were undergraduate student volunteers or volunteers from the community with a confirmed diagnosis of OCD. Participants with OCD were excluded if they met current criteria for or had a history of psychosis, met current criteria for alcohol or substance dependence, or reported evidence, though rare, of organic etiology of the disorder (e.g., head injury). They were included in this study if they had overt compulsions, had symptoms for at least six months, were at least 18 years old but not older than 60 years of

age, and were married or cohabiting (with or without children) or single and living with their parent(s) or legal guardian(s). (If participants with OCD were single and lived alone, they were included in the study, and their data were used for the nonlinear dynamic analysis of the logbooks.) Prior psychological or medical treatment for OCD was not a criterion for exclusion. Participants with OCD were paid 25 dollars for their participation; however, student volunteers with OCD were provided with either extra credit or payment. Table 1 presents the demographic distribution of the sample.

Insert Table 1 about here

Controls. The control group consisted of 50 undergraduate psychology students at a Midwestern university. Two participants were excluded due to alcohol or substance abuse history, and one participant was excluded due to requiring immediate attention for suicidal ideation. A total of 47 students completed the study. Of these 11 participants were male and 36 were females. Forty-three were Caucasian, two were African American, one was East Indian, and one reported Other. These volunteers were obtained through class announcements that promoted extracurricular participation in research for the purposes of obtaining extra credit. Undergraduate volunteers were excluded from the study if they met current diagnostic criteria for anxiety disorder, major mood disorder, eating disorder, alcohol or substance dependence/abuse, and/or psychosis.

Data from 16 controls were used in the analysis after being matched to OCD participants using gender, habitation (e.g., alone, with spouse, etc.), and OCD symptoms as matching criterion. First, participants were matched based on gender. Males were

matched with males and females were matched with females. Second participants were then matched based on habitation. For example, as often as possible, OCD participants who lived with their family of origin were matched with control participants who also lived with their family of origin. Last participants were then matched based on symptoms endorsed on a questionnaire. For example, OCD participants who endorsed washing symptoms were matched to control participants who endorsed washing symptoms, albeit to a much lesser degree. If control participants and OCD participants shared more than one OCD symptom concern, the match was based upon the more prominent symptom. For example, if participants had both washing and checking concerns and checking concerns were rated higher than washing, then participants were matched for checking rather than washing. (Seventeen controls were matched. However, data from one control participant were obtained while the participant was on vacation. Because the data did not reflect a typical week for the participant, the data were excluded from the analysis.)

Control participants who completed the 7-day logbook received extra credit toward their course grade regardless of whether their data were used in the analysis. Undergraduate volunteers who met the exclusionary criteria obtained partial credit based on the duration of their participation. Table 1 presents the demographic distribution of the control sample.

Materials

The *SCID-I/P W/PSYCHOTIC SCREEN*. The *SCID-I/P W/PSYCHOTIC SCREEN* (from now on referred to as *SCID*) is a semi-structured diagnostic interview used to assist in making reliable DSM-IV diagnoses (First et al., 2002). It was designed

for use with patients in settings in which psychotic disorders are not expected, or in studies in which psychotic disorders are being screened out. The inter-rater and test-retest reliability for Axis I disorders is quite good. Test-retest κ for Axis I disorders has been shown to range from .35 to .78 ($N = 52$) and the interrater κ has been shown to range from .57 to 1.0 (Zanarini, et al., 2000). For OCD, the interrater and test-retest κ has been shown to be in the fair to good range (.57 and .60, respectively; Zanarini et al., 2000).

Obsessive-compulsive symptom inventory. To help match participants by similar OC symptom experiences, the Obsessive-Compulsive Inventory – Revised (OCI-R; Foa et al., 2002b; see Appendix A) was administered. The OCI-R is an 18-item, self-report questionnaire for assessing symptoms common to OCD. Items are rated on a five-point Likert scale. The OCI-R is composed of six subscales: (a) Washing, (b) Checking, (c) Ordering, (d) Obsessing, (e) Hoarding, and (f) Mental Neutralizing.

The psychometric properties of the OCI-R were examined in a sample of patients with OCD, generalized social phobia, and posttraumatic stress disorder, and a nonclinical student sample (Foa et al., 2002b). They found that the measure has good to excellent internal consistency across sample populations for the total score (α s ranged from .81 to .93) and across patient populations for all six subscales (α s ranged from .76 to .90). Good internal consistency was reported for nonclinical controls for five of the six subscales (α s ranged from .65 to .89). The OCI-R was also found to have excellent test-retest reliability for the total score and subscales for patients with OCD (r s ranged from .74 to .91) and good to excellent test-retest reliability for the total score and subscales for nonclinical controls (r s ranged from .57 to .87).

The OCI-R showed high correlations between the Washing and Checking subscales with the corresponding subscales of the Maudsley Obsessive-Compulsive Inventory (Washing: $r = .78$; Checking: $r = .72$) and a moderate correlation between the OCI-R Obsessing subscale and the YBOCS Obsession score ($r = .51$; Foa et al., 2002b). The OCI-R was translated into Spanish to assist native Spanish speakers participating in this study (see Appendix B). See Table 1 for descriptive data for OCD and Control participants.

Activity log. To measure the temporal structure of overt compulsions and perceived family reactions to these compulsions over time, the data collection strategy used in this study was inspired by the daily logbook techniques used by Csikzentmihalyi (1990) and Guastello et al. (1999).

The logbook technique permits both a dynamical analysis of ritual activity and an analysis of individual differences in dynamical outcomes. Participants recorded in a 7-day logbook (see Appendix C for a sample page of the logbook): daily activities that lasted at least 15 minutes; the amount of time spent performing rituals; and perceived family reactions to the compulsive behavior. Each page of the logbook was composed of six columns and approximately 17 rows and had approximately 68 boxes within which participants could record information. The columns were labeled: Time, Day, Activity, Ritual, Reaction, and Response. (For data analysis, two additional columns were added: Ritual Saturation and Emotional Saturation.) The Time and Day column were prerecorded for participants. Time intervals ascended in 15-minute increments, with each page containing a total of eight hours for a total of approximately 38 pages.

Measure of OCD symptom severity. To assess symptom severity, the Yale-Brown Obsessive Compulsive Scale (YBOCS; Goodman et al., 1989a; Goodman et al., 1989b) was administered. The YBOCS is a 10-item, clinician-rated scale. Information is obtained by way of a semi-structured interview. Symptom severity is determined by: (a) how much symptoms occupy the patient's time; how much symptoms interfere with normal functioning; (b) how much subjective distress the symptoms cause; (c) how actively symptoms are resisted; and (d) the degree to which patients can control the symptoms (Goodman et al., 1989b). Items are rated on a scale ranging from 0 (no symptoms) to 4 (extreme symptoms). Higher scores correspond to greater illness severity. The total YBOCS score can range from 0 to 40, with mild to moderate symptoms ranging from 10 to 20, moderate symptoms ranging from 20 to 30, and severe symptoms ranging from 30 to 40 (Goodman et al., 1989b).

The 10-item YBOCS is a reliable scale for assessing symptom severity. A study by Goodman et al. (1989b) found the interrater reliability to be excellent ($N = 4$, $r = .98$, $p < .0001$). They also reported good internal consistency ($N = 4$, $\alpha = .89$, $p < .0001$). The YBOCS also has good convergent validity with other OCD scales. Another study by Goodman et al. (1989a) found the YBOCS to be highly convergent with the National Institute of Mental Health Global Obsessive Compulsive Scale ($r = .67$, $p < .001$) and the CGI-Obsessive Compulsive Scale ($r = .74$, $p < .0001$). If needed, a Spanish translator was used to assist with the administration of the YBOCS to native Spanish speakers. See Table 1 for descriptive data for OCD and control participants.

Procedure for Participants with OCD

Before continuing with the study, participants with OCD were briefed about the procedures of the study and what the study entailed. After the procedures were explained, those who wanted to continue with the study were required to provide written, informed consent, which was provided in English and Spanish (see Appendix D and E). After giving their informed consent, OCD participants completed a demographics questionnaire (see Appendix A and B) and the OCI-R.

Selection of and procedures for OCD participants. After completing the questionnaire and the OCI-R, OCD participants were interviewed using the SCID to determine whether they met DSM-IV criteria for OCD and to rule out other diagnoses and exclusionary criteria. Those participants who met the criteria for inclusion were given the option to continue with the study. Those participants agreeing to continue with the study were administered the YBOCS to obtain information about the content and severity of the OCD symptoms. Participants were also interviewed about the family environment. Next, participants were given the 7-day activity logbook and instructed on its use.

After OCD participants were instructed on how to complete the logbooks, they scheduled a time to meet the researcher and return the logbooks. At that time, participants were debriefed about the study and any questions they had were answered. Participants also reviewed aspects of their logbook with researcher to ensure accuracy in coding data later, which permitted the researcher time to clarify any activities that may have been unclear. For instance, logbook 105 described what task was being performed. During the exit interview logbook 105 was able to share that these behaviors reflected

rituals, which was consistent with the information gathered during the initial interview. Additionally, participants were able to share events that occurred during the week that they perceived as atypical. For instance, logbook 108 shared with the researcher that the family member who most often reacted to rituals was away during the week activities were recorded.

Procedure for recording activities. All participants were asked to complete a 7-day log of daily activities, daily ritual saturation, perceived family reactions, and their emotional response to any family reactions. First, participants were told how to log their daily activities. Participants were instructed to record throughout the day in as few words as possible each activity they performed for 15 minutes or more. To simplify the process, participants were told to think of a general activity rather than minute tasks. For example, rather than record individual tasks like getting toothbrush, putting toothpaste on toothbrush, brushing teeth, putting on pants, etc., participants could simply record “preparing to leave for work” or “getting ready” in the logbook. To assist participants, a list of possible activities was provided in both English and Spanish (see Appendix F and G, respectively). However, participants were instructed that they were not confined to only recording activities that appeared on the list. In order to improve the accuracy of recording, participants were instructed to record activities on-the-spot (i.e., before beginning or immediately after completing an activity). However, when participants were in situations in which real-time reporting was inconvenient (e.g., at a movie) or redundant (e.g., lasting longer than one hour), retrospective reporting was permitted provided that individuals immediately recorded the beginning time of the activity and the remaining information within 15 to 30 minutes of completing the activity.

To ease the recording process, when participants were engaged in the same activity for 30 minutes or more, a line could be drawn through the succeeding boxes to indicate the continuation of the same task. However, if any new activity was begun while in the middle of an activity, participants were asked to record the new activity as well (provided the new activity was performed for 15 minutes or more). In situations where tasks were not begun exactly on the 15-minute time interval, participants were told to select a 15-minute time increment closest to the actual start time. Whenever participants changed activities, they recorded a new entry in the logbook following the same procedure outlined above.

To illustrate how to record daily activities, the experimenter demonstrated how to complete the activity logbook by reading from a prepared script (see Appendix H). Appendix I presents the Spanish translation of the English text that was used for native Spanish speakers if necessary. If after answering questions the participants still did not understand how to record daily activities, the experimenter created other examples for practice using phraseology similar to the established script.

Variables were coded to reflect the activity descriptions provided to participants by researcher. This was done, because the majority of participants used the activity descriptors contained in the activity list that was provided to them as their activity. In the rare event that participants used their own descriptors, the activity was coded in such a way as to be consistent with the majority of logbooks. For instance, if participants described their activity as praying or at Mass, the activity was coded for data entry purposes as religious activity, which was the description used on the coding list.

Additionally, how to record some information was determined during the exit interview. Data were entered as nominal variables to be used in the analysis.

Procedure for recording ritual. After instructing participants on how to log their daily activities, they were next told how to record rituals. Ritual refers to any compulsive or neutralizing behavior used to reduce anxiety (e.g., washing or checking). Participants were instructed to indicate the number of 15-minute time intervals in which compulsive behaviors occurred. They were told to log this information by simply placing an X or a checkmark in the appropriate box. For example, if any aspect of a ritual was performed during a 15-minute time interval, regardless of the duration in minutes, participants marked a box. Rituals were recorded under two conditions: (a) if participants performed their ritual in conjunction with any daily activity, or (b) if the ritual was the daily activity performed separate from other activities. Participants were told to leave a box in the ritual column blank if no aspect of a ritual was performed.

To illustrate how to record rituals, the experimenter demonstrated how to record rituals by reading from a prepared script. Any questions about recording rituals were addressed. If after answering questions the participants continued to not understand how to record rituals, the experimenter created other examples for practice using the prepared script as a guide. If participants understood how to log rituals, they were next instructed on how to record family reactions.

Procedure for recording family reactions. After participants performed their rituals or whenever applicable (i.e., family members or others were present to witness rituals), participants were instructed to record in their own words how the observers reacted to their compulsions. Participants with OCD were told that there were no right or

wrong answers, because what was recorded was based on their own unique experience. Participants were also told that there was no limit to the number of responses that could be made while a ritual was being performed; and that they did not have to focus on only one specific response, but rather, they should record whatever responses occurred. To assist participants an example of possible family reactions was provided (see Appendix F and G); however, participants were instructed that their recording of family reactions were not limited to what appeared on the list.

If participants recorded multiple responses, they were instructed to designate who was responsible for the reaction. To illustrate how participants were instructed to record family reaction, detailed instructions from a script were read to each participant. Any questions participants had were answered. However, if further clarification was required, the experimenter created other examples for practice using similar language to the prepared script.

Variables were coded in accordance with the family reaction descriptions provided to participants by researcher. This was done, because participants used the reaction descriptors contained in the list that was provided to them. In no case did participants record a family reaction using language that was not contained in the descriptor list. The family reaction data were entered and used as a means to create new variables to be used in the analysis. A discussion regarding how the family reactions were used in the analysis follows later.

Procedure for recording emotional responses. After recording any family reactions, participants were asked to record their emotional response to the perceived family reaction to their ritual. Participants were told to rate their emotional response on a

scale from zero to five, with zero meaning no distress and five meaning there was so much distress that they could not handle it or needed to ritualize. In case participants forgot any details about how to record information, English and Spanish take-home instructions were provided to participants (see Appendix J and K, respectively).

Procedures for Controls

Before going on with the study, controls were briefed about what the experiment entailed. Those who wanted to continue were required to sign and give their informed consent (See Appendix L). After giving their informed consent, control participants who wanted to continue with the study were interviewed with the SCID to determine whether they met the exclusionary criteria. Those students who did not meet the exclusionary criteria were given the option to continue with the study. Those who could not be included due to the presence of a more serious Axis I disorder or suicidality were given partial extra credit and referred to the Center for Psychological Services of Marquette University's Department of Psychology for treatment.

After the SCID was administered, those control participants who did not meet the exclusionary criteria completed a brief demographic questionnaire and the OCI-R. Next, controls were given the 7-day activity logbook and instructed on its use.

Like OCD participants, the controls were instructed to record in as few words as possible each activity in which they engaged provided that the activity lasted at least 15 minutes. Controls were also provided with a list of activities to help in the recording of data; however, they were also told that they were not limited to recording activities that appeared on the list. As with the OCD participants, controls were told to think of general activities rather than specific tasks. They were instructed to record activities immediately

before or after completion of an activity. Retrospective recording was permitted in situations in which on-the-spot recording was inconvenient or redundant, provided that the beginning time of the activity was recorded before beginning the task and the remaining information was recorded within 15 to 30 minutes of completion.

To simplify recording, controls could also draw a line through succeeding boxes to indicate the continuation of a task. In situations where tasks were not begun exactly on the 15-minute time interval, they were told to select a 15-minute time increment closest to the actual start time. Whenever controls changed activities, they recorded a new entry in the logbook following the same procedure outlined above. The experimenter demonstrated how to record daily activities in the logbook by reading an excerpt similar to the one that was read to OCD participants (see Appendix M). Other examples could be created to illustrate how to record daily activities, if questions remained.

The controls were also instructed to record “ritual-like” behavior; that is, the behavior they endorsed on the OCI-R, provided that the behavior was used to decrease anxiety or stress. They were told to indicate the number of 15-minute time intervals in which the ritual-like behavior they endorsed on the OCI-R occurred. (Controls were only asked to record ritual-like behavior if it was performed to reduce distress or anxiety.) They were told to log this information by simply placing an X or a checkmark in the appropriate box. For example, if any aspect of a ritual-like behavior was performed during a 15-minute time interval, regardless of the duration in minutes, participants marked the box in the Ritual column that corresponded to the 15-minute time interval.

As with the OCD participants, rituals were recorded under two conditions: (a) if sub-clinical ritual-like behaviors occurred in conjunction with any daily activity, or (b) if

the ritual-like behavior was the sole daily activity performed for 15 minutes or more. Participants were told to leave a box in the Ritual column blank if no aspect of the sub-clinical ritual-like behavior was performed. Student controls were also asked to log any responses received from family members, roommates, or peers to any ritual-like behavior that occurred in the same manner as outlined for OCD participants above. Also, they were provided a list of examples of family reactions and instructed to think of it as an example and not an exhaustive list of choices. To help control participants remember instructions, they were provided with take-home instructions (see Appendix N).

Analytic Strategy

Descriptive analysis. The first phase of the analysis is the production of a descriptive summary of the data set. Measures of central tendency were computed for demographic variables and the 10-item YBOCS, the OCI-R, as well as the variables created for this study, which will be discussed below. Lastly, frequencies were computed for demographic variable.

Nonlinear analysis. The first phase of the analysis was testing two nonlinear models. Model 1 examined the data of all participants with OCD and was used in the comparison with controls, whereas Model 2 only examined the data of OCD participants who recorded family reactions. Before any calculations could take place that examined the impact of rituals and family members, two new columns for time-series data entry were created and labeled Ritual Saturation and Reaction Saturation.

Ritual Saturation was created by a running average with a lag of 2. If a ritual occurred in a 15-minute time interval, then a 1 was recorded for that time interval, as well as the previous interval. The running average reflected the dynamic depiction of anxiety,

thereby numerically showing a buildup of anxiety and its eventual release. For instance, if rituals were performed in four consecutive time frames, the running average would begin with the 15-minute time interval preceding the first time interval containing a ritual and end with last time interval containing a ritual. If four consecutive rituals were recorded the data entry would be as follows: 1, 2, 2, 2, 1. If no rituals were performed, a 0 was entered for the time interval. As such, if consecutive rituals were recorded across multiple time-intervals, the maximum saturation score would be 2. Therefore, the ritual saturation scores could range from 0 to 2.

Family reactions were converted to time-series data by creating the Reaction Saturation variable. If a family reaction occurred during a 15-minute time interval, the value 1 was assigned to that interval. Unlike Ritual Saturation, a running average was not employed, rather a lag of 1 was employed; therefore, if no reaction occurred in the preceding or succeeding interval, 0 was assigned. Also, if consecutive family reactions were recorded, for each interval containing a family reaction a 1 was recorded. Therefore, the Reaction Saturation variable score could only range from 0 to 1.

The Emotional Response variable was a conversion of logbook responses to a time-series variable. Participants were asked to record their emotional response to the family reaction along a five-point Likert scale with 1 indicating that very little distress or anxiety was experienced and 5 indicating that “a lot” of distress or anxiety were experienced. For each interval that contained a family reaction an emotional response was recorded for that interval. As with Reaction Saturation, no running averages were used. As such, the recorded emotional response was entered for the 15-minute time interval and any time interval that did not contain a recorded emotional response was

recorded as 0. The range of scores for the Emotional Response variable could range from 0 to 5.

After the creation of the time-series variables, this study used analytical techniques and equations developed by Guastello et al. (1999). For each person, data sets for logbook entries were transformed into a time series such that each frame of data pertained to a 15-minute time interval. Daily Activities was the time series dependent measure and Ritual Saturation, which was created for the linear analysis was the independent variable. (See previous discussion of linear analysis for details about the creation of Ritual Saturation.) These variables were used to compute NLR models for exponential expansion, Lyapunov exponent and the test for chaos, and the linear model counterparts. See appendix O for a data entry example of how Ritual Saturation, Reaction Saturation, and Emotional Response variables were prepared for data analysis.

The next step was to transform the time series variable by location and scale. Following procedures outlined by Guastello (2011), the transformed variable was named z_2 to indicate that it is the observation at time 2 such that:

$$z_2 = \exp(\alpha z_1 t) + \beta, \quad (1)$$

where α is the critical Lyapunov exponent, β is a constant, and z_2 and z_1 are consecutive values of Ritual Saturation; t is time, which was set to equal units of 1.0; α and β were determined through NLR. The statistical conversion of the Lyapunov exponent first appeared in Guastello (1995) and then again in Guastello, et al. (2009) and later in Guastello and Gregson (2011). Next, another variable was computed by creating a lag variable of z_1 that paired each value of z_2 with a value at two steps previous, since after running the analysis using several different lag lengths, a lag length of 2 was found to be

the most optimal. Periods of sleep were removed from the analysis, since the large blocks of time dedicated to sleep would affect the overall complexity of the data; however, napping done in small increments throughout the day were included in the analysis. Thus, models were tested using 30-minute lag intervals for each logbook. The resulting Lyapunov exponent (D_L) was (Guastello & Liebovitch, 2009):

$$D_L + e^\lambda. \quad (2)$$

To determine whether the nonlinear models were superior to linear models at explicating stability of dynamics, R^2 for nonlinear models were compared against the R^2 obtained for the linear counterparts, where

$$z_2 = \beta_1 z_1. \quad (3)$$

For Model 2, to determine the impact of family reactions and emotional responses, the Reaction Saturation variable and Emotional Response variable were transformed by dividing these variables by their respective standard deviations (SDs; Guastello, 2011), thereby creating two new variables, FR and ER. These new variables, were treated like linear variables and used to obtain the R^2 coefficient for Model 2, where

$$z_2 = \exp(\beta_1 z_1) + \gamma * FR + \delta * ER + \epsilon. \quad (4)$$

Comparison of nonlinear indicators. In the final phase of the analysis, regression parameters and Lyapunov exponents that were calculated for each participant for Model 1 and 2 were correlated with variables of interest to explain the origins of those values or to explicate any moderation those variables may have on the strength of the deterministic relationship. Because of the small sample size, Spearman's rank correlation coefficient was used. If possible, to further explicate the impact of specific types of reactions (i.e.,

EE and FA), the recorded family reactions were categorized as either EE or FA to see how these two variables independently relate to emotional distress and OCD rituals.

Results

Nonlinear Dynamics

Model 1. R^2 coefficients, which informs whether nonlinear dynamics are present in the data and the goodness of fit of the model, and regression models were calculated for each participant using Eq. 1 at lag lengths of 30 minutes. Linear R^2 coefficients were computed at the same lag interval for ease of comparison. R^2 coefficients were computed such that Daily Activities was the dependent variable and Ritual Saturation was the independent variable. Table 3 presents the NLR and linear regression (LR) results for OCD participants and matched controls using equation one. Statistical significance ($p < .05$) was attained for all regression weights.

Insert Table 2 about here

For OCD participants, the R^2 coefficients of the nonlinear model exceeded those of their linear counterparts in all cases. The mean value (standard deviations in parentheses; SD) of R^2 coefficient for the nonlinear model was 0.32 (0.13). The mean value (SD in parentheses) of R^2 coefficient for the linear model was 0.03 (0.04). A comparison of the mean values of the nonlinear and linear R^2 coefficients for OCD participants was computed using a paired sample t -test. The contrast of the mean difference between the nonlinear and linear R^2 coefficients was statistically significant beyond the specified .05 level, $t(16) = 10.73$, $p < .001$, $MD = 0.29$, 95% CI [0.23, 0.35].

Critical to this study is the determination that OCD exhibits characteristics of a dynamical disease. The mean values of R^2 coefficients for the nonlinear model in Equation 1 between OCD participants and controls were compared to determine whether the foregoing effects were consistent with a dynamical disease. The mean value of R^2 coefficient for control participants was 0.03 (SD = 0.09). A one-way ANOVA determined that the difference between the mean values of the nonlinear R^2 coefficients of OCD and control participants was statistically significant ($F(1, 31) = 52.78, p < .001$).

Chaotic dynamics vary in complexity. The Lyapunov exponent quantifies this complexity as the amount of divergence present in the attractor dynamics of OCD and control participants' data. The Lyapunov exponent was represented by the b -parameter in Equation 1 for the OCD participants and the matched controls. All Lyapunov exponents were statistically significant. The mean values of the Lyapunov exponent for OCD and control participants were 0.07 (SD = 0.02) and 0.01 (SD = 0.02), respectively. A comparison of the mean Lyapunov exponent values of OCD and control participants using a one-way ANOVA was statistically significant ($F(1, 31) = 61.05, p < .001$). The two means correspond to fractal dimensions of 1.07 and 1.01 respectively.

Model 2. To determine whether the family reactions and emotional responses increase stability in the dynamics, R^2 coefficients and regression models were calculated for each participant using Ritual Saturation lag lengths of 30 minutes and Family Reaction and Emotional Response lag lengths of 15 minutes. Linear R^2 coefficients were computed at the same lag interval for ease of comparison. R^2 coefficients were computed such that Daily Activities was the dependent variable and Ritual Saturation, Family Reaction Saturation, and Emotional Response were the independent variables. Of

additional importance, statistical significance ($p < .05$) was attained for the R^2 coefficients, the Lyapunov exponent, and the constant; however, the contribution of family reactions and emotional responses was computationally significant.

Computational significance refers to contributions of variables that serve as cooperative components such that their outcomes influenced the other variables; as such, they had a larger effect on the type of dynamic and the overall level of model fit rather than the uniqueness of individual components (Butner, Amazeen, & Mulvey, 2005). Moreover, family reactions and emotional responses flipped the signs of the other two coefficients from negative to positive and vice versa.

For OCD participants, the R^2 coefficients exceeded those of their linear counterparts in all cases. Moreover, these values in all cases exceeded the R^2 coefficients attained in Model 1 (see Table 5 for raw R^2 coefficient data for Models 1 and 2). The results of the regression analyses are presented in Table 3.

Insert Table 3 about here

Mean R^2 coefficients were computed for both the NLR and LR analyses. The mean value of R^2 coefficient for the nonlinear model was 0.36 (SD = 0.15). The mean value of R^2 coefficient for the linear model was 0.05 (SD = 0.05). A comparison of the mean values of the nonlinear and linear R^2 coefficients for OCD participants with family reactions was computed using a paired sample t -test, which was statistically significant ($t(11) = 8.14, p < .001, MD = 0.31, 95\% CI [0.22, 0.39]$).

Because one of the study's main interests was in explicating the family's role in OCD, the mean nonlinear R^2 coefficients that were calculated from each logbook were compared to the mean nonlinear R^2 coefficients computed for Model 1. This comparison determined whether the differences in R^2 coefficients attained were meaningful. The mean difference in R^2 coefficients was compared using a paired-sample t -test. This t -test revealed that the mean difference between the two coefficients was statistically significant ($t(11) = 4.17$, $p = .002$, $MD = 0.01$, 95% $CI [0.004, 0.013]$). No control participant recorded family reactions. Thus, it was not possible to compare R^2 coefficients and Lyapunov exponents between OCD and control participants for Model 2.

The data calculated for Model 2 were then examined for complexity. Lyapunov exponents were calculated for each OCD participant's logbook that contained family reactions. Equation 2 resulted in exact Lyapunov exponents that were virtually identical to those obtained for Model 1 after rounding (see Table 4). A paired-sample t -test was computed to examine whether the minimal differences between the exact values of the Lyapunov exponents are meaningful. The difference between the mean value Lyapunov exponents was not significant ($t(11) = -1.00$, $p = .339$).

Insert Table 4 about here

Comparison of Nonlinear Indicators

The final analysis took into account any moderating effects of the variables of interest on the accuracy of the nonlinear model. Two sets of linear correlations were computed between key distribution parameters and variables of interest. Due to the small

sample size and non-normal distributions, Spearman rank order correlation coefficients were computed.

Correlational analysis of Model 1. For Model 1, Spearman's rank order correlation and Means and SDs were calculated between the NLR R^2 coefficient and Lyapunov exponent and the YBOCS, ritual saturation, and working for pay, volunteering and, going to school (Table 5). (Model 1 consisted of all OCD participants' data and therefore, no family reactions were considered.) The R^2 coefficient for the nonlinear model was strongly related ($r = .73, p < .01$) to the YBOCS. The Lyapunov exponent, which denoted the complexity of the time series, was not significantly related to the R^2 coefficient for the nonlinear model ($r = .43, p > .05$), which was not surprising, because the two values are independently estimated; however, it was strongly related to the YBOCS ($r = .74, p < .01$). Ritual saturation was moderately related to the YBOCS ($r = .69, p < .01$).

Insert Table 5 about here

Correlational analysis of Model 2. Correlational analysis of Model 2 focused on OCD participants who recorded family reactions. Again Spearman rank order coefficients were computed between the parameters of interest and the YBOCS, ritual saturation, family reactions, emotional responses, and working for pay, volunteering, and school, due to the small sample size. Table 6 shows the results of the linear correlation analysis and the Means and SDs of the variables used. The R^2 coefficients were moderately related to the YBOCS ($r = .68, p < .05$) and family reactions ($r = .64, p <$

.05), which were of particular interest in this study. The emotional response to the family reaction was not found to be related to either the R^2 coefficient or the Lyapunov exponent; however, it was very strongly related to the family reaction ($r = .90, p < .01$). The Lyapunov exponent was not significantly related to the R^2 coefficient, family reactions, or emotional response; however, it was moderately related to the YBOCS ($r = .68, p < .05$).

Insert Table 6 about here

Discussion

The primary purposes of this study were (a) to examine the dynamical nature of OCD by means of analyzing both the occurrence of rituals as they transpire over time, (b) to examine the influence the family environment may have upon the spatiotemporal structure of symptoms, and (c) to demonstrate that OCD may exhibit characteristics of a dynamical disease. To accomplish this, several hypotheses were proposed in conjunction with two NLR models that were computed and assessed.

Model 1 tested the hypothesis that the time series of participants with OCD would manifest characteristics of chaotic dynamical disease, such that their time series will follow a lower-dimensional deterministic structure, denoting greater rigidity, when compared to controls. Moreover, Model 1 sought to examine whether the lower-dimensional deterministic structure would be moderated by symptom severity. Furthermore, it was hypothesized that the overall accuracy of the nonlinear model would be better than that of the linear model.

Model 2 tested the hypothesis that the time series of participants with OCD who recorded family reactions would also manifest characteristics of chaotic dynamical disease to a greater degree when comparing NLR parameters and Lyapunov exponents to those computed for Model 1. Additionally, analyses involving Model 2 examined whether symptom severity moderated the dynamics observed, and whether the NLR parameters and Lyapunov exponents calculated for each subject would correlate with reported family reactions to explain the origin of those values.

Hypotheses for Model 1

Regarding the dynamics of OCD, the first major hypothesis was that the time series of participants with OCD would manifest characteristics of a dynamical disease, such that their time-series would follow a low-dimensional deterministic structure, because the number of rituals performed by persons with OCD would display the complex, rhythmic processes resulting in dynamical processes that are relatively constant. For OCD participants, the NLR analysis for Model 1 resulted in significant R^2 coefficients and Lyapunov exponents. Testing revealed a significant difference between OCD participants and controls, which implies that the exponential model fit the OCD participants well, whereas for the controls, it did not. Because the Lyapunov exponent is positive but close to zero, it implies the presence of an aperiodic attractor. The value falls within the range that is usually associated with self-organized processes (Bak, 1996).

These findings suggest that for individuals with OCD, their environment remains relatively constant in space and time compared to those who do not have OCD; as such, this finding may suggest that the datasets for OCD participants lack the randomness of the control group logbooks. As predicted, therefore, the logbooks of OCD participants exhibited less complexity and more structure. As such, this finding is consistent with this study's premise that OCD may possess the qualities of a dynamical disease, which is also consistent with previous research finding a low-dimensional attractor for depressed participants (e.g., Gottschalk et al., 1995; Heiby et al., 2003).

It was also hypothesized that symptom severity, as measured by the YBOCS, will positively correlate with the NLR parameters and Lyapunov exponents. For Model 1, here the finding was that symptom severity for the nonlinear model was strongly

correlated with the R^2 coefficient and the Lyapunov exponent. Not only, then, does symptom severity moderate the basic function by strengthening the model, but also may affect the turbulence in the data by way of increasing or decreasing the complexity. Correlational analyses for Model 1 also revealed a very strong correlation between ritual saturation and the Lyapunov exponent and symptom severity, which suggests that the complexity of the data is also affected by rituals.

The second major hypothesis of this investigation for Model 1 assumed that within the OCD individual's time series the overall accuracy of the nonlinear model would be greater than the linear model; that is, the nonlinear model would be superior to the linear model in explaining more of the variance. In all cases and instances, the nonlinear model R^2 coefficient exceeded that obtained for the linear models. On average the nonlinear model R^2 coefficient explained more than 10 times the variance of its linear counterpart. These findings support this study's proposal that nonlinear dynamical models of OCD should be used, because they better capture the dynamics of OCD.

These findings considered in conjunction with the results of the NLR analysis suggest that the datasets for OCD participants are both nonlinear and aperiodic, and, as such, have a structure that cannot be captured by linear models. Moreover, the logbooks of OCD participants are significantly more organized compared to controls and can be characterized by the presence of a low-dimensional chaotic attractor that is observed as ritual saturation, and as such the dynamics fit that of a dynamical disease.

Hypotheses for Model 2

Regarding the effects of the family reactions on OCD, similar patterns to those captured in Model 1 emerged in the datasets. The first major hypothesis for Model 2

predicted that the time-series data of OCD participants who have recorded family reactions would also manifest characteristics of chaotic dynamical disease. However, the NLR parameters and Lyapunov exponents calculated would be greater than the regression parameters computed for Model 1, showing that family reactions and emotional responses result in more determinism and structure.

For OCD participants included in the analysis for Model 2, the NLR analysis for Model 2 resulted in significant R^2 coefficients and Lyapunov exponents. Testing revealed a significant difference between OCD participants' R^2 coefficients calculated for Model 1 and 2. Even though the additional variance the family reactions and emotional responses explained was small, it was meaningful. However, the difference between the Lyapunov exponents calculated for Models 1 and 2 was not significant.

The NLR analysis for Model 2, therefore, only found partial support for this study's prediction. In other words, the variables of family reactions and emotional responses did not combine to affect the turbulence in the data. Overall, however, the results of the NLR analysis were consistent with Model 1. In other words, the logbooks of OCD participants included in the analysis for Model 2 exhibited less complexity and more structure, and compared to Model 1, at least showed greater levels of determinism. While the family reactions and emotional responses combined to explain a little bit more of the variance, they did not contribute significantly to increased periodicity of the dataset.

The symptoms' effect on the regression parameters and Lyapunov exponents for Model 2, findings were consistent with Model 1. The nonlinear R^2 coefficient was moderately correlated with symptom severity; therefore, symptom severity continues to

moderate the amount of time spent on an activity. In other words, there was greater determinism and less noise for people with more severe OCD symptoms; however, symptom levels were also moderately and significantly related to the Lyapunov exponent, which suggests that not only do symptoms moderate the basic function, but also contribute significantly to increasing the turbulence in the data. In other words, participants with fewer symptoms would exhibit dynamics that were less predictable than those with more severe symptoms. As with Model 1, ritual saturation continued to be significantly correlated with symptom severity and the Lyapunov exponent. Once again, the more rituals performed, the more predictable were the dynamics.

In all logbooks, the NLR R^2 coefficient calculated for Model 2 exceeded that obtained for the linear models. On average the nonlinear model R^2 coefficient explained more than 7 times the variance of its linear counterpart. Moreover, with the addition of the family reactions and emotional responses to Model 2 and the corresponding linear model, the gap between R^2 coefficients remained large. The results clearly suggest that when attempting to explicate the family's role in OCD, nonlinear models are superior to linear models for capturing the dynamics at play.

The second major hypothesis for Model 2 was that the NLR regression parameters and Lyapunov exponents calculated for each subject would correlate with reported family reactions and emotional responses, which would explain the origin of those values. The analysis found that family reactions correlated moderately with the nonlinear R^2 coefficient, but not the Lyapunov exponent. However, emotional responses did correlate strongly with the family reactions, which were not surprising, since emotional responses were only recorded if a family reaction took place.

Regarding the role of the family, this study predicted two linear relationships. The first would occur between the amount of time the patient spends on a ritual task and the level of reported distress caused by the family reaction. That is, greater emotional responses would be related to more rituals. It was believed that more rituals would occur after experiencing increased emotional distress to a family reaction. The second would occur between the family reactions and symptom severity. Unfortunately, this study did not find significant support for either hypothesis.

When considering the inclusion of family reactions and emotional responses to the model, family reactions, when considered alone, appear to moderate the effect of the basic function. In other words, family reactions appear to significantly affect the amount of time participants spent performing rituals. That is, a combination of increased family reactions and higher levels of reported distress did affect how long OCD participants performed rituals. However, family reactions and emotional responses considered together have only a small effect on the particular instances of rituals and appear to have no significant effect on their periodicity; rather, ritual saturation and symptoms play a greater role in increasing the turbulence in the data.

Dynamical Disease and Family Reactions

Compared to many other studies investigating OCD, this study was unique in that it allowed participants to provide: (a) complete accounts of what they do on a particular day, (b) exactly how much time was spent on particular activities, (c) exactly when their rituals happened, (d) how a family member reacted, and (e) how they felt about the family reactions. Although this study is not the first to use the logbook or time-diary method to explore psychopathology from a nonlinear perspective (e.g., Burton, Heath,

Weller, & Sharpe, 2010; Burton, Weller, & Sharpe, 2009; Pincus, Schmidt, Palladino-Negro, & Rubinow, 2008), it is the only one to date that examined OCD specifically. As such it improved upon previous work on OCD by using a large number of time intervals used to record and the diversity of family reactions permitted. The results for both Models 1 and 2 strongly suggested the existence of nonlinear, aperiodic structure in OCD. This type of structure cannot be captured by linear methods. The nonlinearity that was detected in the data from OCD participants was not highly chaotic; rather, the time-series was that of a deterministic and low-dimensional chaotic attractor.

In contrast, the control participants, who either reported subclinical symptoms of OCD or none at all, exhibited characteristics of randomness. Therefore, based on the evidence provided, OCD does exhibit qualities of a dynamical disease. The aperiodic dynamics observed in OCD became more predictable with increased by symptom severity and ritual saturation. It may be concluded, then, that the more severe the OCD symptoms the more deterministic was the behavior, whereas milder forms of OCD may likely result in logbooks that exhibit less turbulence, comparatively. Additionally, since overall ritual levels also affected turbulence, it is likely that the greater the number of rituals the more likely it is that dynamics will be relatively volatile, whereas fewer rituals would result in comparatively less complex processes. As such, symptom severity and rituals appear to affect the periodicity much more than the other variables examined.

Family reactions and emotional responses combined to account for only a very modest increase in the variance explained and in the amount of turbulence. Although the pattern of this finding is consistent with predictions, the size of the effect is much smaller than expected and predicted. Surprisingly, contrary to what was predicted, family

reactions and emotional responses were not significantly correlated with rituals or symptom severity. Evidence suggested, however, that family reactions and emotional responses combined to moderate the predictability of the model. This finding was surprising, considering that previous research found that persons with OCD who perceived their relatives to be critical or hostile were more likely to have more severe OCD symptoms (Van Noppen & Steketee, 2009) and increased compulsive behaviors (Amir et al., 2000), and that symptom severity and compulsions were found to be predictors of increased FA (Stewart et al., 2008). Nonetheless, this study did find that family reactions and emotional responses affect OCD, albeit differently than predicted by previous studies. Nonlinear modeling found that family reactions and emotional responses affect the variance accounted for by the nonlinear model; in other words, while they do little to make the rituals go away, they strengthen the dynamics.

Van Noppen and Steketee (2009) provided the most information to date regarding the effect of family reactions on OCD by using structural equation modeling (SEM). Although SEM allows for testing of multiple hypothesized pathways using computations similar to multiple linear regression analysis, it cannot test directionality in relationships. Moreover, the directions of arrows in SEM represent the researcher's hypotheses of causality within a system, which in turn limit the SEM's ability to recreate the variance patterns that have been observed in nature. Thus for all intents and purposes it is subject to all the same limitations as other general linear models. Thus SEM could not have found the nonlinear and aperiodic structure of OCD.

Limitations and Directions for Future Research

Although the results of this study provided support for the theoretical model, conclusions must be viewed considering certain limitations. First, our sample size for the experimental group at 17 was not very large; however, it is consistent with sample sizes in other published studies using diaries (see Burton et al., 2010; Heiby et al., 2003). Even though large sample sizes are not required to explicate chaotic processes because of the long time series inherent in each logbook, the study was not able to explore the differential effects of the family constructs of EE and FA using questionnaires due to the small sample size. Unfortunately, it cannot be known exactly *how* the specific types of reactions moderate the nonlinear model because the number of family reactions recorded did not allow for analyses of specific types of family reactions. Future studies investigating the dynamics of OCD should look at the effect of these specific types of reactions.

On the other hand, even though this study cannot specifically address the effects of EE and FA on OCD, another aspect of this study that sets it apart from others, is that it took into account the effects of a wider array of reactions. Since families do not consistently interact using only one type of reaction or the other (i.e., family interactions are not limited to only EE and FA), it would be also helpful to explicate how all types of interactions affect OCD dynamics. Such revelations may have interesting treatment implications.

Second, the analyses were affected by the accuracy of the logbooks themselves. Like all psychological research, this study relied heavily upon the amount of information participants were willing to share about their lives and days. There was either an

abundance of details, or lack thereof, included in the logbooks. For instance, some participants provided only one or two-word descriptions of the activity, whereas others provided commentary to describe in more detail what the actual activity was.

Moreover, some activities were vaguely stated, and judgments had to be rendered regarding what the activity was. (This was more of a problem with the controls than the OCD participants.) In some cases, interviews had to guide data entry for some of the OCD logbooks activities. For instance, logbook 105 would often not record a ritual as the activity, but rather would describe what he was doing. For instance, at 2 AM, logbook 105 recorded “washed dishes.” Based on the interview, the participant who completed logbook 105 would rewash dishes late at night, because the spouse did not place the dishes symmetrically in the cupboard; rather than rearrange the dishes, s/he would rewash the dishes to remove contaminants that got on them after they were removed from the cupboard.

Third, family reactions were recorded as they occurred during the day; rather than by administering self-report questionnaires. During the exit interview, it was learned that many OCD participants sought privacy, whenever possible, when doing rituals. For instance, logbook 105 performed the majority of rituals when the spouse was asleep, or would not record rituals at work, fearing the reactions of coworkers. Logbook 107 reported doing most rituals in private, due to feelings of embarrassment, and Logbook 103’s rituals were performed subtly to avoid attention from family and peers.

In some cases, the family reaction may be quite low for having already accommodated the OCD. For instance, logbook 102’s parents sectioned off a portion of the basement for her to put her saved things. Since logbook 102’s section of the

basement is “smaller” than the section put aside for logbook 102’s mother, it may be that the family does not offer too many reactions. Either the OCD is something the family structure is accustomed to dealing with already, or it could be that the OCD is not yet severe enough to be problematic for the level of accommodation already present in the home.

In some situations, those from whom the participant received the most reactions were away. For instance, based on the interview with logbook 108, the primary responder to the OCD symptoms happened to be away the week s/he recorded data. The same was true for a portion of the week that logbook 107 recorded information. Consequently, logbooks would have OCD rituals recorded, but many fewer family reactions recorded or none at all. There could also have been sensitivity to recording family reactions, such that participants may have avoided sharing all family reactions fearing how their family member may appear. Taken together, it is reasonable to conclude that in some cases, the R^2 coefficients and Lyapunov exponents computed for Model 2 may be conservative estimates.

Fourth, participants were not limited in the types of family reactions that they could record. As such, many behaviors recorded could not be categorized as either EE or FA because they could be interpreted as neutral reactions, e.g., “watched.” As such, had these neutral reactions been removed to only include those that were more easily identifiable as EE or FA, this study would have been hindered in its attempts to explicate the potential role of the family, because too few family reactions would be available to test the hypotheses. Therefore, family reactions had to be considered as a whole and not by category type.

On the other hand, research has shown that it may not necessarily be the specific family reactions, but rather the manner in which persons with OCD perceive the reaction that predicts more severe OCD symptoms (Renshaw et al., 2003). Because of the importance of perception in interpretation of reactions, future research should examine the effect of perception not only on the dynamics of OCD, but also as a means to categorize those reactions that could be categorized as neutral. For instance, a family member impatiently watching may have a much different effect on the dynamics compared to a family member patiently watching; as such, future logbooks ought to create a category permitting participants to share their perceptual experience of the reaction.

Fifth, the study focused on overt compulsive behaviors. For most logbooks, obsession symptoms accounted for nearly half of the total YBOCS score. As such, many OCD symptoms that affect the dynamics were ignored; in particular, this study did not address how mental rituals and obsessions affect the dynamics of OCD. Although mental events are not readily observable by family members, they are an important part of OCD. For instance, a few of the OCD participants recorded higher or equal symptom complaints on the obsession scale compared to the compulsion scale of the YBOCS. By only focusing on overt symptoms of OCD, the study limited how much of the dynamic that could be explicated. Consequently, the R^2 coefficients and Lyapunov exponent may not accurately reflect what is occurring in OCD. As such, future research should consider finding ways to study the effects of mental rituals and obsessions on the dynamics of OCD. Also, future research should seek to further our understanding of how the family

affects the dynamics of OCD, when obsessions and mental rituals are included in the investigation.

Sixth, logbook 101 and 106 may have been affected by translation difficulties. Native Spanish speakers completed these two logbooks and all take-home information was provided to these participants in Spanish. Even though all documents were thoroughly reviewed and painstakingly translated into Spanish by a bilingual, native Spanish speaker, it is probable that some things got lost in translation; however, no concerns regarding translation problems or unclear procedural requirements were received from Spanish-speaking participants. Moreover, these two logbooks provided some of the most thoroughly recorded information, so it is unlikely that language problems were operating here.

Seventh, the sample population of this study was not as inclusive as hoped. The majority of participants who volunteered tended to be Caucasian and younger than 30. Therefore, there was not enough diversity to draw inferences about specific ethnic groups or older adults. In other words, our results might reflect a response style characteristic of this demographic set. On the other hand, the relative homogeneity of the sample does control for some variables that might fall outside of the scope of the present study. For instance, families of different ethnic cultural backgrounds may respond very differently with regard to emotional exchanges, tolerance of clinical symptoms, and closeness of family relationships. As such, the current sample supports the generalizability of our findings to young Caucasian adults.

Eighth, the small effect size of the family reactions and emotional responses that was found may in large part be attributed to the overall design of the study. The study

design sought to uncover whether OCD could be thought of as a dynamical disease and to find what could explain any dynamics observed. Because of this, the study design did not include the range of specific family dynamics that clinicians might consider. Future research should include the constructs of relationships, roles, responses, rules, realities, conflict, closeness, and control (Pincus & Guastello, 2005). A typical design that revolves around those variables could still be structured as individual time series, but each frame of data would include categorical variables, which in turn lend themselves to symbolic dynamics analysis.

Last, the study focused on adults with OCD. It is quite probable that the small effect size of the family reactions and emotional responses could be a dynamic that is characteristic of adults, but not children. It is possible that family reactions would have a more significant effect on the dynamics of children with OCD. For instance, increased FA has also been shown to be related to symptom severity, functional impairment, and externalizing and internalizing behavior problems in children (Merlo et al., 2009; Peris et al., 2008; Storch et al., 2007b; Storch et al., 2010a). Similarly, studies have shown that children and adolescents with OCD were more sensitive to parental criticism (Leonard et al., 1993). Considering these, future research should attempt to replicate these findings with children to determine if the effect size of the family reaction would be greater for children compared to adults.

Conclusions and Implications for Treatment

Despite these limitations, this paper concludes that persons with OCD lack the dynamical complexities that are the norm for individuals without psychopathology. In other words, the dynamics of OCD are likely more organized compared to controls and

can be characterized by the presence of a low-dimensional chaotic attractor that is observed as ritual saturation, and as such the dynamics fit that of a dynamical disease. Because ritual saturation is observed as an aperiodic attractor and strongly affected by symptom severity, this study offered indirect support of the validity of treatment focus being almost exclusively on symptom reduction, which would likely have the largest overall effect on restoring complex dynamics. Since the overall effect of the family was smaller than predicted, dedicating significant treatment time to helping the overall family system would likely not be warranted.

On the other hand, this is not to say that the family does not play a role in OCD. For instance, even though nonlinear modeling found that family reactions and emotional responses do little to make the rituals go away; they were found to strengthen the dynamics. Additionally, the family reactions may serve as a deterrent or obstacle to the performance of rituals, like work and school. Anecdotally, Logbook 106 remarked that s/he often felt rushed to finish or skip rituals, due to spousal reactions or presence. Because of this, any therapy involving family members ought to focus on helping them become more effective deterrents to rituals. Educating family members about effective ways to assist persons with OCD to resist doing rituals could do this. For instance, family members could be educated about how to offer encouragement appropriately to avoid unnecessarily escalating emotional distress, since research seems to suggest that what family members perceive as helpful may not actually be helpful (see Van Noppen & Steketee, 2009). Therapists should also prepare family members on how to respond to undesirable responses from the patients, as clinical experience informs that patients with OCD are not always willing to fully engage in exposure homework or to resist rituals.

How to react in these situations may be especially helpful to correctly deterring OCD rituals.

Providing families with education about reactions may result in helping to restore a portion of the complexity of dynamics. Future research will need to expand the results of this study by addressing its limitations and increasing our understanding of the dynamics of OCD, thereby allowing professionals to more fully address the needs of individuals with OCD.

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Appendix A

DEMOGRAPHICS INFORMATION

1. How old are you? _____
2. Are you male or female? _____
3. Are you married, single or cohabiting? _____

OBSESSIVE-COMPULSIVE INVENTORY – REVISED

The following statements refer to experiences that many people have in their everyday lives. Read each statement and place the number in the space next to the statement that best describes **HOW MUCH** that experience has **DISTRESSED or BOTHERED you during the PAST MONTH**. The numbers refer to the following verbal labels:

0 = Not at all
Extremely

1 = A little

2 = Moderately

3 = A lot

4 =

1. I have saved up so many things that they get in the way. _____
2. I check things more often than necessary. _____
3. I get upset if objects are not arranged properly. _____
4. I feel compelled to count while I am doing things. _____
5. I find it difficult to touch an object when I know it has been touched by strangers or certain people.

6. I find it difficult to control my own thoughts. _____
7. I collect things I don't need. _____
8. I repeatedly check doors, windows, drawers, etc. _____
9. I get upset if others change the way I have arranged things. _____
10. I feel I have to repeat certain numbers. _____
11. I sometimes have to wash or clean myself simply because I feel contaminated. _____
12. I am upset by unpleasant thoughts that come into my mind against my will. _____
13. I avoid throwing things away because I am afraid I might need them later. _____
14. I repeatedly check gas and water taps and light switches after turning them off. _____
15. I need things to be arranged in a particular order. _____
16. I feel that there are good and bad numbers. _____
17. I wash my hands more often and longer than necessary. _____
18. I frequently get nasty thoughts and have difficulty in getting rid of them. _____

Appendix B

INFORMACIÓN DEMOGRÁFICA.

- 1.- ¿Cuántos años tienes?_____
- 2.- ¿Eres hombre o mujer?_____.
- 3.- ¿Eres soltero, casado o en vives en unión libre?_____

Inventario-Revisión Obsesivo Compulsiva.

Las declaraciones siguientes se refieren a experiencias que muchas personas tienen en su vida diaria. Lea cada declaración y coloque el número en el espacio, junto a la declaración que describe mejor **CUÁNTO** de esa experiencia **HA PADECIDO O LE HA MOLESTADO** durante el mes pasado. Los números se refieren a los siguientes niveles verbales:

0= Nada en absoluto. 1=Un poco. 2=Moderadamente 3=Mucho 4=excesivamente.

1. ¿He guardado tantas cosas, que ahora me estorban?_____
2. ¿Yo reviso las cosas más frecuentemente que lo necesario?_____
3. ¿Yo me molesto si las cosas no están arregladas apropiadamente?_____
4. ¿Me siento obligado a contar mientras hago otras cosas?_____
5. ¿Se me hace difícil tocar un objeto cuando yo sé que ha sido tocado por extraños o por ciertas personas?

6. ¿Encuentro difícil controlar mis propios pensamientos?_____
7. ¿Recolecto cosas que no necesito?_____
8. ¿Verifico repetidas veces puertas, ventanas, cajones, etc?_____
9. ¿Me molesto si otros cambian la manera en que yo he arreglado las cosas?_____
10. ¿Siento que tengo que repetir ciertos números?_____
11. ¿Siento la necesidad de que tengo que lavarme o limpiarme varias veces solo porque me siento contaminado? _____
12. ¿Me molesto por los pensamientos desagradables que vienen a mi mente en contra de mi voluntad?_____
13. ¿Evito tirar las cosas porque tengo miedo de necesitarlos posteriormente?_____
14. ¿Verifico repetidas veces las llaves del gas y del agua y los interruptores de luz después de apagarlos?

15. ¿Necesito que las cosas estén arregladas en un orden en particular?_____
16. ¿Siento que hay números buenos y números malos?_____
17. ¿Me lavo las manos más frecuentemente o por mayor tiempo que lo necesario?_____
18. ¿Tengo con frecuencia pensamientos desagradables y tengo dificultad para deshacerme de ellos?_____

Appendix C

Daily Activity Log					
				Logbook ID No.	
Time	Day	Activity	Ritual	Reaction	Response
7:00 AM	1				
7:15 AM	1				
7:30 AM	1				
7:45 AM	1				
8:00 AM	1				
8:15 AM	1				
8:30 AM	1				
8:45 AM	1				
9:00 AM	1				
9:15 AM	1				
9:30 AM	1				
9:45 AM	1				

Appendix D

Marquette University Agreement of Consent for Research Participants

When I sign this statement, I am giving consent to the following basic considerations:

I understand clearly that the purpose of this research study titled, "*OCD as a Dynamical Disease and the Familial Context of Ritual Rigidity: A Nonlinear Dynamics Perspective*" is to examine rituals. I understand that the study takes place in one interview session lasting about 4 hours and that I will be asked to record information about my life for 7 days. I also understand that there will be approximately 8 participants with OCD in this study. I understand that there will be a total of 24 participants.

I understand that the interview session involves several questionnaires that measure the most common symptoms of OCD. I also understand that I will be asked questions about my family, as well as asked to provide information about my age, gender, marital status, education level, what medications I take, and family attitudes. I understand that I will also be interviewed about other problems that I might be experiencing in addition to OCD. I understand that a family member will be asked to log my daily activities. I understand that I may refuse to allow my family member to participate. I understand that if my family member does not want to participate that I may still participate in this study. I understand that I will be required to attend a follow-up session. I understand that the purpose of the follow-up session is to return the logbook and receive payment. I understand that at the follow-up session I may ask questions about the study.

I understand that all information I reveal in this study will be kept confidential and can only be released with my permission. All my data will be assigned an arbitrary code number rather than using my name or other information that could identify me as an individual. When the results of the study are published, I will not be identified by name. I understand that the data and all electronic files will be destroyed or deleted 1 month and 5 years after the completion of the study.

I understand that the risks associated with participation in this study may include emotional risks, since I will be required to answer personal questions about my family and rituals. I also understand that the only benefits of my participation are to help improve scientific understanding of OCD and 25 dollars. I understand that I will only receive 25 dollars if I complete the study in its entirety. I understand that the monetary compensation will be in the form of a cashier's check. I understand that I will not receive payment until I have completed the study and returned the logbook. I understand that I am not obligated to accept payment for my participation. I understand that participating in this study is completely voluntary and that I may stop participating in the study at any time without penalty or fear that it will affect treatment. I understand that all data collected prior to my terminating participation in the study will be used in the study.

All my questions about this study have been answered to my satisfaction. I understand that if I later have additional questions concerning this project, I can contact Robert Bond at 414-288-3487 or at robert.bond@marquette.edu. Additional information about my rights as a research participant can be obtained from Marquette University's Office of Research Compliance at 414-288-1479.

_____ Date: _____
(signature of subject giving consent)

_____ Date: _____
(signature of researcher)

Appendix E

Acuerdo de consentimiento para participantes de investigación Universidad de Marquette.

Cuando yo firmo esta declaración, yo estoy dando consentimiento de las siguientes consideraciones básicas:

Yo entiendo claramente que el propósito de este estudio de investigación titulado: TOC como una Enfermedad Dinámica y el contexto Familiar de Rigidez Ritual: Una perspectiva dinámica no Lineal” es para examinar rituales.

Yo entiendo que el estudio toma lugar en una sesión de al menos 2 horas, y que yo seré solicitado para registrar mi información por 7 días. Yo también entiendo que habrán aproximadamente 8 participantes con TOC en este estudio.

Yo entiendo que la sesión de entrevista incluye varios cuestionarios, que mide los síntomas más comunes del TOC. Yo también comprendo que se me realizarán preguntas acerca de mi familia, y que se me pedirá proporcionar información acerca de mi edad, género, estado civil, nivel de educación, qué medicamentos tomo y actitudes familiares.

Yo entiendo que también que seré interrogado acerca de otros problemas que yo pudiera estar experimentando en adición al TOC. Yo entiendo que un miembro de mi familia será solicitado para anotar mis actividades diarias. Yo entiendo que puedo negarme a permitir la participación del miembro de mi familia. Yo entiendo que si el miembro de mi familia no quiere participar, yo puedo aún participar en este estudio.

Yo entiendo que seré solicitado para asistir a una sesión de seguimiento. Yo entiendo que el propósito de la sesión de seguimiento es para regresar el libro de registro de actividades y recibir el pago. Yo entiendo que en la sesión de seguimiento puedo realizar preguntas acerca del estudio.

Yo entiendo que toda la información que yo revelo en este estudio podrían incluir riesgos emocionales, puesto que yo seré requerido para responder preguntas personales acerca de mi familia y rituales.

Yo también entiendo que los únicos beneficios de mi participación son, el ayudar a mejorar el entendimiento científico del TOC y 250 pesos. Yo entiendo que solo recibiré los 250 pesos si yo completo el estudio en su totalidad. Yo entiendo que la compensación monetaria será en forma de un cheque de cajero. Yo entiendo que no recibiré pago hasta que yo haya completado el estudio y regrese el libro de registro de actividades. Yo entiendo que no estoy obligado a aceptar el pago por mi participación.

Yo entiendo que participar en este estudio es completamente voluntario y que yo puedo dejar de participar en el estudio en cualquier momento, sin ninguna sanción o temor de que esto afectará el trato. Yo entiendo que todos los datos recolectados anteriormente a la terminación de mi participación en el estudio, serán usados en el estudio.

Todas mis preguntas acerca de este estudio han sido contestadas a mi satisfacción. Yo entiendo que, si más tarde yo tengo preguntas adicionales concernientes a este proyecto, yo puedo contactara Robert Bond 414-288.3487 o a robert.bond@marquette.edu.

Información adicional acerca de mis derechos como participante de investigación, pueden ser obtenidos de la Oficina de Regulación de Investigaciones de la Universidad de Marquette al 414-288-1479.

_____ Fecha: _____ (Firma del sujeto dando su consentimiento)

_____ Fecha: _____ (Firma del investigador)

Appendix F

Activities List for Logbooks

1. Eating (food preparation, restaurants, etc.)
2. Entertainment (TV, music, movies, etc.)
3. Exercise (jogging, aerobics, sports, etc.)
4. Child Care
5. Home Management (housecleaning, laundry, yard work, paying bills, etc.)
6. Free Time (waiting for something, relaxing, thinking, using the internet, etc.)
7. Hobbies (musical instruments, painting, etc.)
8. Medical (doctor or dentist visits, taking care of an illness, etc.)
9. Night Out (dancing, drinking, clubs, bars, etc.)
10. Personal Care (showers, changing clothes, brushing teeth, etc.)
11. Leisure Reading (books newspapers, magazines, etc.)
12. Religious Activities
13. School (in class, changing classes, etc.)
14. Shopping (going to stores, running errands, etc.)
15. Sleeping (including naps)
16. Socializing (telephone, visiting friends or relatives, dates, etc.)
17. Social events (weddings, funerals, graduations, etc.)
18. Studying (homework, research, etc.)
19. Transportation (car, bus, etc.)
20. Volunteer work
21. Working for pay
22. Rituals

Family Reactions List for Logbooks

1. Critical
2. Hostile
3. Angry
4. Guilt inducing
5. Easy going
6. Withdrawn/Indifferent
7. Understanding
8. Reassuring
9. Helpful (help to do or complete a ritual)
10. Patient (waited for ritual to be performed)
11. Tolerant
12. Participated (took part in ritual)
13. Judgmental
14. Disapproving
15. Unsympathetic
16. Disapproving
17. Sympathetic
18. Harsh
19. Concerned

Appendix G

Lista de actividades para libro de registros.

- 1.-Comidas (preparación de comidas, restaurantes, etc)
- 2.-Entretenimiento (televisión, música, películas, etc.)
- 3.-Ejercicio (trotar, aerobics, deportes, etc)
- 4.-Cuidado de niños.
- 5.-Manejo de la casa. (limpieza de casa, lavandería, trabajo del patio, pago de cuentas, etc)
- 6.-Tiempo libre (esperando por algo, relajándose, pensando, usando el internet, etc)
- 7.-Pasatiempos (instrumentos musicales, pintura, etc.)
- 8.-Medicina (Visitas al doctor o al dentista, estando al cuidado de una enfermedad, etc.)
- 9.-Noche fuera (Bailando, bebiendo, clubes, bares, etc).
- 10.-Cuidado Personal. (baño, cambio de ropas, cepillando los dientes ,etc.)
- 11.-Lectura en tiempo libre (libros, periódicos, revistas, etc.)
- 12.-Actividades religiosas.
- 13.-Escuela (en clases, cambio de clases, etc.)
- 14.-Compras (acudiendo a tiendas, haciendo encargos, etc)
- 15.-Durmiendo (Incluyendo siestas)
- 16.-Socializando(teléfono, visitando amigos o parientes, citas, etc)
- 17.-Eventos Sociales (bodas, funerales, graduaciones, etc.)
- 18.-Estudiando(Tareas, investigaciones, etc.)
- 19.-Transportación. (auto, autobús, etc)
- 20.-Trabajo voluntario.
- 21.-Trabajando para pagar.
- 22.-Rituales.

Lista de reacciones familiares para el libro de registros

1. Criticismo
2. Molesto
3. Enojado
4. Induciendo culpa
5. Easy going
6. Evasivo/Indiferente
7. Comprensivo
8. Reafirmando/Corroborando
9. Colaborador (ayudando a hacer o completar el ritual)
10. Paciente (espera a que el ritual sea realizado)
11. Tolerante
12. Participativo
13. Juzgando acciones
14. Desaprovando acciones
15. En desacuerdo
16. De acuerdo con acciones
17. Critico en forma irrespetuosa.
18. Preocupado

Appendix H

Directions for Participants with OCD

Activity Logbook Instructions

Please use the Daily Activity Log to record your daily activities. The logbook is composed of 42 pages. Six pages equals one day. Each page has 5 columns and 16 rows and 80 boxes where you can record information. Each column has a label: Time, Daily Activity, Ritual Occurrence, Family Reaction, and Emotional Response. The time increments in the Time column have already been recorded for you. Each page begins at 7 AM and time intervals ascend in 15-minute time increments. The other columns are blank so that you can record information about your day. For seven days, you will record daily activities, ritual occurrence, family reactions, and how these reactions made you feel.

In this column, please record, in as few words as possible each activity you do that lasts at least 15 minutes. This can seem quite burdensome if you think of individual tasks. But remember, the task has to occur for at least 15 minutes for it to be recorded. For example, combing your hair, brushing your teeth, washing your face, etc, separately might not take 15 minutes; however, altogether, they might total 15 minutes or longer. It would be too much to have you record each of these tasks independently. What I would like you to do is think in terms of general activities. For example, brushing your teeth, combing your hair, washing your face might combine to create the activity “personal care.” So, instead of writing the list of individual tasks, you would only record personal care in the box. Along with the logbook, an activity list is included to help guide you. You see, I am interested in the general activity, not all the little things that combine to create the activity. Similarly, you wouldn’t record: got cereal box, poured cereal, got the milk, poured the milk, etc. Instead, you might record something like this: “Eating.”

As often as possible, I would like you to record the activity on the spot. That means that you should record the activity immediately before beginning it and immediately after completing it. Make sure to take note of the time so that you record the activity in the correct box. For example, if you prepared and ate breakfast from 7:00 to 7:30 AM: this might include getting the ingredients, turning on the stove, getting the appropriate utensils, etc. You begin by locating the Daily Activity column. Next, you locate the Time Column. Scan the Time column until you come to the box designated 7:00 AM. Once you locate the 7:00 AM row, you then write, “Eating” in the box that corresponds to the 7:00 AM row in the Daily Activity column, like this. Again, remember, you should focus on the general activity and not the individual tasks. In this example, breakfast was prepared and eaten until 7:30 AM. Since you did the same activity for 30 minutes, you can simply draw a line from this box here to this box here to indicate that you did the same activity for 30 minutes. Don’t make the line too thick, because you might begin another activity in this 30-minute time block that will need to be recorded. Every time you begin a new activity, please record it in the same way.

There might be several times during the day when on the spot recording is inconvenient (e.g., you are at a movie) or redundant (e.g., the activity lasts longer than one hour). In these situations, retrospective reporting is allowed provided that you try your best to record the

beginning time of the activity and the remaining information within 15 to 30 minutes of completing the activity. Retrospective recording simply allows you to record the majority of the information after it has occurred. For example, if you are at a movie, you wouldn't have to record "Entertainment" every 15 minutes, since there will be no new activities until the movie is over. Make sure that you record the remaining information within 15 to 30 minutes of completing the activity. So, let's assume that the movie was 3 hours long and began at 7 PM. Simply record "Entertainment" in the appropriate column and row. Next draw a line through these boxes, to the box in the 10 PM row, like this. This method applies to activities lasting longer than an hour. For example, if you were in class or at work for several hours, you wouldn't have to record "School" or "Work" every 15 minutes.

While you are noting the time, you might discover that the activity start time differs from the pre-recorded 15-minute time intervals. Time increments were recorded for your convenience. If you find that the start time does not begin exactly on the 15-minute time interval recorded, simply select a 15-minute time interval closest to the actual start time. When in doubt between two time intervals, go with your best guess. Remember that whenever you begin a new activity, you record the activity in the same way as outlined above. Thus, you will be recording something every time you change activities. Again, only record activities last 15 minutes or more.

Ritual Occurrence Instructions

Ritual occurrence refers to how much of a day was consumed by compulsive behavior. Before I gave you the logbook, you completed an interview where we discussed your OCD symptoms. We determined that your compulsive behavior involves [state behavior]. Whenever these behaviors occur, please record it by placing an X or a checkmark in the appropriate box. So, if any aspect of a ritual was performed during a 15-minute time interval, even if it was for only 2 minutes, mark a box.

During the day, compulsive behavior might occur in a couple of ways. First, your compulsive behavior might occur in combination with a daily activity. For instance, you might be preparing breakfast and performing your rituals at the same time. In the previous example, we imagined that you prepared and ate breakfast from 7:00 AM to 7:30 AM. Notice that this time period consists of two, 15-minute time periods. Let's say, for example, that while preparing breakfast between 7:00 AM and 7:30 AM, you performed part or all of your ritual for the first 10 minutes of preparing breakfast. That is, from 7:00 until 7:10 your ritual occurred. If you recorded the activity before you began it, then you will only have to place a mark in this box. You do this by locating the 7:00 AM row and the Ritual Occurrence column. You would place an X in the corresponding box. If your rituals were performed for 20 minutes, that is, from 7:00 to 7:20 AM, you would mark these two boxes, like this, because the 20-minute ritual took place within two 15-minute time intervals. If you did not record the activity before you began it, then record the daily activity here and ritual occurrence here, like this.

Also, your compulsions might occur independent of any other daily activity. In this case, the ritual is the daily activity. In this situation, you would only need to record "Compulsions" or "Rituals" in a box in the Daily Activity column that corresponds to the appropriate time interval or intervals. For example, if your ritual occurred from 8 AM until 10 AM, you would record the ritual activity as outlined above. So, in this box you record the activity and then simply draw a line to this box here. Remember, this indicates that you did the ritual for 2 hours. To record ritual occurrence, you simply place a mark in these boxes here. There are eight 15-minute time intervals in 2 hours. So, eight boxes receive an X or check mark.

Now, when you don't perform your ritual, you simply leave the box blank. So, if from 10:15 AM to 3 PM you did not perform your rituals, you have nothing to record in the Ritual Occurrence column. It might be difficult to record the beginning time of your ritual before you start it and it might be difficult to interrupt your ritual once you have started it to record information; so, it is okay to use retrospective recording than interrupt your rituals. We want your participation to fit into your day without disrupting it too much. So, when recording rituals, if you aren't able to record the start time before you begin, it is okay to mark it down afterwards. Again, do not let more than 15 to 30 minutes go by before recording an activity or ritual. That way the information is still fresh in your mind.

Familial Reaction Instructions

Each time you perform a ritual, please record how your family members reacted to your rituals. If no family member was present to observe and comment on the ritual, there is nothing for you to record. If someone from the family was present, I would like you to record the reaction in this column. I want you to record in your own words how you think they reacted. The reaction can be verbal or behavioral. The important thing to remember is that there is no right or wrong answers. What you record is based on your own unique experiences with your family. Along with the logbook, a list of family reactions was included to help guide you. There are no limits to the number of responses family members can make to your rituals. You don't have to focus on one family member in particular; however, it is preferred that you focus more on the responses of your [spouse, wife, husband]. If you record more than one family members' reaction, make sure you designate who reacted which way. Let's say, for example, that while you were performing your ritual between 7:00 AM and 7:30 AM, you perceived your [state relative] to be very critical and your [state relative] to be very helpful. That is, your [relative] criticized you and your [relative] helped you complete your ritual. In this box right here, you can write a [state letter] to stand for your [family member] and then the word critical and a [state letter] to stand for your [family member] followed by the word helpful. There is no limit to what you perceive and even if your family member disagrees with what you wrote, I don't want you to change your response, because I am only interested in how you see things. There is no right or wrong answers and there is no limit to what you might perceive. You could perceive family members as angry, distant, hostile, supportive, caring, critical, helpful, etc. Family members might even give various reactions to the same ritual at the same time. For example, a family member could be very critical, but still help you complete the ritual or reassure you that everything is okay. After you write the reaction, I want you to rate on a scale from 1 to 5 how much you were bothered by the reaction. A one means you were not bothered at all and a 5 means that the reaction bothered you greatly. Do you have any questions?

For Practice

Now, why don't you try one on your own for practice? And if you have any questions after doing one on your own, we can address them together. For practice, let's say that you are watching a movie and you do this from 8:00 to 10:00 PM. Let's also say that from 8:35 PM to 9:00 PM you prepared and ate popcorn. Next let's say that while you were preparing popcorn you performed your ritual for 12 minutes. And last, let's say that during your ritual, your [name family member] helped you complete the ritual. How would you go about recording this information? [Answer questions and offer help only when participants have attempted this on their own]. [If the participant is struggling with the information, the examiner is permitted to walk through the example taking each activity one by one]. [If the participant struggled with the

first example, other examples can be created until the participant is comfortable with the procedure].

Okay, thank you for participating in this study. Since today is [state day of the week] and you will begin to record in the logbook tomorrow, how about you return the logbook on [ninth day after receiving]. Does this day work for you? When you return the logbook, a check will be handed to you to thank you for your participation. If you can't make it on [state day], please call 414-288-3487 and let me know. We can arrange another time for you to return the logbook. Do you have any questions?

Appendix I

INSTRUCCIONES PARA EL LIBRO DE ACTIVIDADES.

Por 7 días usted usará este diario para anotar información acerca de su día, Son 42 páginas y cada página tiene 5 columnas, 16 filas y 80 espacios vacíos dónde usted puede registrar su información y cada columna tiene un nivel, tiempo, día, actividad, ritual ocurrido, reacción familiar y respuesta emocional.

Los incrementos del tiempo han sido registrados para usted, las otras columnas son espacios en blanco para que usted pueda registrar información acerca de su día y yo le explicaré a usted cómo hacerlo.

INSTRUCCIONES DE ACTIVIDADES.

En esta columna, usted registrará en tan pocas palabras como le sea posible, cada actividad que realice hasta durante al menos 15 minutos o más. Esto puede verse como mucho si usted piensa en todas las pequeñas cosas que usted realiza cada día. Por ejemplo, peinando su cabello, lavando sus dientes, lavando su cara, etc. En lugar de registrar todas estas cosas, yo quiero que piense acerca de ello como actividades generales que usted realiza, Por ejemplo: lavar sus dientes, peinar su cabello y lavar su cara pueden ser parte de la actividad general de "cuidado personal" o "preparación". Por tanto, todo lo que usted tiene que registrar son las actividades generales que ha estado realizando por 15 minutos o más.

En adición al libro de registro, una lista de actividades es incluida para ayudarle a guiarse.

Tan pronto como sea posible, me gustaría que registrara la actividad inmediatamente. Esto significa que usted podría registrar la actividad antes de comenzarla y más tarde al completarla. Antes de registrarla, asegúrese de revisar el tiempo, para asegurar que está registrando la información en el renglón correcto. Por ejemplo, si usted preparo y comió el desayuno de las 7:00 a las 7:30, usted registrará "comiendo" aquí. Para hacer esto más fácil para usted, desde que usted está realizando la misma actividad por 30 minutos, usted puede simplemente dibujar una línea del renglón inicial en el apartado que indica que inició una actividad hasta el momento en que la terminó después de 30 minutos. Cada vez que usted comience una nueva actividad que al menos dure 15 minutos o más, por favor regístrelos en la misma manera.

Podrían haber varios momentos durante el día en los cuales el registrar las actividades inmediatamente podría ser inconveniente (por ejemplo cuando está viendo una película), o redundante (si permanece haciendo la misma actividad por más de una hora), en estas circunstancias, usted puede registrar la información después de que la finalice. De cualquier manera trate de que la información sea registrada sin que hayan pasado más de 30 minutos de haber completado la actividad.

Mientras usted esté registrando la información, usted puede descubrir que el tiempo en que comenzó la actividad difiere del intervalo de 15 minutos registrados por usted, si esto sucede, simplemente seleccione el intervalo de 15 minutos más cercano al tiempo actual. Cuando tenga duda entre dos intervalos, escoja su mejor opción.

Nuevamente recuerde que siempre que comience una nueva actividad debe registrarla en la misma forma que yo describí, por tanto, usted estará registrando algo cada vez que cambie de actividad, siempre y cuando la actividad sea de 15 minutos o mayor.

INSTRUCCIONES DEL RITUAL.

Durante la entrevista, nosotros determinaremos sus rituales involucrados (estado ritual).

Siempre que estos comportamientos ocurran, por favor regístrelos poniendo una X o una marca en el renglón correspondiente, aún cuando el ritual solo duró 2 minutos.

Durante el día los rituales pueden ocurrir de dos maneras:

Primero; Rituales que pueden ser parte de la actividad diaria.

Por ejemplo: Usted puede preparar el desayuno y realizar algunos rituales, en esta situación, usted podrá registrar la actividad como " comiendo " y poner una marca en el renglón o renglones correspondientes en la columna de rituales. Por ejemplo, imagine que está desayunando de 7:00 a 7:30 AM e imagine que mientras está preparando el desayuno, realiza un ritual por 10 minutos entre las 7:00 y las 7:15. Usted registrará la actividad " comiendo" como lo discutimos anteriormente, pero usted también deberá registrar el ritual. Para registrar su ritual, simplemente ponga una marca en el espacio correspondiente. Si su ritual ocurrió por lo menos 15 minutos durante el intervalo de 7:00 a 7:15 y luego nuevamente en el intervalo de 7:15 a 7:30, usted pondrá una marca en este espacio y en la columna del ritual.

Segundo. Algunos rituales pueden tomar 15 minutos o más.

Si alguno de estos rituales dura 15 minutos o más, entonces usted registrará el ritual como una actividad en la columna de actividades pero escribiendo " Ritual" en el espacio. Por ejemplo, si un ritual ocurre de las 8 AM hasta 10 AM, usted podrá registrar "Ritual" en este espacio y dibujar una línea hasta ese espacio. Si un ritual es registrado como una actividad, usted no tiene que registrar nada en la columna de rituales.

Puede ser difícil registrar el comienzo de un ritual y aún más difícil interrumpir un ritual una vez que ha comenzado. Cuando registre los rituales, estará bien si los registra después de haber realizado el ritual o bien, un miembro de la familia puede registrar la información del ritual por usted. Nuevamente, no permitas que pasen más de 30 minutos antes de anotar una actividad o ritual.

INSTRUCCIONES PARA REACCION FAMILIAR.

Cada vez que realice un ritual, por favor registre cómo un miembro de tu familia reacciona al ritual.

Si no hay un miembro de su familia presente para observar y comentar el ritual, no deberá registrar nada. Si algún miembro de la familia estuvo presente, me gustaría que usted registrara la reacción en la columna de reacciones, usando pocas palabras para describir cómo usted piensa que el miembro de la familia reaccionó.

No hay respuestas correctas o incorrectas. Lo que usted registre estará basado en su propia y única percepción. Junto con el libro de registro, una lista de reacciones familiares fue incluida para ayudarle. No hay límites en el número de respuestas que los miembros de su familia puedan hacer a sus rituales.

También es preferible que usted se enfoque más en las respuestas de su esposo(a) o del miembro de su familia que reacciona la mayoría de las veces a sus rituales. Por ejemplo: Imagine que está realizando un ritual entre 7:00 y 7:30 AM y un miembro de su familia le critica. En el espacio usted puede escribir "criticó". Si por el contrario, el miembro de su familia le ayuda a hacer su ritual, usted puede escribir "ayudó" en la casilla correspondiente.

La información está basada en su propia percepción, por tanto no debe cambiar su respuesta aún cuando algún miembro de su familia no esté de acuerdo con lo que usted escribió. Adicionalmente me gustaría saber cómo cada reacción le hizo sentir. Después de que registre la reacción me gustaría que evalúe tus sentimientos en escala del 1 al 5. Un 1 significa que usted no estaba molesto y un 5 significa que usted estuvo muy molesto por la reacción. Usted registrará este número en la columna de respuestas. ¿Tiene alguna pregunta? Muy bien, gracias por participar en este estudio. Usted recibirá su compensación cuando regrese el libro de registro.

Appendix J

Activity Logbook Instructions

Time Column: In this column, time increments have already been recorded. Each page begins at 7 AM and time intervals ascend in 15-minute time increments. Use this column to help you locate the row where you will record information. If you find that the start time does not correspond to one of these 15-minute time intervals, select an interval closest to the actual start time. When in doubt, go with your best guess.

Activity Column: In this column, please record in as few words as possible each activity you do that is 15 minutes or more. Think about the general activity that you are doing. Use the suggested activity key to help you. Try to record the information immediately after completing it. Every time you change activities, please record it in the same way. If it is inconvenient to record the information immediately, you may record within 30 minutes of completing the activity.

Ritual Column: Whenever a ritual occurs, please record that information in the Ritual column by placing an X or a checkmark in the appropriate box or boxes. It is important to know at what time the ritual occurred so that you record the mark in the correct box. If rituals occur while performing an activity (e.g., eating), please record the activity “eating” in the Activity column and put a mark in the correct box of the Ritual column. If a ritual occurs 15 minutes or longer, then record “Ritual” in the Activity. If the ritual is recorded in the activity column, you do not have to record anything in the Ritual column. Again, note the time so that you record information in the correct spot. If you don’t perform a ritual, nothing is recorded in the Ritual column. If it is difficult to record the beginning time of your ritual, please record the information after you complete it and estimate as best as you can the beginning time. Try not to allow more than 15 minutes to pass before recording information about your ritual.

Reaction and Response Column: Each time you perform a ritual, please record any family members’ reaction to it. If a family member did not observe and comment on the ritual, there is nothing for you to record. If someone from your family was present, please record the reaction to your ritual. Reactions can be verbal or behavioral. Record your own unique perceptions. You can use the Reaction Key to help you. There is no right or wrong answers. There are no limits to the number of responses you can record or to the number of responses family members can make. Try to focus on the responses of parents, spouses, or relationship partners before siblings or children. Once you record a reaction, please do not change it. First impressions are often the best. After you record the family member’s reaction, please rate on a scale from 1 to 5 how much you were bothered by the reaction(s) and record this number in the Response column: A 1 means that you were not bothered and a 5 means that the reaction bothered you a lot.

Appendix K

INSTRUCCIONES DEL LIBRO DE ACTIVIDADES

Columna del tiempo: En esta columna, los incrementos del tiempo han sido ya registrados. Cada página comienza a las 7:00am y el intervalo de tiempo asciende en incremento de 15 minutos. Use esta columna para ayudarse a localizar la fila dónde usted registrará información. Si usted encuentra que el tiempo de inicio no corresponde a uno de estos intervalos de 15 minutos de tiempo, seleccione un intervalo más cercano al tiempo actual de inicio. Cuando tenga duda, solo opte por la opción que le parezca mejor.

Columna de actividades. En esta columna por favor registre en el menor número de palabras posible cada actividad que usted realice, que sea de 15 minutos o más. Piense en general sobre las actividades que está haciendo. Use la guía de actividades sugeridas para ayudarse. Trate de registrar la información inmediatamente después de completarla. Cada vez que usted cambie de actividades, por favor regístrelo de la misma manera. Si es inconveniente registrar la información inmediatamente, usted podrá registrarla sin que pasen 30 minutos de haber completado la actividad.

Columna de Rituales. Cualquiera que sea el ritual que ocurra, por favor registre esa información en la columna del ritual colocando una X o una marca en el espacio o espacios correspondientes. Esto es importante para saber en qué momento el ritual ocurrió, por tanto usted debe registrar la marca en el espacio correcto. Si el ritual ocurrió mientras realizaba una actividad (Ej. Comiendo), por favor registre la actividad "comiendo" en la columna de actividades y coloque una marca en el espacio correcto de la columna de rituales. Si un ritual ocurre por 15 minutos o más, entonces registre "Ritual" en las actividades. Si el ritual es registrado en la columna de actividades, usted no tiene que registrar nada en la columna de Rituales. Nuevamente, revise el tiempo para que usted registre la información en el lugar correcto. Si usted no realiza ningún ritual, entonces nada será registrado en la columna de Rituales. Si es difícil registrar el tiempo de inicio de su ritual, por favor registre la información después de que lo complete y estime lo mejor que usted pueda el tiempo de inicio del mismo. Trate de no permitir el paso de más de 15 minutos antes de registrar la información acerca de su ritual.

Columna de Reacción y Respuesta. Cada vez que usted realice un ritual, por favor registre cualquier reacción de la familia a éste. Si un miembro de la familia no observó u comentó el ritual, no hay nada para usted que deba registrar. Si alguno de su familia estuvo presente, por favor registre la reacción a su ritual. Las reacciones pueden ser verbales o de comportamiento. Registre sus propias y únicas percepciones. Usted puede utilizar la guía de reacciones para ayudarse. No hay respuestas correctas o incorrectas. No hay límite en el número de respuestas que usted pueda registrar o en el número de respuestas que los miembros de la familia puedan hacer. Trate de enfocarse en la respuesta de sus padres, esposo (a), o en su pareja antes que la de sus hermanos o de los niños. Una vez que haya registrado una reacción, por favor no la cambie. Las primeras impresiones son por lo general las mejores. Después de registrar la reacción del miembro de la familia, por favor evalúe en una escala del 1 al 5 cuánto estuviste molesto por la reacción o reacciones y registra este número en la columna de respuestas: Un 1 significa que usted no estuvo molesto y un 5 significa que la reacción le molestó mucho.

Appendix L

Marquette University Agreement of Consent for Research Participants (Students)

When I sign this statement, I am giving consent to the following basic considerations:

I understand clearly that the purpose of this research study titled, "*OCD as a Dynamical Disease and the Familial Context of Ritual Rigidity: A Nonlinear Dynamics Perspective*" is to examine rituals. I understand that the study takes place in one interview session lasting about 4 hours and that I will be asked to record information about my daily activities for 7 days. I also understand that there will be approximately 24 participants in this study.

I understand that the interview session involves several questionnaires that measure the most common symptoms of OCD. I also understand that I will be asked questions about my family and/or rooming environment, as well as asked to provide information about my age, gender, marital status, education level, past therapy, family attitudes, and roommate reactions. I understand that I will also be interviewed about psychological problems that I may be experiencing. I understand that I will be required to attend a follow-up session. I understand that the purpose of the follow-up session is to return the logbook and receive extra-credit points. I understand that at the follow-up session I may ask questions about the study.

I understand that all information I reveal in this study will be kept confidential. All my data will be assigned an arbitrary code number rather than using my name or other information that could identify me as an individual. When the results of the study are published, I understand that I will not be identified by name. I understand that the data will be destroyed by shredding paper documents and deleting electronic files 1 month and 5 years after the completion of the study.

I understand that the risks associated with participation in this study may include emotional risks, since I will be required to answer personal questions about my life and detail my activities for one week. I understand that the only benefits of my participation are extra credit points and the improvement of scientific understanding of OCD. I understand that participating in this study is completely voluntary and that I may stop participating in the study at any time without penalty. I understand that if I withdraw early from the study that I will only be awarded 2 points and that I will receive the 2 points when I return the logbook. I understand that if I am unable to participate or choose not to participate that I will receive 1 point of extra credit at the interview session. I understand that I will only receive the total extra-credit points allotted by completing the study and that I will not receive the points until I return the logbook. I understand that if I withdraw from the study that all data collected prior to my terminating participation in the study may be used in the study.

All my questions about this study have been answered to my satisfaction. I understand that if I later have additional questions concerning this project, I can contact Robert Bond at 414-288-3487 or at robert.bond@marquette.edu. Additional information about my rights as a research participant can be obtained from Marquette University's Office of Research Compliance at 414-288-1479.

_____ Date: _____ (signature of subject giving consent)

_____ Date: _____ (signature of researcher)

Appendix M

Directions for Control Participants

Activity Logbook Instructions

Please use the logbook to record your daily activities. The logbook is composed of 38 pages. Each page has 6 columns and boxes where you can record information. Each column has a label: Time, Activity, Ritual, Reaction, and Response. The time increments in the Time column have already been recorded for you. Each page begins at 7 AM and the time intervals ascend in 15-minute time increments. The other columns are blank so that you can record information about your day. I want you to record your daily activities, rituals, reactions, and your emotional reactions for 7 days.

In this column, please record, in as few words as possible each activity you do that lasts 15 minutes or longer. This can seem quite burdensome if you think of individual tasks. For example, combing your hair, brushing your teeth, washing your face, etc would be a lot of stuff to record. Remember, I only want you to record activities that last at least 15 minutes. It would be too much to have you record each of these tasks independently. What I would like you to do is think in terms of generalities. So, separately all of these tasks might not take 15 minutes; however, altogether, they might total 15 minutes or longer. For example, brushing your teeth, combing your hair, washing your face might combine to create the activity “personal care.” So, instead of writing the list of individual tasks, you would only record personal care or something similar in the box. Along with the logbook, an activity list is included to help guide you. You see, I am interested in the general activity, not all the little things that combine to create the activity. Similarly, you wouldn’t record: got cereal box, poured cereal, got the milk, poured the milk, etc. Instead, you might record something like this: “Eating.”

As often as possible, I would like you to record the activity on the spot. That means that you should record the activity immediately before beginning it or immediately after completing it. Make sure to take note of the time so that you record the activity in the correct box. For example, if you prepared and ate breakfast from 7:00 to 7:30 AM: this might include getting the ingredients, turning on the stove, getting the appropriate utensils, etc. You begin by locating the Activity column. Next, you locate the Time Column. Scan the Time column until you come to the box designated 7:00 AM. Once you locate the 7:00 AM row, you then write, “Eating” in the box that corresponds to the 7:00 AM row in the Activity column. Again, remember, you should focus on the general activity and not the individual tasks. In this example, breakfast was prepared and eaten until 7:30 AM. Since you did the same activity for 30 minutes, you can simply draw a line from this box here to this line here to indicate that you did the same activity for 30 minutes. Don’t make the line too thick, because you might begin another activity in this 30-minute time block that will need to be recorded. Every time you begin a new activity, please record it in the same way.

There might be several times during the day when on the spot recording is inconvenient (e.g., you are at a movie) or redundant (e.g., the activity lasts longer than one hour). In these situations, retrospective reporting is allowed provided that you try your best to record the beginning time of the activity and the remaining information within 15 to 30 minutes of completing the activity. Retrospective recording simply allows you to record the majority of the information after it has occurred. For example, if you are at a movie, you wouldn’t have to record “Entertainment” every 15 minutes, since there will be no new activities until the movie is over. Make sure that you record the remaining information within 15 to 30 minutes of completing the activity. So, let’s assume that the movie was 3 hours long and began at 7 PM. Simply record “Entertainment” in the appropriate column and row. Next draw a line through these boxes, to the box in the 10 PM row, like this. Another example: if you were in class or at work for several hours, you wouldn’t have to record “School” or “Work” every 15 minutes.

While you are noting the time, you might discover that the activity start time differs from the pre-recorded 15-minute time intervals. Time increments were recorded for your convenience. If you find that the start time does not begin exactly on the 15-minute time interval recorded, simply select a 15-minute time interval closest to the actual start time. When in doubt between two time intervals, go with your best guess. Remember that whenever you begin a new activity, you record the activity in the same way as outlined above. Thus, you will be recording something every time you change activities. Again, only record activities last 15 minutes or more.

Ritual Occurrence Instructions

Ritual occurrence refers to how much of a day was consumed by compulsive-like behavior. Before I gave you the logbook, you completed a questionnaire that assessed symptoms common to OCD. According to the questionnaire, you tend to be more concerned with [state behavior]. Whenever these behaviors occur, please record it by placing an X or a checkmark in the appropriate box. I only want you to record it as a ritual, if you do it to reduce stress or anxiety. So, let's say between 9:00 AM and 9:15 AM this occurs. You simply place a checkmark or an X in this box.

During the day, these compulsive-like behaviors might occur in a couple of ways. First, they might occur in combination with a daily activity. For instance, you might be preparing breakfast and [state compulsive-like behavior] at the same time. In the previous example, we imagined that you prepared and ate breakfast from 7:00 AM to 7:30 AM. Notice that this time period consists of two, 15-minute time periods. Let's say, for example, that while preparing breakfast between 7:00 AM and 7:30 AM, you [state behavior] 3 times within the first 10 minutes of preparing breakfast. That is, from 7:00 until 7:10 AM. If you recorded the activity before you began it, then you will only have to place a mark in this box. You do this by locating the 7:00 AM row in the Ritual Occurrence column and placing an X in the corresponding box. If for any reason you [state behavior] more than 2 times within a 20 minute period, you would mark these two boxes, like this, because the 20-minute ritual took place within two 15-minute time intervals. If you did not record the activity before you began it, then record the daily activity here and ritual occurrence here.

Also, your compulsive-like behaviors might occur independent of another daily activity. In this situation, the compulsive-like behavior is the daily activity. In order for this to occur, you would have to have performed the behavior for 15 minutes or more. If this happens, you would only need to record "Compulsions" or "Rituals" in a box in the Daily Activity column that corresponds to the appropriate time interval or intervals. For example, if you [state behavior] from 8 AM until 8:30 AM, you would record the ritual activity as outlined above. So, in this box you record the activity and then simply draw a line to this box here. There are two 15-minute time intervals in one half hour. So, two boxes receive an X or check mark. It is more likely that your behaviors will occur while performing other daily activities.

Now, when you don't perform [state behavior], you simply leave the box blank. So, if from 10:15 AM to 3 PM you did not [state behavior], you have nothing to record in the Ritual column. It might be difficult to record the beginning information of [state behavior]; so, it is okay to use retrospective recording. I want your participation to fit into your day without disrupting it too much. So, when recording ritual-like behavior, if you aren't able to record the start time before you begin, it is okay to mark it down afterwards. Try not to allow more than 15 to 30 minutes to go by before recording an activity or ritual. That way the information is still fresh in your mind.

Familial Reactions Instructions

It is probably more likely that you don't live at home with your parents, but rather, share a room with a peer. So, if a family member's reaction isn't available, please record how a friend or roommate reacted to your [state behavior]. Each time you [state behavior], please record how your roommate or friends reacted to your ritual-like behavior in this column here. I want you to record the reaction in your own words. Reactions can be verbal or behavioral. What you record is based on your own unique

perception. Along with the logbook, a list of family reactions was included to help guide you. The important thing to remember is that there are no right or wrong answers. Also, there are no limits to the number of responses people can make. If you record more than one person's reaction, make sure you designate who reacted which way. Let's say, for example, that while you were [state behavior] between 7:00 AM and 7:30 AM, you perceived your [state individual] to be very critical and your [state individual] to be very helpful. In this box right here, you can write a [state letter] to stand for your [state individual] and then the word critical and a [state letter] to stand for your [state individual] followed by the word helpful. Again, there are no right or wrong answers, only what you perceive. You could perceive others as angry, distant, hostile, supportive, caring, critical, helpful, etc. Some might even give various reactions to the same [state behavior] at the same time. For example, someone could be very critical, but then reassure you that things are okay. After you write the reaction, I want you to rate on a scale from 1 to 5 how much you were bothered by the reactions. A one means you were not bothered at all and a 5 means that the reaction bothered you greatly. If no one observed you [state behavior], there is nothing record. Do you have any questions?

For Practice

Now, why don't you try one on your own for practice? And if you have any questions after doing one on your own, we can address them together. For practice, let's say that you are watching a movie and you do this from 8:00 to 10:00 PM. Let's also say that from 8:35 PM to 9:00 PM you prepared and ate popcorn. Next let's say that while you were preparing popcorn you [state behavior]; and last, let's say that during your ritual, your [name individual] expressed frustration. How would you go about recording this information? [Answer questions and offer help only when participants have attempted this on their own]. [If the participant is struggling with the information, the examiner is permitted to walk through the example taking each activity one by one]. [If the participant struggled with the first example, other examples can be created until the participant is comfortable with the procedure].

Okay, thank you for participating in this study. Since today is [state day of the week] and you will begin to record in the logbook tomorrow, how about you return the logbook on [ninth day after receiving]. Does this day work for you? When you return the logbook, you will receive your extra credit points for your participation. If you can't make it then, please call 414-510-5949 and let me know and we can arrange another time. Do you have any questions?

Appendix N

Activity Logbook Instructions

Time Column: In this column, time increments have already been recorded. Each DAY begins at 7 AM and time intervals ascend in 15-minute time increments. Use this column to help you locate the row where you will record information. If you find that the start time does not correspond to one of the recorded 15-minute time intervals, select a 15-minute time interval closest to the actual start time. When in doubt, go with your best guess.

Activity Column: In this column, please record in as few words as possible each activity that lasts at least 15 minutes or longer. Do not think in terms of individual tasks, but in terms of the general activity. For example, do not record combing hair, brushing teeth, washing face, etc., because each on their own might not take 15 minutes; however, if you think of them as combining to create an activity, they might total 15 minutes or longer. Instead of recording these simple tasks, please record “personal care” or something similar. Use the Suggested Activity key attached to help guide you. Record the information immediately before beginning it and after completing it. Be sure to note the time so that information is recorded in the appropriate row. Every time you change activities, please record it in the same way. If you are unable to record information on the spot, use retrospective reporting; however, try to record the start time and then the remaining information within 30 minutes of completing the activity.

Ritual Column: Ritual occurrence refers to how many times ritual-like behavior occurs each day. Remember to only record a “ritual,” if you used the behavior to reduce anxiety or distress. Whenever ritual-like behavior occurs, record that information in the Ritual Occurrence column by placing an X or a checkmark in the appropriate box or boxes. It is important to record as best you can the beginning time. Note the ending time of ritual-like behavior so that the appropriate number of boxes is marked. The exact duration is not recorded. If ritual-like behavior occurs in combination with a daily activity (e.g., preparing food), record the activity and mark the appropriate number of boxes in the Ritual Occurrence column. Note the time so that information is recorded in the appropriate row(s). If ritual-like behavior occurs independent of another daily activity, record “Ritual” in the Daily Activity column and record the information as you would any other activity. Again, note the time so that you record information in the appropriate row(s) and then mark the corresponding boxes in the Ritual Occurrence column with Xs or checkmarks. If your ritual activity is recorded in 8 boxes, 8 boxes in the Ritual Occurrence column will receive a mark. If you don’t perform ritual-like behavior, nothing is recorded in the Ritual Occurrence column. If it is difficult to record the beginning time, record the information after you complete it and estimate as best as you can the beginning time. Try not to allow more than 15 minutes pass before recording information about your ritual-like behavior.

Reaction Column: Each time you perform ritual-like behavior, please record how family members or others reacted. If no one observed you, there is nothing to record. If someone was present, please record the reaction. Reactions can be verbal or behavioral. Record your own unique perceptions. You can use the Reaction Key attached to help you. There are no right or wrong answers. There are no limits to the number of responses you can record or to the number of responses that can be made. If you record more than one persons’ reaction, please note who reacted which way. Use the Family Member Key to assist you.

Response Column: Once you record a reaction, please do not change it. First impressions are often the best. After you record the reaction, please rate on a scale from 1 to 5 how much you were bothered by the reaction(s): a 1 means that you were not bothered and a 5 means that the reaction bothered you greatly.

Appendix O

Time	Day	Activity	Ritual	RitSat	React	Reactsat	Resp
7:00	1	Eating	no	0	none	0	0
7:15	1	Eating	no	0	none	0	0
7:30	1	home management	no	0	none	0	0
7:45	1	home management	no	1	none	0	0
8:00	1	transportation	yes	1	angry	1	4
8:15	1	transportation	no	0	none	0	0
8:30	1	working for pay	no	1	none	0	0
8:45	1	working for pay	yes	2	annoyed	1	5
9:00	1	working for pay	yes	1	annoyed	1	5
9:15	1	working for pay	no	0	none	0	0
9:30	1	working for pay	no	0	none	0	0
9:45	1	working for pay	no	0	none	0	0

Table 1
Descriptive Data for Participants

	N	Mean	SD	Minimum	Maximum
OCD Participants					
Age	17	21.94	5.72	18	34
YBOCS Total Score	17	17.24	7.35	8	40
YBOCS Obsession Score	17	7.94	4.15	0	20
YBOCS Compulsive Score	17	9.29	3.44	5	20
OCI-R Hoarding	17	5.82	3.25	1	12
OCI-R Checking	17	3.76	3.46	0	11
OCI-R Symmetry	17	5.29	3.02	1	11
OCI-R Counting	17	1.82	2.1	0	7
OCI-R Washing	17	2.41	3.04	0	12
OCI-R Obsession	17	2	2.42	0	8
Control Participants					
Age	16	19.19	1.47	18	23
YBOCS Total Score	4*	4.75	2.06	3	7
OCI-R Hoarding	16	3.06	2.57	0	9
OCI-R Checking	16	1.19	1.05	0	3
OCI-R Symmetry	16	1.44	1.37	0	4
OCI-R Counting	16	0.38	0.72	0	2
OCI-R Washing	16	0.69	1.25	0	4
OCI-R Obsession	16	0.69	1.01	0	3

Note. YBOCS = Yale Brown Obsessive Compulsive Scale. OCI-R= Obsessive Compulsive Inventory Revised. *Controls who endorsed subclinical levels of OCD.

Table 2

Data for Regression Analyses for OCD and NAC Participants

Participant	Group	Obs	NLR			LR
			R2	b-param	c-param	R2
101	OCD	467	0.36	0.09	10.90	0.02
102	OCD	445	0.36	0.09	11.98	0.10
103	OCD	445	0.26	0.10	6.76	0.03
104	OCD	357	0.28	0.11	5.75	0.03
105	OCD	522	0.75	0.08	17.59	0.09
106	OCD	494	0.48	0.09	8.31	0.13
107	OCD	435	0.35	0.09	9.84	0.04
108	OCD	454	0.32	0.07	19.08	0.01
109	OCD	412	0.16	0.07	14.42	0.01
110	OCD	433	0.31	0.06	19.04	0.06
111	OCD	449	0.34	0.07	17.45	0.01
112	OCD	499	0.32	0.06	24.42	0.01
113	OCD	423	0.24	0.05	30.78	0.01
114	OCD	405	0.26	0.07	17.74	0.03
115	OCD	461	0.29	0.05	29.21	0.01
116	OCD	418	0.18	0.05	25.87	0
117	OCD	503	0.27	0.04	31.40	0.02
1	NAC	388	0	0	0	0
2	NAC	483	0	0	0	0
3	NAC	477	0	0	0	0
4	NAC	460	0	0	0	0
7	NAC	473	0	0	0	0
8*	NAC	420	0.19	0.05	33.31	0
9	NAC	464	0	0	0.00	0
11	NAC	382	0	0	0.00	0
12	NAC	404	0	0	0.00	0
13	NAC	451	0	0	0.00	0
14	NAC	410	0	0	0.00	0
15	NAC	463	0	0	0.00	0
19*	NAC	420	0.08	0.02	67.50	0
20*	NAC	549	0.31	0.03	67.59	0.02
21	NAC	473	0	0	0	0
46*	NAC	444	0	0.09	0	0

Note. Equation 1: $z_2 = \exp(\alpha z_{1t}) + \beta$. Obs = Number of Observations. *Control participants who endorsed subclinical levels of OCD. NLR = Nonlinear Regression. LR = Linear Regression.

Table 3

Data for Regression Analyses for OCD Participants with Family Reactions

Participant	NLR					LR
	R2	b-param	c-param	d-param	e-param	R2
101	0.37	0.09	-0.06*	2.16	10.21	0.04
102	0.38	0.09	-0.09*	-0.65*	12.18	0.13
103	0.27	0.10	10.90*	-217.46*	6.72	0.03
104	0.28	0.11	3.46*	-79.90*	5.77	0.03
105	0.77	0.08	0.11	-0.28*	17.51	0.09
106	0.50	0.09	-0.03*	2.30	7.87	0.14
107	0.35	0.09	10.66*	-117.82*	9.88	0.04
108	0.32	0.07	0.06*	-1.00*	19.22	0.02
109	0.17	0.07	-0.02*	-1.10*	14.52	0.02**
110	0.32	0.06	0.16*	1.01*	18.89	0.07
112	0.32	0.06	0.07*	-0.58*	24.41	0.01**
113	0.24	0.05	-0.11*	1.26*	30.84	0.01**

Note. Equation 4: $z_2 = \exp(\beta_1 z_1) + \gamma*FR + \delta*ER + \epsilon$. NLR = Nonlinear Regression. LR = Linear Regression. Unless indicated all data were significant at the .05 level. * computationally significant. ** $p > .05$.

Table 4

 Comparison of Model 1 and Model 2 Nonlinear Regression Analyses Results

Participant	Model 1		Model 2	
	R2	b-param	R2	b-param
101	0.36	0.09	0.37	0.09
102	0.36	0.09	0.38	0.09
103	0.26	0.10	0.27	0.10
104	0.28	0.11	0.28	0.11
105	0.75	0.08	0.77	0.08
106	0.48	0.09	0.50	0.09
107	0.35	0.09	0.35	0.09
108	0.32	0.07	0.32	0.07
109	0.16	0.07	0.17	0.07
110	0.31	0.06	0.32	0.06
112	0.32	0.06	0.32	0.06
113	0.24	0.05	0.24	0.05

Note. All data were statistically significant at the .05 level.

Table 5

Summary of Rank Order Correlations for OCD Participants for Model 1

Variable	1	2	3	4	5	M	SD
1 YBOCS	—	0.69 *	0.74 *	0.73 *	0.10	17.24	7.35
2 Ritual Saturation	0.69 *	—	0.41	0.96 *	-0.11	0.30	0.23
3 NLR - R2	0.74 *	0.41	—	0.43	0.47	0.32	0.13
4 Lyapunov	0.73 *	0.96 *	0.43	—	-0.15	0.07	0.02
5 WVS	0.10	-0.11	0.47	0.47	—	102	84.68

Note. Correlations for OCD participants ($n = 17$) are presented above. YBOCS = Yale Brown Obsessive Compulsive Scale; NLR-R2 = Nonlinear Regression R-squared; WVS = Work, Volunteer, School. * $p < .01$.

Table 6
Summary of Rank Order Correlations for OCD Participants with Family Reactions for Model 2

Variable	1	2	3	4	5	6	7	M	SD
1 YBOCS	—	0.67*	0.68 *	0.68 *	0.20	0.19	0.05	19.17	7.95
2 RS	0.67 *	—	0.14	0.94 *	-0.09	-0.20	-0.34	0.37	0.24
3 NR2	0.68 *	0.14	—	0.22	0.64 *	0.56	0.34	0.36	0.15
4 Lyapunov	0.68 *	0.94*	0.22	—	-0.06	-0.15	-0.44	0.08	0.02
5 FR	0.20	-0.09	0.64 *	-0.06	—	0.90**	0.31	0.02	0.03
6 ER	0.19	-0.20	0.56	-0.15	0.90**	—	0.47	0.07	0.12
7 WVS	0.05	-0.34	0.34	-0.44	0.31	0.47	—	112.33	97.50

Note. Correlations for OCD participants who recorded family reactions ($n = 12$) are presented above. YBOCS = Yale Brown Obsessive Compulsive Scale; RS = Ritual Saturation; NR2 = Nonlinear Regression R-squared; FR = Family Reaction Saturation; ER = Emotional Response; and WVS = Work, Volunteer, School. * $p < .05$. ** $p < .01$.