OBSESSIVE-COMPULSIVE DISORDER AND TREATMENT INTENSITY: A RATIONAL-CHOICE PERSPECTIVE

Gideon Yaniv

Research Papers
No. 1

March 2008
OBSESSIVE-COMPULSIVE DISORDER AND TREATMENT INTENSITY: 
A RATIONAL-CHOICE PERSPECTIVE

by

Gideon Yaniv

Forthcoming in Mathematical Social Sciences

Abstract

Obsessive-compulsive disorder (OCD) is a mental syndrome characterized by intrusive thoughts that trigger some repetitive action the individual feels driven to perform in order to relieve the anxiety engendered by the disturbing thoughts. A natural measure for the severity of OCD is the duration of the repetitive ritual. This paper presents a dynamic model of rational OCD that determines the optimal number of compulsory repetitions over the individual’s lifecycle through the choice of therapy intensity. The analysis reveals that in the case of mild disorder, compulsory repetitions rise steadily along the rationally optimal trajectory. In the case of severe disorder, the rationally optimal trajectory is U-shaped, with compulsory repetitions declining for some time before turning around and rising again. Recent studies suggest, however, that the majority of patients experience a waning and waxing course of illness. In particular, symptoms are often worse during times of psychological stress. Incorporating stress into the model, the paper shows that a waning and waxing course may be the outcome of rational coping with the emergence of stress.
I. Introduction

The fourth edition of *Diagnostic and Statistical Manual of Mental Disorders* [DSM-IV (1994)] defines obsessive-compulsive disorder (OCD) as a mental syndrome characterized by two distinct phenomena: obsessions and compulsions. Obsessions are intrusive, persistent and anxiety-provoking thoughts that are difficult to dismiss despite their disturbing nature. They are not simply excessive worries about real-life problems, but typically have senseless content. Compulsions are repetitive behaviors that the individual feels driven to perform in order to relieve the anxiety engendered by the obsession. The repetitive behavior is clearly excessive or is not connected in any realistic way with the anxiety it is meant to relieve, a fact that the individual typically recognizes. The most common obsessions involve intrusive thoughts about contamination (e.g., becoming infected by shaking hands or touching a dirty object), which compel the individual to wash hands or shower countless of times during the day, and nagging doubts of whether some safety act has been appropriately performed (e.g., turning off the gas stove or locking up the front door), which compel the individual to check and re-check his or her performance repeatedly. Other obsessions include need for symmetry or exactness, forbidden or perverse sexual thoughts, and fear of harming others or of doing something embarrassing. Other compulsions include repetitive ordering and arranging of household items, counting forward and backward, and repeating words silently. The repetitive behavior is time-consuming, causes considerable distress to the individual, and significantly interferes with his or her normal functioning, daily routine, and relationships with others.

Until the mid-1980's, the prevalence of OCD was considered to be extremely low (approximately 0.05 percent of the population). However, in a large empirical psychiatric study, the National Epidemiological Catchment Area study, conducted in the Unites States in 1984, OCD was found to be the fourth most common psychiatric disorder (after depression, substance abuse, and phobias), with a lifetime prevalence of 2.5 percent [Pato et al (1997)]. This means that in the United States alone about seven million people suffer from OCD. It is viewed as a chronic illness that if untreated will disable the individual for life. The most recommended treatment is behavioral therapy combined with medication [March et al (1997)]. Behavioral
therapy involves gradual exposure to the feared situation that provokes the obsession while attempting to resist the urge to perform the compulsive response. Medication helps reduce anxiety, thereby increasing the ability to utilize and benefit from behavioral therapy. The treatment results in considerable improvement for the majority of patients, although a complete cure is extremely rare [Jenike (1995)].

A natural measure for the severity of OCD is the duration of the repetitive ritual, or the number of times the individual compulsively repeats a certain act over and over again. The present paper introduces a dynamic model of rational OCD, which determines the optimal number of compulsory repetitions over the individual’s lifecycle. The basic idea underlying the analysis is that compulsory repetitions substitute for mental health in the attainment of peace of mind: the lower the individual’s mental health capital, the greater the number of repetitions he or she feels compelled to perform in order to relieve his or her anxiety. However, mental health capital can be increased through engaging in behavioral therapy, which involves a monetary cost and, like the repetitive ritual, requires the use of time. The repetitive ritual adversely affects the individual's utility, which is also assumed to increase with leisure and with the consumption of an aggregate good. The individual's problem is to choose a path of therapy intensity over time that maximizes his or her lifetime utility subject to peace-of-mind, budget, and time constraints. In doing so he or she necessarily determines an optimal path for the severity of OCD. Compulsory repetitions thus become the outcome of rational choice.

The paper applies the mathematical technique of optimal control to deriving rationally optimal trajectories of compulsory repetitions and therapy intensity over the individual’s lifecycle. The analysis reveals two prototypes of rationally optimal trajectories, depending on the initial severity of OCD. In the case of mild disorder, compulsory repetitions rise steadily along the rationally optimal trajectory. In the case of severe disorder, the optimal trajectory is U-shaped, with compulsory repetitions declining for some time before turning around and rising again. In the latter case, therapy intensity declines steadily over time; in the former case, therapy intensity rises for some time before declining. Surprisingly, there is no rationally optimal trajectory that exhibits a progressively improving course of illness over time.
Recent studies suggest, however, that relatively few patients experience a progressively improving or a progressively deteriorating course of illness over time. The majority of patients experience a waning and waxing course [Rasmussen and Eisen (1991)]. In particular, symptoms are often worse during times of psychological stress [Pato et al (1997)]. Perceiving stress as an exogenous shock to mental health capital, the paper shows that a waning and waxing course of OCD may be the outcome of rational coping with the emergence of stress.

II. The individual’s problem

Consider an individual who, at any instant of time \( t \), is flooded with obsessive thoughts regarding the possibility that he or she has been exposed to some unreasonable health risk (e.g., contamination by shaking someone's hand) or has inappropriately performed some safety act (e.g., locking up the front door). Suppose that the obsessive thoughts engender significant anxiety that undermines the individual's peace of mind. Consequently, he or she feels compelled to perform some repetitive act (e.g., washing hands) or ritual (e.g., unlocking and relocking the door) until a satisfactory level of peace of mind, \( P \), is restored. Attaining a satisfactory level of peace of mind may be viewed as a short-run production process which involves the individual's mental health capital, \( H(t) \), as a fixed input, and the number of repetitions, \( n(t) \), as a variable one: the lower the stock of mental health capital, the more intensive the obsessive thoughts, hence the greater the number of repetitions the individual is compelled to perform in order to maintain peace of mind. For simplicity, suppose that the peace-of-mind production function is multiplicative in \( H(t) \) and \( n(t) \), namely

\[
P = P[H(t), n(t)] = H(t)n(t),
\]

and that the satisfactory level of peace of mind is unity. That is, the individual seeks to maintain \( H(t)n(t) = 1 \). This implies that if \( H(t) \) is unity, \( n(t) = 1 \), in which case the individual performs the anxiety-relieving act only once. \( H(t) = 1 \) thus represents "normal" mental health. Abnormal mental health will consequently be represented by
$H(t) < 1$, in which case $n(t)$ will exceed unity: if, for example, $H(t) = 1/10$, the individual will repeat the anxiety-relieving act 10 times.

While compulsory repetitions help restore peace of mind, they are time consuming and a source of considerable distress to the individual. Suppose therefore that at some point of time ($t = 0$) the individual consults with a psychiatrist, who suggests medication in combination with behavioral therapy as an appropriate treatment. While the psychiatrist determines the dosage of medication, the individual is free to choose the intensity of behavioral therapy. Given the prescribed dosage of medication, suppose that devoting $b(t)$ units of time to behavioral therapy increases future mental health capital by $f[b(t)]$ units, where $f'(b) > 0$, $f''(b) < 0$ and $f(0) = 0$, $f'(0) = \infty$.

The chronic course of OCD implies that at any instant $t$ mental health capital is also subject to depreciation. That is, without treatment, mental health capital is bound to deteriorate continuously. The motion equation for the mental health capital is therefore given by

$$
\dot{H}(t) = f[b(t)] - \delta H(t),
$$

(2)

where $\dot{H}(t)$ denotes the instantaneous change in the individual's mental health capital at instant $t$ and $\delta$ denotes an exogenously given rate of depreciation. Differentiating the peace-of-mind constraint, $H(t)n(t) = 1$, with respect to $t$ and substituting $\dot{H}(t) = -[\dot{n}(t)/n(t)]H(t)$ and $H(t) = 1/n(t)$ in equation (2), the motion equation for the number of compulsory repetitions, $n(t)$, is given by

$$
\dot{n}(t) = n(t)[\delta - n(t)f[b(t)]],
$$

(3)

where $\dot{n}(t)$ denotes the instantaneous change in the number of repetitions at instant $t$.

Behavioral therapy, the same as compulsory repetitions, is a time-consuming activity. Work and leisure require the use of time as well. Suppose, for simplicity, that time devoted to work is institutionally fixed. Suppose further that at any instant $t$ the individual is left with one unit of time to be divided between compulsory repetitions,
\( n(t) \), behavioral therapy, \( b(t) \), and leisure, \( \ell(t) \). Assuming that each repetition requires \( z (< 1) \) units of time, the individual's instantaneous time constraint is given by

\[
zn(t) + b(t) + \ell(t) = 1.
\]  

(4)

Behavioral therapy also entails a monetary cost, as a fee must be paid to the therapist. Money must also be spent on the consumption of a composite good, \( c(t) \), the price of which is normalized to 1. Suppose, for simplicity, that the individual cannot lend or borrow money, so that monetary expenses at any instant \( t \) are constrained by his or her current earnings, \( G \). Denoting the therapist's fee per unit of therapy time by \( \pi \), and assuming that the cost of medication is fully covered by health insurance, the individual's instantaneous budget constraint is given by

\[
c(t) + \pi b(t) = G.
\]  

(5)

The individual's instantaneous utility, \( U(t) \), is assumed to be an increasing function of consumption and leisure, but a decreasing function of the number of repetitions. That is, the instantaneous utility function is given by

\[
U(t) = U[c(t), \ell(t), n(t)],
\]  

(6)

where \( U_c > 0 \), \( U_\ell > 0 \), and \( U_n < 0 \). Notice that compulsory repetitions are assumed to have a direct negative effect on utility, even though they already bear an adverse effect on utility through competing with leisure on the individual's off-work time. The reason for this is that the repetitive ritual is not just time-consuming, but also causes considerable distress to the individual as well as shame and/or reputation loss due to public exposure of the compulsive behavior.\(^1\)

\(^1\)Reputation loss might lead to low-paying employment, as a result of which the individual's budget constraint might be endogenous rather than fixed, despite an institutionally fixed working time. That is, earnings might fall with reputation, the variation in which over time may be assumed to be proportional to the difference between the overall number of compulsory repetitions and the number of socially excusable ones. This, however, requires the introduction of reputation as a second state variable in the model, which would extremely complicate the analysis.
The individual's problem is to choose a path of therapy intensity over a given planning horizon (from time 0 to time $T$) so as to maximize the present value of his or her lifetime utility

$$
\int_{0}^{T} e^{-\rho t} U(c(t), \ell(t), n(t)) dt,
$$

subject to constraints (3), (4), and (5), where $\rho$ denotes a constant rate of time preference. It immediately follows from the motion equation (3) that by choosing an optimal path of therapy intensity over time the individual also chooses a rationally optimal path of compulsory repetitions.

The individual's problem may be viewed as a problem in optimal control which involves a state variable, $n(t)$, which is subject to a dynamic constraint (3) and a static time constraint (4), and a control variable, $b(t)$, which is subject to static time and budget constraints, (4) and (5). The control variable influences the objective function (7) directly (through its own value) and indirectly through its impact on the evolution of the state variable. The maximization problem is carried out for an initial value of the state variable, $n(0) > 1$, which reflects the severity of OCD at the beginning of the planning horizon. The terminal value of the state variable, $n(T)$, is left free, to be optimally determined by the individual. It cannot, however, fall below unity, obeying the restriction $n(T) \geq 1$.

III. Optimum conditions and stationary loci

Applying Pontryagin's Maximum Principle, and using constraints (5) and (4) to eliminate $c(t)$ and $\ell(t)$ from the objective function (7), the problem at hand calls for the maximization of the current value Hamiltonian.

---

2 For excellent expositions of the optimal control approach to dynamic optimization and the core of its solution procedures, known as Pontryagin's maximum principle, see Chiang (2000) and Leonard and Van Long (1998).
\[ M(b, n, \psi, t) : U[G - \pi b(t), 1 - b(t) - zn(t), n(t)] + \psi(t)n(t)\{[\delta - n(t)f(b(t))] \}, \quad (8) \]

where \( \psi(t) \) is a dynamic multiplier representing the 'shadow price' of compulsory repetitions at time \( t \). That is, \( \psi(t) \) reflects the individual's subjective valuation of a slight increment in the number of repetitions. Because repetitions are undesirable (an increase in their number reduces utility), \( \psi(t) \) must obtain a non-positive value.

Notice, however, that consumption, \( G - \pi b(t) \), and leisure, \( 1 - b(t) - zn(t) \), cannot be negative, hence the choice of treatment intensity, \( b(i) \), is subject to two upper bounds: the constraint on consumption implies that \( b(t) \leq G / \pi \), whereas the constraint on leisure implies that \( b(t) \leq 1 - zn(t) \). Assuming, however, that \( G / \pi > 1 \), only the time constraint may be binding. Accordingly, the problem requires the maximization of the Lagrangean

\[ L(b, n, \psi, \lambda, t) = M(b, n, \psi, t) + \lambda(t)[1 - zn(t) - b(t)] \quad (9) \]

with: \( \lambda(t) \geq 0; \ 1 - zn(t) - b(t) \geq 0; \ \lambda(t)[1 - zn(t) - b(t)] = 0 \),

where \( \lambda(t) \) is the Lagrange multiplier. The control variable is also subject to a non-negativity restriction, \( b(t) \geq 0 \), to which we may apply the Kuhn-Tucker conditions without introducing a specific multiplier.

To facilitate the mathematical analysis, we proceed by assuming that the individual's instantaneous utility function is linear in its three arguments. That is

\[ U[G - \pi b(t), 1 - b(t) - zn(t), n(t)] = \alpha[G - \pi b(t)] + \beta[1 - b(t) - zn(t)] - \gamma n(t) \], \quad (10) \]

where \( \alpha > 0, \beta > 0, \gamma > 0 \). Substituting (10) into (8), and (8) into (9), the necessary conditions for the maximization of \( L \) are (suppressing, for simplicity, the time argument, \( t \))
\[
\frac{\partial L}{\partial b} = -\alpha \pi - \beta - \psi n^2 f'(b) - \lambda \leq 0
\]  \hspace{1cm} (11)

with: \hspace{1cm} b \geq 0; \quad b \frac{\partial L}{\partial b} = 0

\[
\psi = -\frac{\partial L}{\partial n} + \psi \rho = (\beta + \lambda) z + \gamma + \psi [\rho + 2nf(b) - \delta] \tag{12}
\]

\[
\dot{n} = \frac{\partial L}{\partial \psi} = n[\delta - n(f(b)] \tag{13}
\]

and the transversality condition:

\[
\psi(T) \leq 0; \quad \psi(T)[n(T) - 1] = 0, \tag{14}
\]

which requires that compulsory repetitions lose their (negative) value at the end of the planning horizon.

We first consider the set of interior solutions, for which the lower and upper bounds on treatment intensity are not binding, thus \(0 < b < 1 - zn\) and \(\lambda = 0\). The Lagrange multiplier drops out of (11) and (12), and the necessary conditions reduce to those that maximize the Hamiltonian, \(M\), with (11) holding as an equality.\(^3\) Interpreting (11), notice that \(\alpha\) and \(\beta\) denote the marginal utility from consumption and leisure, respectively, thus \(\alpha \pi + \beta\) is the full price, or the marginal cost, of therapy in utility terms. Condition (11) thus requires that the intensity of therapy will be determined such that the marginal cost equal the marginal benefit, \(-\psi n^2 f'(b)\). The latter expression stems from the fact that a marginal increase in \(b\) increases mental health capital by \(f'(b)\) units, while each additional unit of mental health capital reduces the number of repetitions by \(n^2\) (notice from the peace-of-mind constraint that \(\partial n/\partial H = -n/H = -n^2\)).

\(^3\) Notice that \(\partial^2 M / \partial b^2 < 0\) and \(\partial^2 M / \partial n^2 > 0\), implying that the Hamiltonian is concave in the control variable and convex in the state variable. Hence, the Mangasarian’s theorem on the sufficiency of Pontryagin’s maximum-principle conditions is not valid in this case, due to the non-concavity of the Hamiltonian in the state variable.
Differentiating now (11) with respect to time yields a second differential equation for the shadow price, \( \psi \):

\[
\dot{\psi} = \frac{[2f'(b)\dot{n} + f''(b)n\dot{b}][\alpha\pi + \beta]}{[f'(b)]^2n^3},
\]

(15)

and using (13) to eliminate \( \dot{n} \) from (15), substituting (11) into (12) to eliminate \( \psi \), and equating (15) and (12) to eliminate \( \dot{\psi} \), yields a differential equation for the treatment intensity, \( b \):

\[
\dot{b} = \frac{[\beta z + \gamma f'(b)n^2 - (\rho + \delta)(\alpha\pi + \beta)]f'(b)}{(\alpha\pi + \beta)f''(b)}.
\]

(16)

Equations (13) and (16) constitute a system of two differential equations which can be represented in a state-control space, known as a phase diagram (Figure 1). In particular, the stationary locus for compulsory repetitions (satisfying \( \dot{n} = 0 \)) is represented by the negatively sloped isocline

\[
n\big|_{\dot{n} = 0} = \frac{\delta}{f(b)},
\]

(17)

whereas the stationary locus for therapy intensity (satisfying \( \dot{b} = 0 \)) is represented by the positively-sloped isocline

\[
n\big|_{\dot{b} = 0} = \left[ \frac{(\rho + \delta)(\alpha\pi + \beta)}{(\beta z + \gamma)f'(b)} \right]^{\frac{1}{2}}.
\]

(18)

Notice that \( (\alpha\pi + \beta) / f'(b) \) is the marginal cost, in utility terms, of producing health capital, and \( (\rho + \delta)(\alpha\pi + \beta) / f'(b) \) is the individual's cost of using a unit of health capital at any instant of time. Along the stationary locus for therapy intensity, the individual's user cost of health capital equates the utility gain derived from an additional unit of capital via the reduction in compulsory repetitions, \( (\beta z + \gamma)n^2 \).
Figure 1: Phase diagram of therapy intensity and compulsory repetitions
The stationary combination of therapy intensity and compulsory repetitions is unique and obtained at the intersection of the two isoclines. It is assumed to lie within the individual’s time constraint, $zn + b \leq 1$, represented by the triangle OCD.

IV. The rational evolution of OCD

The phase diagram may now be used to track down the rationally optimal trajectory of therapy intensity and compulsory repetitions over time. To do this, we must first determine the directions of motion of $n$ and $b$ in each region of the phase diagram (indicated by two small perpendicular arrows). Partially differentiating the two motion equations (13) and (16), we obtain

$$\frac{\partial \dot{n}}{\partial b} = -n^2 f'(b) < 0 \quad (19)$$

$$\frac{\partial \dot{b}}{\partial n} = \frac{(\beta z + \gamma)f''(b)2n}{(\alpha x + \beta)f''(b)} < 0, \quad (20)$$

respectively. Equation (19) indicates that as $b$ rises beyond the $\dot{n} = 0$ locus (goes eastward), $\dot{n}$ becomes negative, so the $n$-arrowheads must point downward above the $\dot{n} = 0$ locus, and upward below it. Similarly, equation (20) indicates that as $n$ rises above the $\dot{b} = 0$ locus (goes upwards), $\dot{b}$ becomes negative, so the $b$-arrowheads must point westward to the right of the $\dot{b} = 0$ locus, and eastward to the left of it. The trajectories drawn in accordance with these arrowheads imply that the stationary combination of $n$ and $b$ is a saddle point: while there are two paths converging to the stationary point, there are also two paths leading away from it.

If the planning horizon were infinite (i.e., if the individual believed he or she will live forever), a trajectory converging to the stationary solution would be rationally optimal: for any given level of $n(0)$, the individual would select $b(0)$ that lies on that trajectory. However, in a finite-horizon problem, a key determinant of the rationally optimal trajectory is the transversality condition, $\psi(T)[n(T) - 1] = 0$. That is, the
shadow price must go to zero at the end of the planning horizon, or the individual entirely heals (i.e., the anxiety-relieving act is performed only once). The former possibility, \( \psi(T) = 0 \), implies, by the optimum condition (11), that \( \partial L/\partial b < 0 \), requiring that therapy intensity at the last instant of planning, \( b(T) \), be zero. Indeed, because therapy is costly, in both money and time, it is irrational to invest in therapy that could only bear fruit after the termination of the planning horizon. The latter possibility, \( n(T) = 1 \), is not admissible, because it calls for \( b(T) > 0 \). It thus follows that a rationally optimal trajectory of therapy intensity and compulsory repetitions must end on the vertical axis.

Figure 1 reveals two prototypes of rationally optimal trajectories, denoted by the starting points \( A \) and \( B \), which differ in the initial severity of OCD: trajectory \( A \) corresponds to a state of mild disorder [low level of \( n(0) \)], whereas trajectory \( B \) corresponds to a state of severe disorder [high level of \( n(0) \)]. Along trajectory \( A \), compulsory repetitions continuously increase with time, despite an initial increase in therapy intensity. This is due to the high depreciation (on the high stock of mental health capital accounting for the mild disorder), which is not fully offset by the production of new capital through behavioral therapy. Consequently, the stock of capital falls with time, compelling the individual to increase the number of repetitions. As therapy intensity begins to fall with time, the deterioration of illness is exacerbated.

In contrast, trajectory \( B \) is U-shaped, along which compulsory repetitions first decrease with time, despite an accompanying fall in therapy intensity. This is due to the low depreciation (on the low stock of mental health capital generating the severe disorder), which is more than offset by the production of new capital. Consequently, the stock of capital increases with time, enabling the individual to reduce the number of repetitions. However, as time progresses, trajectory \( B \) changes direction, exhibiting, the same as trajectory \( A \), continuous deterioration in OCD. Notice that trajectory \( B \) suggests itself only if the steady state solution lies within the individual’s time constraint. Otherwise, only trajectory of type \( A \) is rationally optimal.
For any initial severity of OCD, the initial intensity of therapy selected by the individual depends on the length of the planning horizon: the longer the planning horizon, the higher the initial intensity of therapy and the deeper the curvature of the optimal trajectory. No matter how long is the planning horizon, it is always possible to select a path like trajectory $B$, because (ignoring the upper bound on $b$) there is always one that goes down arbitrarily close to the steady state equilibrium (point $s$), where movements along the path are very slow, before turning up again. However, when the planning horizon is very short, trajectories $A$ and $B$ will begin on the left side of the $n = 0$ and $b = 0$ isoclines, respectively. Trajectory $B$ will consequently lose its declining segment, displaying continuous deterioration in OCD. While a rationally optimal trajectory may monotonically exacerbate OCD over time, it nevertheless moderates the progression of illness as compared to the alternative of no therapy, and is preferable to the latter, which will only be chosen if the planning horizon consists of just one instant of time (i.e., if there is no tomorrow). Unfortunately, there is no rationally optimal trajectory that exhibits a progressively improving course of illness over time.

Consider finally the case in which the upper bound on therapy intensity is active. This means that for any given value of the state variable, $n$, the control variable, $b$, must be set at $1 - zn$, even though an unconstrained optimization would call for a higher value of $b$. In terms of Figure 1, the selected value of $b$ must lie on the hypotenuse of the OCD triangle. Starting with an arbitrary $n(0)$, suppose that the matching value of $b(0)$ on the unconstrained optimal path is represented by point $F$. The constrained value of $b(0)$ is thus represented by point $E$. To determine the movement of the constrained path, we substitute $b = 1 - zn$ in (13), which fails to yield a clear-cut sign for $\dot{n}$. Hence, while the unconstrained path moves from point $F$ in the southwest direction, the constrained path may move northwest along the $CD$ bound. In this case, it may (but must not necessarily) leave the $CD$ line at some point, if the upper bound ceases

---

4 Because the constrained value of $b(0)$ is lower than its optimal value, the production of new health capital may not suffice to meet the current level of depreciation. Hence, the net addition to the stock of capital may be negative, resulting in an increased number of repetitions.
to be active. If, alternatively, the constrained path begins moving southeast along the $CD$ line, it must eventually take a U-turn so as to terminate on the vertical axis.

V. OCD and psychological stress

Recent studies suggest that relatively few patients experience a progressively improving or a progressively deteriorating course of illness over time. The majority of patients experience a waning and waxing course [Rasmussen and Eisen (1991)]. That is, symptoms are present continuously, with varying degrees of intensity over time. In particular, symptoms are worse during times of psychological stress [Pato et al (1997)]. We now show that the introduction of stress to the model may generate a rationally optimal path of compulsive repetitions over time that is consistent with observed behavior.

The emergence of stress may be viewed as an exogenous shock to the model, which causes a fall, of size $S$, in mental health capital. The motion equation for the mental health capital will then become

$$\dot{H} = f(b) - \delta H - S,$$  \hspace{1cm} (2')

implying that the motion equation for the number of compulsory repetitions is

$$\dot{n} = n(\delta - n[f(b) - S]).$$  \hspace{1cm} (3')

Consequently, the negatively sloped isocline representing the stationary locus for compulsory repetitions ($\dot{n} = 0$) will change to

$$n|_{\dot{n}=0} = \frac{\delta}{f(b) - S},$$  \hspace{1cm} (17')

shifting upwards with the emergence of stress, as $n$ will be higher at each $b$ for $S > 0$. 

13
Figure 2 depicts the $n=0$ locus in the absence and presence of stress, denoted by $R$ and $R'$, respectively. Consider an individual who, in the absence of stress, begins to slide down along trajectory $B$. Suppose that by the time he or she reaches point $C$, stress emerges. Consequently, the $n=0$ locus shifts from $R$ to $R'$, inducing the individual to change direction and climb up the bold trajectory toward point $D$. By the time he or she reaches that point, stress subsides. Consequently, the $n=0$ locus shifts back from $R'$ to $R$. This induces the individual to change direction again and slide down on the bold trajectory toward point $E$. At that point he or she switches again to an upward course toward point $F$. In sum, the rationally optimal trajectory becomes $BCDEF$, displaying a waning and waxing course of illness. The behavior of OCD patients over time thus conforms with rational response to the emergence of stress.

VI. Concluding Remarks

The present paper has introduced a dynamic model of rational OCD that determines the optimal number of compulsory repetitions over the individual’s lifecycle. It belongs to a growing economic literature that applies rationality to the analysis of mental health disorders, such as addiction behavior [e.g., Becker and Murphy (1988), Svanov et al (1999), Ferguson (2000)], agoraphobia [Yaniv (1998)], anorexia [Levy (2002)], insomnia [Yaniv (2004)], or depression [Levy (2006)]. Economists have applied optimization techniques to these problems, traditionally considered to lie within the domain of clinical psychology, showing that they may be consistent with rational behavior. While the onset of OCD is determined by the interaction of genetic and neurobiological factors (although a recent psychological theory, psychobizarreness theory [Rofe (2000)] perceives the onset of OCD as the consequence of rational choice), the present paper suggests that the severity of the illness, as reflected by the number of compulsory repetitions, may be viewed as the outcome of rational choice: because behavioral therapy is costly, involving time and money expenses, a cost-conscious individual may opt to insufficiently engage in therapy despite recognizing its favorable effect on his or her future welfare. Moreover, behavioral therapy is based on the principle of exposure and response prevention, requiring the patient to endure the anxiety that the obsession provokes while refraining from compulsions that allay the anxiety. This psychic cost of therapy, which has not been
Figure 2: The effect of stress on the rationally optimal trajectory of compulsory repetitions.
incorporated into the present model, may constitute a further deterrence to intensive participation. Weighing the current costs against the future benefits of therapy, a rational individual may allow the severity of OCD to exacerbate with time, if he or she finds this course too costly to avoid.
REFERENCES


Obsessive-Compulsive Disorder (OCD) is an anxiety disorder and is characterized by recurrent, unwanted thoughts (obsessions) and/or repetitive behaviors (compulsions). For many patients, EX/RP is the add-on treatment of choice when SRIs or SSRIs medication does not effectively treat OCD symptoms or vice versa for individuals who begin treatment with psychotherapy. Other Treatment Options. In 2018, the FDA approved Transcranial Magnetic Stimulation (TMS) as an adjunct in the treatment of OCD in adults.