Positive Affect and the Complex Dynamics of Human Flourishing

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*Extending B. L. Fredrickson's (1998) broaden-and-build theory of positive emotions and M. Losada's (1999) nonlinear dynamics model of team performance, the authors predict that a ratio of positive to negative affect at or above 2.9 will characterize individuals in flourishing mental health. Participants (*N = *188) completed an initial survey to identify flourishing mental health and then provided daily reports of experienced positive and negative emotions over 28 days. Results showed that the mean ratio of positive to negative affect was above 2.9 for individuals classified as flourishing and below that threshold for those not flourishing. Together with other evidence, these findings suggest that a set of general mathematical principles may describe the relations between positive affect and human flourishing.*

Keywords: nonlinear systems, emotions, broaden-and-build theory, positive psychology, subjective well-being

To *flourish* means to live within an optimal range of human functioning, one that connotes goodness, generativity, growth, and resilience. This definition builds on path-breaking work that measures mental health in positive terms rather than by the absence of mental illness (Keyes, 2002). Flourishing contrasts not just with pathology but also with *languishing*: a disorder intermediate along the mental health continuum experienced by people who describe their lives as "hollow" or "empty." Epidemiological work suggests that fewer than 20% of U.S. adults flourish and that the costs of languishing are high; relative to flourishing (and comparable to depression), languishing brings more emotional distress, psychosocial impairment, limitations in daily activities, and lost work days (Keyes, 2002).

What predicts whether people will flourish or languish? Are the predictors similar for individuals, relationships, and larger groups? Drawing together existing theory and research on affect and nonlinear dynamic systems, we propose that a key predictor of flourishing is the ratio of positive to negative affect.

Over time, and in both private and social contexts, people experience a range of pleasant and unpleasant emotions and moods, and they express a variety of positive and negative evaluative sentiments or attitudes. We use *affect* to represent this spectrum of valenced feeling states and attitudes, with *positive affect* and *positivity* interchangeably representing the pleasant end (e.g., feeling grateful, upbeat; expressing appreciation, liking) and *negative affect* and *negativity* representing the unpleasant end (e.g., feeling contemptuous, irritable; expressing disdain, disliking). The affective texture of a person's life—or of a given relationship or group—can be represented by its *positivity ratio*, the ratio of pleasant feelings and sentiments to unpleasant ones over time. Past research has shown that for individuals, this ratio predicts subjective well-being (Diener, 2000; Kahneman, 1999). Pushing further, we hypothesize that—for individuals, relationships, and teams—positivity ratios that meet or exceed a certain threshold characterize human flourishing. Although both negative and positive affect can produce adaptive and maladaptive outcomes, a review of the benefits of positive affect provides a particularly useful backdrop for our theorizing.

Benefits of Positive Affect: Empirical Evidence

A wide spectrum of empirical evidence documents the adaptive value of positive affect (for a review, see Lyubomirsky, King, & Diener, in press). Beyond their pleasant subjective feel, positive emotions, positive moods, and positive sentiments carry multiple, interrelated benefits. First, these good feelings alter people's mindsets: Experiments have shown that induced positive affect widens the scope of attention (Fredrickson & Branigan, 2005; Rowe, Hirsch, & Anderson, 2005), broadens behavioral repertoires (Fredrickson & Branigan, 2005), and increases intuition (Bolte, Goschkey, & Kuhl, 2003) and creativity (Isen, Daubman, & Nowicki, 1987). Second, good feelings alter people's bodily systems: Experiments have shown that induced positive affect speeds recovery from the cardio-

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vascular aftereffects of negative affect (Fredrickson, Mancuso, Branigan, & Tugade, 2000), alters frontal brain asymmetry (Davidson et al., 2003), and increases immune function (Davidson et al., 2003). Third, good feelings predict salubrious mental and physical health outcomes: Prospective studies have shown that frequent positive affect predicts (a) resilience to adversity (Fredrickson, Tugade, Waugh, & Larkin, 2003), (b) increased happiness (Fredrickson & Joiner, 2002), (c) psychological growth (Fredrickson et al., 2003), (d) lower levels of cortisol (Steptoe, Wardle, & Marmot, 2005), (e) reduced inflammatory responses to stress (Steptoe et al., 2005), (f) reductions in subsequent-day physical pain (Gil et al., 2004), (g) resistance to rhinoviruses (Cohen, Doyle, Turner, Alper, & Skoner, 2003), and (h) reductions in stroke (Ostir, Markides, Peek, & Goodwin, 2001). And fourth, perhaps reflecting these effects in combination, good feelings predict how long people live: Several well-controlled longitudinal studies document a clear link between frequent positive affect and longevity (Danner, Snowdon, & Friesen, 2001; Levy, Slade, Kunkel, & Kasl, 2002; Moskowitz, 2003; Ostir, Markides, Black, & Goodwin, 2000).

The Broaden-and-Build Theory

The varied good outcomes empirically linked with positive affect support the *broaden-and-build theory*, which asserts that positive emotions are evolved psychological adaptations that increased human ancestors' odds of survival and reproduction (Fredrickson, 1998). The theory holds that unlike negative emotions, which narrow people's behavioral urges toward specific actions that were life-preserving for human ancestors (e.g., fight, flight), positive emotions widen the array of thoughts and actions called forth (e.g., play, explore), facilitating generativity and behavioral flexibility. Laboratory experiments support these claims, showing that relative to neutral states, induced negative emotions narrow people's momentary thought–action repertoires, whereas induced positive emotions broaden these same repertoires (Fredrickson & Branigan, 2005).

The theory holds that in contrast with the benefits of negative emotions—which are direct and immediately adaptive in life-threatening situations—the benefits of broadened thought–action repertoires emerge over time. Specifically, broadened mindsets carry indirect and long-term adaptive value because broadening builds enduring personal resources, like social connections, coping strategies, and environmental knowledge. As an illustration, consider the link between interest and exploration. Research shows that initially positive attitudes—like interest and curiosity—produce more accurate subsequent knowledge than do initially negative attitudes—like boredom and cynicism. Positivity, by prompting approach and exploration, creates experiential learning opportunities that confirm or correct initial expectations. By contrast, because negativity promotes avoidance, opportunities to correct false impressions are passed by (Fazio, Eiser, & Shook, 2004). These findings suggest that positive affect—by broadening exploratory behavior in the moment—over time builds more accurate cognitive maps of what is good and bad in the environment. This greater knowledge becomes a lasting personal resource.

Although positive affect is transient, the personal resources accrued across moments of positivity are durable. As these resources accumulate, they function as reserves that can be drawn on to manage future threats and increase odds of survival. So experiences of positive affect, although fleeting, can spark dynamic processes with downstream repercussions for growth and resilience.

Whereas traditional perspectives hold that positive affect marks or signals current health and well-being (Diener, 2000; Kahneman, 1999), the broaden-and-build theory goes further to suggest that positive affect also produces future health and well-being (Fredrickson, 2001). Put differently, because the broaden-and-build effects of positive affect accumulate and compound over time, positivity can transform individuals for the better, making them healthier, more socially integrated, knowledgeable, effective, and resilient. Supporting this view, prospective studies by Fredrickson and colleagues have shown that positive affect at initial assessment predicts increases in well-being several weeks later, in part by broadening people's mindsets (Fredrickson & Joiner, 2002) and building their psychological resources (Fredrickson, Brown, Cohn, Conway, & Mikels, 2005). This evidence motivates our prediction that positive affect is a critical ingredient within flourishing mental health.

A Nonlinear Dynamic Systems Perspective

We favor a nonlinear dynamic systems approach to positive affect for several reasons. First, theory and research on affective phenomena have already established that emo-

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tions are multicomponent *systems* that simultaneously alter patterns of thinking, behavior, subjective experience, verbal and nonverbal communication, and physiological activity. Second, such multicomponent affect systems are *dynamic*: They change over time as the various components within the affect system mutually influence one another. For instance, just as positive thinking and positive actions can trigger pleasant feeling states, so too can pleasant feeling states trigger positive thinking and positive actions (Fredrickson & Joiner, 2002). Such reciprocal causality and feedback within dynamic systems is best modeled with nonlinear equations because nonlinearity allows interactive and bidirectional relations (Nowak & Vallacher, 1998). Third, available evidence suggests that the dynamic systems that characterize affect are indeed *nonlinear*. For instance, even mild and fleeting positive affect can produce large benefits in the long run (Danner et al., 2001), underscoring the fact that outcomes (e.g., longevity) are not always proportional to inputs (e.g., expressed positivity). That observation may reflect the hallmark feature of nonlinear dynamic systems, known as *sensitive dependence on initial conditions*, often conveyed symbolically as the butterfly effect: As in weather forecasting, seemingly trivial inputs—like the flap of a butterfly's wings in one location—can disproportionately determine later conditions elsewhere (Lorenz, 1993).

Fourth, the broaden-and-build theory resonates with two intertwined core concepts within nonlinear dynamic systems—namely, local unpredictability and global stability. Complex biological systems illustrate these concepts. In good health, people's heart rates show beat-to-beat irregularity reflective of chaos (Goldberger, Rigney, & West, 1990). This heart rate variability is adaptive because "chaotic systems operate under a wide range of conditions and are therefore adaptable and flexible. This plasticity allows systems to cope with the exigencies of an unpredictable and changing environment" (Goldberger et al., 1990, p. 49). Similarly, fast and accurate perception seems to depend on chaotic neural systems. "Chaos underlies the ability of the brain to respond flexibly to the outside world and to generate novel activity patterns, including those that are experienced as fresh ideas" (Freeman, 1991, p. 78). In both cardiac and neurological systems, then, seemingly unpredictable local changes give rise to stable and flexible global outcomes.

A similar dynamic emerges for positive affect systems. Given that positive affect broadens momentary thought–action repertoires whereas negative affect narrows those same repertoires, people are indeed less predictable in positive states than in negative states. The broaden-and-build theory holds that the momentary unpredictability characteristic of positive states over time yields resilience that allows people to flexibly adapt to inevitable crises (Fredrickson et al., 2003). The links among positivity, local unpredictability, and global stability have been demonstrated empirically at multiple levels of analysis. Within individuals, people induced to feel positive emotions, as noted earlier, report wider arrays of action urges in the moment (Fredrickson & Branigan, 2005), which would make predicting their behavior more difficult. Relatedly, people's trait positivity predicts greater variability and complexity within the microdynamics of their moment-to-moment moods (Schuldberg & Gottlieb, 2000). Despite this momentary unpredictability of affect and behavior, over time, people who regularly experience positive affect exhibit greater resilience to adversity (Folkman & Moskowitz, 2000; Fredrickson et al., 2003). Within married couples, greater marital happiness is associated with less predictability from moment to moment as spouses interact, and yet, over time, these marriages are the ones most likely to last (Gottman, 1994). Within business teams, higher levels of expressed positivity among group members have been linked to greater behavioral variability within moment-to-moment interactions as well as to long-range indicators of business success (Losada & Heaphy, 2004). And within organizations, positive experiences have been linked to broader information processing strategies and greater variability in perspectives across organizational members as well as to organizational resilience in the face of threat (Sutcliffe & Vogus, 2003). The commonalities between affect systems and nonlinear dynamic systems raise the possibility that the complex dynamics of chaos underlie the proposed link between positive affect and human flourishing.

Is There a Critical Positivity Ratio?

Four distinct lines of evidence suggest that high ratios of positive to negative affect would distinguish individuals who flourish from those who do not. First, studies show that mild positive affect characterizes the modal human experience (Diener & Diener, 1996). This *positivity offset* equips individuals with the adaptive bias to approach and explore novel objects, people, or situations (Cacioppo,

Table 1
Coupled Differential Equations Developed by Losada (1999) to Describe the Differential Performance of Low-, Medium-, and High-Performance Teams

Variable	Differential equation	Constant
X = inquiry–advocacy	$dX/dt = (Z - X)a$	a = 10
Y = positivity–negativity	$dY/dt = XZ - bY$	b = 8/3
Z = other–self	$dZ/dt = cX - XY - Z$	c = connectivity[a]

Note. The initial conditions are $X_0 = 1$, $Y_0 = 16$, and $Z_0 = 1$. The integration step, Δt, was set to .02. The integration algorithm was Runge–Kutta Order 4.
[a] The control parameter, defined by the number of empirically observed nexi (strong, lasting social connections, as measured by the cross-correlation function). This parameter was set to 18 (the number of nexi) for low-performance teams, 22 for medium-performance teams, and 32 for high-performance teams.

Gardner, & Berntson, 1999). Second, several recent research reviews have concurred that "bad is stronger than good" (e.g., Baumeister, Bratslavsky, Finkenauer, & Vohs, 2001; Rozin & Royzman, 2001). The implication is that to overcome the toxicity of negative affect and to promote flourishing, experiences of positivity may need to outnumber experiences of negativity, perhaps at ratios appreciably higher than those typically represented in the modal positivity offset. Third, on the basis of a mathematical model of consciousness rooted in Boolean algebra, the reformulated balanced states of mind model (Schwartz, 1997) suggests that optimal mental health is associated with high ratios of positive to negative affect. According to this model, normal functioning is characterized by ratios near 2.5,[1] whereas optimal functioning is characterized by ratios near 4.3 (Schwartz et al., 2002). Fourth, summarizing two decades of observational research on marriages, Gottman (1994) concluded that unless a couple is able to maintain a high ratio of positive to negative affect (~5), it is highly likely that their marriage will end.

Consistent with this earlier evidence, our suggestion that individuals or groups must meet or surpass a specific positivity ratio to flourish derives from a nonlinear dynamics model empirically validated by Losada (1999), who studied the interpersonal dynamics of business teams. From behind one-way mirrors, trained coders observed 60 management teams crafting their annual strategic plans and rated every speech act. Utterances were coded as *positive* if speakers showed support, encouragement, or appreciation, and they were coded as *negative* if speakers showed disapproval, sarcasm, or cynicism. They were coded as *inquiry* if they offered questions aimed at exploring a position and as *advocacy* if they offered arguments in favor of the speaker's viewpoint. They were coded as *self* if they referred to the person speaking, the group present, or the company, and they were coded as *other* if they referenced a person or group who was neither present nor part of the company.

Later, Losada (1999) identified 15 flourishing teams, defined as showing uniformly high performance across three indicators: profitability, customer satisfaction, and evaluations by superiors, peers, and subordinates. Other teams had mixed ($n = 26$) or uniformly low performance ($n = 19$). Observation of the structural characteristics (i.e., amplitude, frequency, and phase) of the time series of the empirical data for these three performance categories led Losada to write a set of coupled differential equations to match each of the structural characteristics of the empirical time series. Table 1 presents these equations. Model-generated time series were subsequently matched to the empirical time series by the inverse Fourier transform of the cross-spectral density function, also known as the *cross-correlation function*. Goodness of fit between the mathematical model and the empirical data was indicated by the statistical probability of the cross-correlation function at $p < .01$.

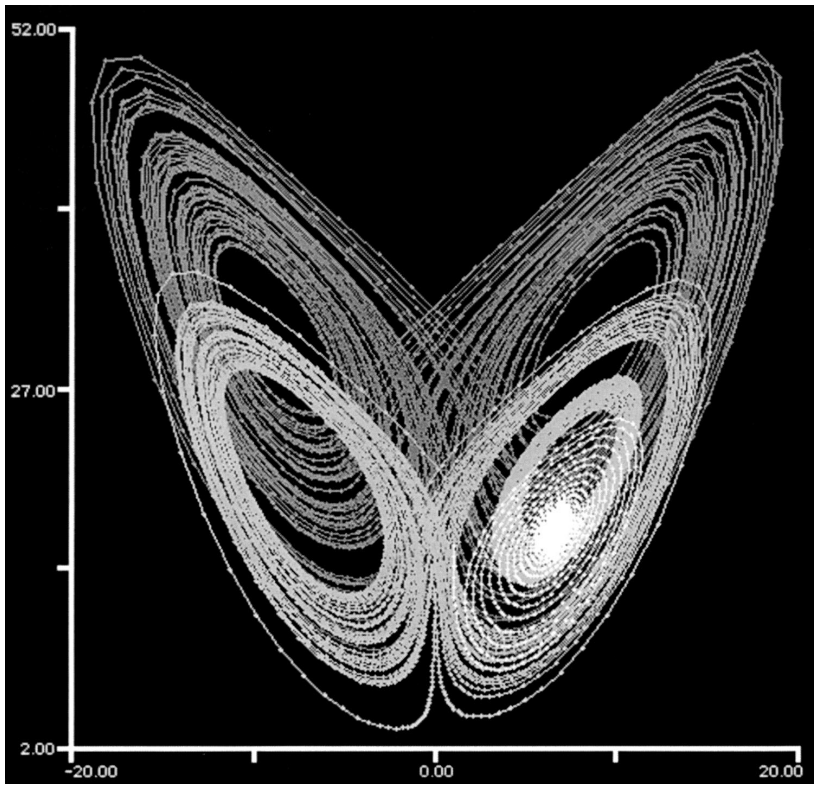
Figure 1 plots the model-generated dynamical structures descriptive of Losada's (1999) three types of business teams in phase space. Readers may recognize here the famous butterfly-shaped chaotic attractor of the Lorenz system, first introduced in 1963 to represent the complex dynamics underlying weather forecasting. The Lorenz system is credited with expanding horizons in many areas of science because the mathematical structure of the original Lorenz system has been found to apply more generally (Hirsch, Smale, & Devaney, 2004; Lorenz, 1993).

The large, dark-gray structure presents the model trajectory derived from the empirical time series of the flourishing, high-performance teams. It reflects the highest positivity ratio (observed ratio = 5.6) and the broadest range of inquiry and advocacy. It is also the most generative and flexible. Mathematically, its trajectory in phase space never duplicates itself, representing maximal degrees of freedom and behavioral flexibility. In the terms of physics and mathematics, this is a chaotic attractor.

The midsized, light-gray structure presents the model trajectory derived from the empirical time series of the medium-performance teams. Although it begins with a structure that mirrors the model for flourishing teams—albeit with a lower positivity ratio (observed ratio = 1.8)

[1] Schwartz et al. (2002) represented affect balance in proportional terms by the ratio of positive affect over the sum of positive and negative affect (i.e., $P/[P + N]$). In the present study, we algebraically transform their ratio to our P/N representation.

Figure 1
The Complex Dynamics of Three Types of Business Teams



Note. The dynamical structures, as represented by trajectories in phase space, generated by Losada's (1999) model to describe high-performance (dark gray), medium-performance (light gray), and low-performance (white) teams. The vertical axis represents emotional space. The formula connecting *P/N* to emotional space is $P/N = (E - i)b^{-1}$, where *E* is emotional space, *i* is the initial value of positivity/negativity (equal to 16), and b^{-1} is the Lorenz inverse constant (equal to 0.375). $P/N = 1$ when $E = 18.66$ (Losada & Heaphy, 2004). Values above and below 18.66 indicate predominance of positivity and negativity, respectively. The horizontal axis represents degrees of inquiry versus advocacy: The left represents asking questions, and the right represents advocating one's own viewpoint.

and narrower range of inquiry and advocacy—its behavioral flexibility is insufficient for resilience. The lowest loop in the left wing of this structure reflects a moment of extreme adversity. After this point (proceeding clockwise) the dynamic model calcifies into a limit cycle inside the right wing. The model suggests that following extreme negativity, these teams lose behavioral flexibility and their ability to question; moreover, they languish in an endless loop centered on self-absorbed advocacy.

The small, white structure presents the model trajectory derived from the empirical time series of the low-performance teams. It reflects the lowest positivity ratio (observed ratio = 0.4) and never shows the complex and generative dynamics of the model derived from high-performance teams but, instead, is stuck in self-absorbed advocacy from the start. But worse than being stuck in an endless loop, its dynamics show the properties of a fixed-point attractor, suggesting that low-performance teams eventually lose behavioral flexibility altogether.

The nonlinear dynamic model that emerged from Losada's (1999) empirical analysis of business teams translates the tenets of the broaden-and-build theory into mathematics. As predicted by the theory, the mathematical model shows that higher levels of positivity are linked with (a) broader behavioral repertoires, (b) greater flexibility and resilience to adversity, (c) more social resources, and (d) optimal functioning (Losada, 1999; Losada & Heaphy, 2004).

Subsequent work on the model (Losada & Heaphy, 2004) revealed that the positivity ratio relates directly to the control parameter by the equation $P/N = (c - Y_0 - 1)\, b^{-1}$, where *P/N* is the ratio of positivity to negativity; *c* is connectivity, the control parameter (see Table 1); Y_0 is 16, the value of the transient before the attractor settles; and b^{-1} is the inverse of the Lorenz constant, equal to 0.375. So, if positivity ratios are known, one can predict whether the complex dynamics of flourishing will be evident. Past mathematical work on Lorenz systems by Sparrow (1982) and others (Frøyland & Alfsen, 1984; Michielin & Phillipson, 1997) has established that when *r*, the control parameter in the Lorenz model, reaches 24.7368, the trajectory in phase space shows a chaotic attractor. Losada

(1999) established the equivalence between his control parameter, *c*, and the Lorenzian control parameter, *r*. Using the above equation, it is known that the positivity ratio equivalent to $r = 24.7368$ is 2.9013.

Mathematically, then, a positivity ratio of about 2.9 bifurcates the complex dynamics of flourishing from the limit cycle of languishing. We call this dividing line the *Losada line*. From a psychological standpoint, this ratio may seem absurdly precise. Yet we underscore that this bifurcation point is a mathematically derived theoretical ideal. Empirical observations made at various levels of measurement precision can test this prediction.

Evidence corroborating the idea that this positivity ratio separates flourishing from languishing can be drawn from Gottman (1994). He and his colleagues observed 73 couples discussing an area of conflict in their relationship. Researchers measured positivity and negativity using two coding schemes: one focused on positive and negative speech acts and another focused on observable positive and negative emotions. Gottman reported that among marriages that last and that both partners find to be satisfying ($n = 37$)—what might be called flourishing marriages—mean positivity ratios were 5.1 for speech acts and 4.7 for observed emotions. By contrast, among marriages identified as being on cascades toward dissolution—languishing marriages at best—mean positivity ratios were 0.9 for speech acts and 0.7 for observed emotions (Gottman, 1994).

Further evidence corroborating the significance of the 2.9 positivity ratio can be extracted from Schwartz et al. (2002). They tracked the outcomes of 66 men undergoing treatment for depression and measured positivity ratios before and after treatment. Before treatment, positivity ratios were very low at 0.5. Schwartz and colleagues reported that among patients who showed optimal remission, indexed by both self-report and clinical ratings ($n = 15$), mean posttreatment positivity ratios were 4.3. Among those who showed typical remission by the same criteria ($n = 23$), mean posttreatment positivity ratios were 2.3. By contrast, among patients who showed no remission whatsoever, mean posttreatment positivity ratios were 0.7 (Schwartz et al., 2002).

Learning that positivity ratios for flourishing marriages and optimal remission from depression surpassed the Losada line inspired us to test the hypothesis that positivity ratios at or above 2.9 also characterize nonpatient samples in flourishing mental health. Although this hypothesis derives from Losada's nonlinear dynamics model, testing it does not require time-series data or knowledge of temporal dynamics. Rather, we computed aggregate positivity ratios by tallying daily reports of emotional experience over a month, and we compared those ratios for people identified as flourishing or not.

Method

Participants

Two samples provided two independent tests of the hypothesis. Sample 1 included 87 first- and second-year students at a large midwestern university (60% women, 40% men). Sample 2 included 101 first-year students from the same university (54% women, 46% men).[2] Participants in Sample 1 were screened with a conservative test for depression, which excluded approximately half of those volunteering.[3]

Measures and Procedure

Flourishing mental health was first indexed by a 33-item measure of positive psychological and social functioning (Keyes, 2002). Items tapping positive psychological functioning measured self-acceptance, purpose in life, environmental mastery, positive relations with others, personal growth, and autonomy (Ryff, 1989). Those tapping positive social functioning measured social coherence, social integration, social acceptance, social contribution, and social actualization. On the basis of Keyes's (2002) diagnostic criteria for identifying the presence of mental health, respondents who scored high on 6 of these 11 signs of positive functioning were classified as flourishing. We followed Keyes's diagnostic criteria with two exceptions. First, because we sought to relate flourishing mental health to daily emotional experience, to avoid conceptual circularity, we omitted the measure of emotional well-being (i.e., frequency of positive feelings) from the diagnostic criteria. Second, because Sample 1 excluded individuals with depressive symptoms, we indexed high levels of the 11 signs of positive functioning as being in the upper 50% of the sample distribution, not the upper tertile. For the more representative Sample 2, we used the upper tertile as Keyes suggested. According to these criteria, 36 participants in Sample 1 and 9 participants in Sample 2 were classified as flourishing.

Each evening for 28 consecutive days, participants logged on to a secure Website to indicate the extent to which they had felt each of 20 emotions in the past 24 hours, from 0 (*not at all*) to 4 (*extremely*; Fredrickson et al., 2003). Positive emotions included amusement, awe, compassion, contentment, gratitude, hope, interest, joy, love, pride, and sexual desire. Negative emotions included anger, contempt, disgust, embarrassment, fear, guilt, sadness, and shame. (Surprise was measured but is excluded here because it can have either negative or positive valence.)

Results

For each day, we tallied the number of positive emotions that were experienced at least *moderately* (≥ 2) and the number of negative emotions experienced at least *a little bit* (≥ 1). We used different thresholds for different valences to account for well-documented asymmetries between positive and negative affect—namely, negativity bias and the positivity offset. Negativity bias reflects the general prin-

[2] Participant sex had no effect on positivity ratios and so is not discussed further.

[3] We screened for depression in Sample 1 because one randomly assigned experimental condition required participants to find negative meaning within their experiences. Although participants were assigned to experimental conditions in both samples, these assignments had no effects on positivity ratios and so are not discussed further.

ciple that bad is stronger than good (Baumeister et al., 2001; Cacioppo et al., 1999), whereas the positivity offset reflects the general principle that most people feel at least mild positive affect most of the time (Cacioppo et al., 1999).

For each participant, we computed a positivity ratio for the month by dividing the total positive emotions experienced by the total negative emotions experienced. The mean positivity ratios for flourishing versus nonflourishing individuals differed significantly in traditional linear terms. For Sample 1, the mean ratio for flourishing individuals was 3.2. For the remaining individuals, it was 2.3, $t(85) = 2.32$, $p = .01$ (one-tailed), $\omega^2 = .05$. For Sample 2, the mean ratios were 3.4 and 2.1, respectively, $t(99) = 1.62$, $p = .05$ (one-tailed), $\omega^2 = .02$. More critical to our hypothesis, however, in each sample, these mean ratios flanked the 2.9 ratio.

Discussion

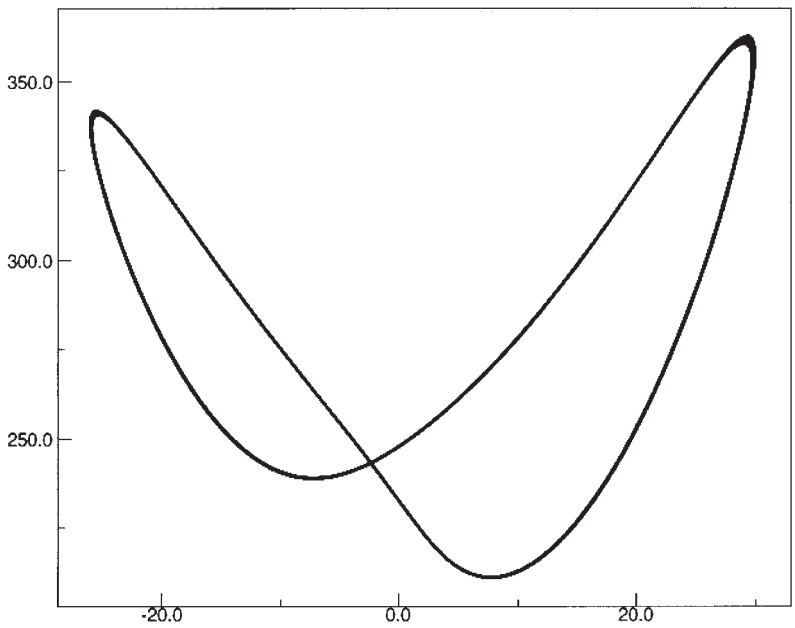
Supporting the hypothesis derived from Losada's (1999) nonlinear dynamics model, we found in two independent samples that flourishing mental health was associated with positivity ratios above 2.9. Together with data from Losada (1999), Gottman (1994), and Schwartz et al. (2002), these data suggest that at three levels of analysis—for individuals, marriages, and business teams—flourishing is associated with positivity ratios above 2.9. Likewise, for individuals, marriages, or business teams that do not function so well—those that might be identified as languishing—positivity ratios fall below 2.9. The relationship between positivity ratios and flourishing appears robust: It emerges repeatedly despite differences in (a) measures of positivity and negativity, (b) measures of flourishing, (c) time scales, and (d) levels of analysis.

Is There an Upper Limit?

If positivity ratios at or above 2.9 are linked to the generative and resilient dynamics of human flourishing, might these qualities increase indefinitely with increasing emphasis on positivity? Apparently not. Past mathematical work on Lorenz equations (Frøyland & Alfsen, 1984; Michielin & Phillipson, 1997; Sparrow, 1982) suggests an upper limit. Using the established link between P/N and r, we estimate that disintegration of the complex dynamics of flourishing first becomes evident at a positivity ratio of 11.6346. To illustrate, we ran Losada's (1999) mathematical model using a positivity ratio representing virtually no negativity at all: $P/N = 100$. Figure 2 portrays the resulting dynamical structure. In contrast with the complex, butterfly-shaped structure in Figure 1, an inflexible limit cycle emerges.

Two intertwined lessons within Figure 2 are that (a) problems can occur with too much positivity (a point also raised by Schwartz et al., 2002) and (b) appropriate negativity may play an important role within the complex dynamics of human flourishing. Without appropri-

Figure 2
Effects of Too Much Positivity



Note. The dynamical structure produced by running Losada's (1999) model with $P/N = 100$. As in Figure 1, the vertical axis represents emotional space, and the horizontal axis represents degrees of inquiry versus advocacy.

ate negativity, behavior patterns calcify. We use the term *appropriate negativity* because we suspect that certain forms of negativity promote flourishing better than others. Gottman (1994) found, for instance, that conflict engagement can be healthy and productive negativity within marriages, whereas expressions of disgust and contempt are more corrosive. Likewise, Fredrickson (2000) argued that negative emotions vary in how much they impact people's future social relations and personal growth. Guilt, for instance, stems from viewing one's behavior as immoral and is more tolerable and soluble than shame, which stems from viewing one's whole self as immoral. Building on this logic, we identify appropriate negativity as time-limited and soluble feedback connected to specific circumstances. By contrast, inappropriate negativity, often gratuitous or global, is an absorbing state (Gottman, 1994) that comes to dominate the affective texture of life.

Just as negativity within the dynamics of human flourishing must be appropriate, positivity must be both appropriate and genuine. Studies of human nonverbal behavior document that smiles that are ingenuine or otherwise disconnected from current circumstances lose credibility as expressions of internal states (Frank, Ekman, & Friesen, 1993) and correlate with regional brain activity typical of negative emotions (Ekman, Davidson, & Friesen, 1990) and abnormal heart function (Rosenberg et al., 2001), suggesting that feigned positivity may be more negative than positive. These findings underscore the importance, in the pursuit of human flourishing, of seeking genuine positivity—meaningfully grounded in the reality of current circumstances—rather than feigned, forced, or trivial positivity (Fredrickson, 2000).

Our discovery of the critical 2.9 positivity ratio may represent a breakthrough. Computed over sizable time spans, this dynamic ideal is wide enough to encompass the many variations in affective states that humans inevitably experience. Despite the apparent simplicity of characterizing individuals, relationships, or groups in terms of their positivity ratios, we caution that quantifying affective states remains difficult (for a discussion, see Larsen & Fredrickson, 1999), and computed positivity ratios invariably reflect the conceptual and temporal resolution of the underlying affect-measurement instruments. Moreover, as suggested above, simple positivity ratios may not account for whether affective states are appropriate, genuine, or meaningful. Complicating intervention efforts, people's habits of affective experience and expression are entrenched and often resistant to change. To the extent that these various issues can be sensitively addressed, we suggest that the computation of positivity ratios over time may be a useful means by which to track the success of efforts to optimize human functioning.

Is a General Theory of Positivity Warranted?

Coherence is emerging among theory, mathematics, and observed data regarding positivity and human flourishing. First, Fredrickson's (1998, 2001) broaden-and-build theory describes the psychological mechanisms through which positivity might fuel human flourishing. Second, Losada's (1999; Losada & Heaphy, 2004) nonlinear dynamics model describes the mathematical relations between certain positivity ratios and the complex dynamics of human flourishing. And third, fine-grained empirical observations at three levels of analysis—within individuals, couples, and business teams—support Fredrickson's theory and Losada's mathematics. This degree of concordance suggests that a more general theory of positivity may be worth articulating and testing. Uniting existing theory on positive emotion (Fredrickson, 1998, 2001) with the mathematics of nonlinear dynamics (Hirsch et al., 2004; Lai & Ye, 2003; Losada, 1999), we make the following seven predictions:

1. Human flourishing and languishing can be represented by a set of mathematical equations drawn from the Lorenz system.

2. The positivity ratio that bifurcates phase space between the limit cycle of languishing and the complex dynamics of flourishing is 2.9.

3. Positivity ratios at or above 2.9 are associated with human flourishing. Flourishing is associated with dynamics that are nonrepetitive, innovative, highly flexible, and dynamically stable; that is, they represent the complex order of chaos, not the rigidity of limit cycles and point attractors.

4. Human flourishing at larger scales (e.g., groups) shows a similar structure and process to human flourishing at smaller scales (e.g., individuals).

5. Appropriate negativity is a critical ingredient within human flourishing that serves to maintain a grounded, negentropic system.

6. The complex dynamics of flourishing first show signs of disintegration at a positivity ratio of 11.6.

7. Human flourishing is optimal functioning characterized by four key components: (a) *goodness*, indexed by happiness, satisfaction, and superior functioning; (b) *generativity*, indexed by broadened thought–action repertoires and behavioral flexibility; (c) *growth*, indexed by gains in enduring personal and social resources; and (d) *resilience*, indexed by survival and growth in the aftermath of adversity. Each of these four components will be linked to positivity ratios at or above 2.9.

We offer this set of predictions to stimulate research on the dynamics of positive affect that might provide a scientific basis to protect and promote human flourishing.

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