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This article presents my response to the article by Brown, Sokal, and Friedman (2013), which critically examined Losada's conceptual and mathematical work (as presented in Losada, 1999; Losada & Heaphy, 2004; and Fredrickson & Losada; 2005) and concluded that mathematical claims for a critical tipping point positivity ratio are unfounded. In the present article, I draw recent empirical evidence together to support the continued value of computing and seeking to elevate positivity ratios. I also underscore the necessity of modeling nonlinear effects of positivity ratios and, more generally, the value of systems science approaches within affective science and positive psychology. Even when scrubbed of Losada's now-questioned mathematical modeling, ample evidence continues to support the conclusion that, within bounds, higher positivity ratios are predictive of flourishing mental health and other beneficial outcomes.

Keywords: positivity ratio, broaden-and-build theory, positive psychology, nonlinear dynamics, Lorenz system

In their lively article "The Complex Dynamics of Wishful Thinking: The Critical Positivity Ratio," Brown, Sokal, and Friedman (2013) offered a critique of the application of nonlinear dynamics and differential equations in two of Marcial Losada's foundational papers (Losada, 1999; Losada & Heaphy, 2004). They also identified additional logical errors that permeate an article that I coauthored with Losada that was published in the *American Psychologist* in 2005. Because that particular article of mine (Fredrickson & Losada, 2005) has been cited widely, this critique by Brown and colleagues is likely to be of considerable interest as well. I was certainly curious to read it myself and learned from my immersion in it. I was also grateful that the editors of the *American Psychologist* (hereafter *AP*) invited Losada and me to prepare a response article. Losada, however, chose not to respond.

I've come to see sufficient reason to question the particular mathematical framework Losada and I adopted to represent and test the concept of a critical tipping point positivity ratio that bifurcates mental health into human flourishing and human languishing (Fredrickson & Losada, 2005). Whether the Lorenz equations—the nonlinear dynamic model we'd adopted—and the model estimation technique that Losada utilized can be fruitfully applied to understanding the impact of particular positivity ratios merits its renewed and rigorous inquiry. Brown and colleagues (2013) are to be credited with raising these important questions and illuminating the conditions under which the use of nonlinear differential equations, particularly chaotic ones such as the Lorenz equations, is appropriate.

My aim in this response article is not to defend Losada's mathematical and conceptual work. Indeed, I have neither the expertise nor the insight to do so on my own. My aim, rather, is to update the empirical evidence for the value and nonlinearity of positivity ratios. My intent is to offer a steadying counterpoint to Brown and colleagues' (2013) article. Absorbing their many critiques of Losada's work might tempt a reader to throw out the proverbial baby with the bath water. Even while Brown and colleagues have called into question some of the claims Losada and I made in 2005, in the intervening years, others of our claims not only remain unchallenged but stand now on even firmer empirical footing.

It bears underscoring that the claims Losada and I made in our 2005 *AP* article (Fredrickson & Losada, 2005) were supported by three interwoven elements: psychological theory, mathematical modeling, and quantitative data. Here I unthread the now-questionable element of mathematical modeling from this braid, which leaves us in territory familiar to most psychological scientists, that at the interface of theory and data. While perhaps not as compelling as the trio of theory and data buttressed by mathematical modeling, the resulting duo nevertheless remains a strong and dynamic one.

Before illuminating the logic and importance of positivity ratios, I lay the necessary theoretical and empirical foundations. These foundations include a brief update on the status of the broaden-and-build theory of positive emotions as well as new evidence for both the role of positive emotions in flourishing mental health and the effects of too much positivity.

The Broaden-and-Build Theory

The psychological theory that was foundational for my and Losada's past claims about the positivity ratio is my broaden-and-build theory of positive emotions, first introduced in 1998 and, in the intervening 15 years, widely tested and

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supported (Fredrickson, 1998, 2001, 2013). The theory posits that the function of positive emotions, as shaped over millennia by the processes of natural selection, was to build an individual's resources for survival. The means by which this build function was achieved was through the accumulated effects of moments marked by an affect-induced broadened scope of awareness, creating a temporary form of consciousness within individuals that included a wider array of thoughts, actions, and percepts than typical. One implication of the broaden-and-build theory is that negative and positive emotions alike came to be part of our universal human nature through selective pressures related to survival, albeit on vastly different time scales. Negative emotions carried adaptive significance in the moment that our human ancestors' experienced them, as their associated action urges—for example, to fight, flee, or spit—drove behaviors that saved life and limb in dire circumstances. Positive emotions, by contrast, carried adaptive significance for our human ancestors over longer time scales. Having a momentarily broadened mindset, after all, is not a key ingredient in the recipe for any quick survival maneuver. It is, however, in the recipe for discovery: discovery of new knowledge, new alliances, and new skills. In short, broadened awareness led to the accrual of new resources that might later make the difference between surviving or succumbing to various threats. Resources built through positive emotions also increased the odds that our ancestors would experience subsequent positive emotions, with their attendant broaden-and-build benefits, thus creating an upward spiral toward improved odds for survival, health, and fulfillment. In sum, the broaden-and-build theory states that positive emotions have been useful and preserved over human evolution because having recurrent, yet unbidden, moments of expanded awareness proved useful for developing resources for survival. Little by little, micro-moments of positive emotional experience, although fleeting, reshape who people are by setting them on trajectories of growth and building their enduring resources for survival. The broaden-and-build theory describes the form of positive emotions as to broaden awareness and their function as to build resources.

Empirical evidence for the broaden-and-build theory has advanced considerably in the eight years since my 2005 *AP* publication with Losada (Fredrickson & Losada, 2005). Notably, evidence that positive emotions expand awareness, temporarily allowing individuals to take in more of their surrounding contextual information than they do during neutral or negative states, termed the *broaden effect*, has mounted across a wide range of tightly controlled experiments carried out in multiple laboratories. For instance, experimentally induced positive emotions have been shown to broaden the scope of visual attention as measured by reaction time behavioral tests (Rowe, Hirsh, & Anderson, 2007) and eye-tracking technology (Wadlinger & Isaacowitz, 2006). Moreover, experiments with brain imaging (e.g., fMRI) reveal that positive emotions expand people's field of view at very early perceptual encoding stages (Schmitz, De Rosa, & Anderson, 2009). Positive emotions, then, quite literally widen people's outlook on the world around them. (See Gable & Harmon-Jones, 2008, for a contrasting view for approach-motivated positive affect.) Moreover, evidence that positive emotions build enduring and consequential personal resources, termed the *build effect*, which was previously based on prospective correlational designs (e.g., Cohn, Fredrickson, Brown, Mikels, & Conway, 2009), is now based on longitudinal experimental designs that teach randomly selected subgroups of people specific skills to self-generate positive emotions in daily life (Fredrickson, Cohn, Coffey, Pek, & Finkel, 2008; Kok et al., 2013). The self-generated upward shifts in positive emotions that these individuals produce, in turn, augment their personal resources, including their cognitive resources (e.g., trait mindfulness), psychological resources (e.g., environmental mastery), social resources (e.g., positive relations with others), and physical resources (e.g., reduced illness symptoms). Extending beyond improvements in self-reported resources, a recent randomized longitudinal experiment uncovered effects of increased daily experiences of positive emotions on cardiac vagal tone (Kok et al., 2013), a marker of physical health, social attunement, and behavioral flexibility (Porges, 2003;Thayer & Sternberg, 2006).

To summarize, empirical support for the broaden-and-build theory has grown appreciably stronger in recent years and has sparked applications to improve both mental and physical health (Fredrickson, 2013; Garland et al., 2010; Johnson et al., 2009) as well as organizational functioning (Sekerka, Vacharkulksemsuk, & Fredrickson, 2012). Readers interested in a recent and detailed review of 15 years of evidence accumulated for the broaden-and-build theory are directed to Fredrickson (2013).

It is worth underscoring here that the claims Losada and I made (Fredrickson & Losada, 2005) about how

certain positivity ratios might be associated with flourishing mental health were cast as an offshoot of the broaden-and-build theory. Specifically, our predictions about the positivity ratio are central to neither the broaden effect nor the build effect, the two core tenets of the theory. As such, if for the sake of argument, this particular offshoot of the theory were to wither and die, the broaden-and-build theory itself would survive with undiminished odds for continued flourishing.

The Role of Positivity in Human Flourishing

Additional background for my updated thinking on positivity ratios concerns the unique role of positive emotions in flourishing mental health. To flourish has become an increasingly popular goal among those interesting in applying the fruits of positive psychology. Loosely speaking, I have described human flourishing as being beyond happiness in that it encompasses both feeling good and doing good (Fredrickson, 2009). This definition is based on the foundational empirical work of Keyes and colleagues, which conceptualizes and measures human flourishing as a multidimensional combination of hedonic and eudaimonic well-being (Keyes, 2002). Following ancient philosophies articulated by Aristotle and others, hedonic well-being captures individuals' global satisfaction with life alongside their pleasant affect, whereas eudaimonic well-being encompasses their sense of purpose and meaning as well as their resilience and social integration. In the article with Losada, we further specified this "feel good plus do good" definition by opening with "To *flourish* means to live within an optimal range of human functioning, one that connotes goodness, generativity, growth, and resilience" (Fredrickson & Losada, 2005, p. 678). Amidst the current rise of interest in human flourishing, major theorists (Huppert & So, 2013;Keyes, 2002; Seligman, 2011) agree that the construct includes both feeling good (i.e., hedonia) and functioning effectively (i.e., eudaimonia) and in this way is the mirror opposite of common mental disorders such as depression and anxiety, which encompass negative (or flat) affect and poor functioning.

Feeling good, however, does more than simply reflect the presence of human flourishing. From the perspective of the broaden-and-build theory, positivity takes on a far more vital role with respect to human flourishing. Beyond being one dimension of flourishing, positive emotions have also been found to promote the development and maintenance of flourishing. Recognizing that many markers of optimal functioning, or eudaimonic well-being, can be just as readily cast as enduring personal resources that aid people in coping with the ever-changing circumstances of daily life illuminates why this is so. Several prospective correlational (Cohn et al., 2009) and now longitudinal randomized experiments (Fredrickson et al., 2008; Kok et al., 2013) demonstrate that daily experiences of positive emotions forecast *and produce* growth in personal resources such as competence (e.g., environmental mastery), meaning (e.g., purpose in life), optimism (e.g., pathways thinking), resilience, self-acceptance, positive relationships, as well as physical health. In other words, feeling good does not simply sit side by side with optimal functioning as an indicator of flourishing; feeling good drives optimal function by building the enduring personal resources upon which people draw to navigate life's journey with greater success.

Further evidence that positive emotions are a key active ingredient in flourishing mental health comes from a detailed unpacking of a Tuesday in the life of flourishing individuals, in comparison to a Tuesday in the life of those not flourishing and to a Tuesday for those identified as depressed (Catalino & Fredrickson, 2011). Using the Day Reconstruction Method, we tested the hypothesis, drawn from the broaden-and-build theory, that flourishers thrive because they experience greater positive emotional reactivity in response to routine pleasant activities and thereby build more resources over the span of two to three months. Our results showed that relative to those who do not flourish or who are depressed, people who flourish experience bigger "boosts" in positivity in response to routine daily events such as helping another person, interacting with others, playing, learning, and engaging in spiritual activity. Moreover, flourishers' greater positive emotional reactivity, over time, predicted their growth in resources. In turn, flourishers' greater growth in resources predicted their higher levels of flourishing symptoms at the end of the study (controlling for initial levels of flourishing). We uncovered virtually no differences between flourishers and others in the degree of negative emotions experienced on the targeted Tuesdays. We also uncovered surprisingly few differences between depressed people and nonflourishers, who had been prescreened and selected for showing no signs of flourishing, depression, anxiety, or substance use. This pattern of results suggests that human flourishing is nourished by small, yet consequential, individual differences in positive emotional experiences in response to pleasant everyday events. Flourishers don't simply "feel good and do good." Rather they do good *by* feeling good. So, just as greater negative emotional sensitivity has been found to seed and maintain depression, a phenomenon called *negative potentiation,* a parallel *positive potentiation* process appears to seed and maintain the beneficial—yet all too rare—state of human flourishing (Catalino & Fredrickson, 2011).

The Effects of Too Much Positivity

Evidence is thus stronger now than it was in 2005 that positive emotions play a unique role in maintaining and promoting flourishing mental health. This does not mean, however, that more is always better. Indeed, evidence has also mounted to support the ancient wisdom that people can get "too much of a good thing," experiencing a downturn in good outcomes with disproportionate levels of positive emotion. Thus, while Brown and colleagues (2013) urged caution in the use of nonlinear dynamics, I will show that the available evidence makes clear that researchers investigating affective phenomena need to recognize and math-

ematically address growing evidence for nonlinearity in their data.

Research on how positive emotions go awry in the context of bipolar disorder is illustrative here. Bipolar disorder, also known as manic-depressive illness, is one of the top 10 causes of disability worldwide and has long been characterized by abnormally elevated positive mood during manic episodes. Recent work by Gruber and colleagues has isolated numerous and specific ways in which people at risk for, and diagnosed with, bipolar disorder experience "too much" positive emotion in a wide range of contexts (for an excellent short review, see Gruber, 2011). First, even outside of manic episodes, individuals with bipolar disorder who are in remission as well as those at risk for developing the disorder experience greater positive emotions relative to controls, as indexed by both self-reports and physiological measures, in response to both current and anticipated pleasant stimuli (Johnson, Gruber, & Eisner, 2007). Second, bipolar disorder is also associated with more contextually inappropriate positive emotions, for instance, in response to negative or neutral stimuli and not just positive stimuli (Gruber, Johnson, Oveis, & Keltner, 2008). Third, these foregoing effects appear limited to self-focused positive emotions that are related to reward and achievement, such as joy and pride (Gruber & Johnson, 2009). Gruber (2011) has synthesized these various findings into what she calls the positive emotion persistence model, which outlines several mechanisms that initiate and maintain heightened, persistent, and at times contextually inappropriate self-focused positive emotions in bipolar disorder.

Within the spectrum of normative emotional experience, the notion that excessive positivity might be harmful is consistent with the long-standing evidence that life satisfaction is better predicted by the frequency rather than the intensity of a person's positive emotions (Diener, Sandvik, & Pavot, 1991) and that by far the most frequently experienced positive emotions are the mild and moderate ones. Whereas increasing levels of positive emotions bring benefits up to a point, extremely high levels of positive emotion carry costs that begin to outweigh these benefits. This classic, nonmonotonic inverted U-shaped relationship has been found between positive emotions and a range of outcomes as diverse as emotional stability (Diener, Colvin, Pavot, & Allman, 1991); creativity (Davis, 2008; George & Zhou, 2007); income, education, and political participation (Oishi, Diener, & Lucas, 2007); risky behaviors (Martin et al., 2002); and longevity (Diener & Chan, 2011; H. S. Friedman et al., 1993). It bears noting, however, that some researchers do not find signs of dysfunction at very high levels of happiness (e.g., E. T. Friedman, Schwartz, & Haaga, 2002).

Drawing on these and other findings, Grant and Schwartz (2011, p. 62) made the case for "a fundamental and ubiquitous psychological principle: There is no such thing as an unmitigated good." They argued that research programs now need to focus on identifying the presence and specific location of inflection points as well as testing the underlying mechanisms and associated context effects and boundary conditions of these pervasive inverted-U patterns (Grant & Schwartz, 2011). The consistent evidence for inverted-U effects for positive emotions is clearly incompatible with traditional linear approaches to modeling psychological phenomena. Even so, the nonlinearity evident in human emotion systems may not be best modeled by the specific set of differential equations that Losada proposed (Frederickson & Losada, 2005). Nevertheless, I remain convinced of the need to identify and test mathematical and statistical models that are sensitive to nonlinear, recursive, and dynamic effects.

The Value of Positivity Ratios

With Losada's mathematics newly called into question, what can be said about the value of positivity ratios? Plenty, actually. Here especially, it will be important to keep close hold of the slippery baby while we drain the somewhat murky bathwater.

In the aforementioned Tuesdays study (Catalino & Fredrickson, 2011), Catalino and I learned that people who flourish stand distinctly apart from others specifically with respect to their daily experiences of positive emotions. Indeed, the prospective analyses in that study revealed that it was flourishing individuals' relatively greater positive emotions, together with the associated increases in resources, that accounted for their future gains in signs of flourishing. While we did not test hypotheses about the positivity ratios per se, the fact that we uncovered virtually no differences between flourishers and nonflourishers in negative emotional responding is compatible with the notion that flourishing is characterized by higher positivity ratios than is nonflourishing.

To be clear, the work of Brown and colleagues (2013) did not question the validity of the empirical evidence, offered in Fredrickson and Losada (2005), that flourishing is associated with higher positivity ratios than is nonflourishing. Indeed, knowing that we were testing a bold idea, we drew our evidence from two independent samples of university students who had provided daily reports of their emotions for 28 days. As such, we both tested our hypothesis and sought to replicate it in the same report. Results were notably consistent across the two samples: In Sample 1 ($n = 87$), the mean positivity ratio for flourishers was 3.2:1, whereas for nonflourishers it was 2.3:1. In Sample 2 ($n = 101$), the mean ratios were 3.4:1 and 2.1:1, respectively. In both samples, the ratios for flourishers and nonflourishers were significantly different according to traditional, linear statistical tests. Indeed, Brown and colleagues (2013) plainly stated that "there is nothing inherently implausible about the idea that people with a higher ratio of positive to negative emotions might experience better outcomes than those with a lower ratio" (p. xxx).

What Brown and colleagues' (2013) work did call into question is the interpretation of these significant differences. Although the ratios obtained in each of the two samples closely flank the critical positivity ratio pinpointed by Losada's mathematical work, to the extent that Losada's mathematical work may have been flawed, inappropriately applied, or both, the apparent empirical support for Losa-

da's critical "tipping point" ratio offered by these data may have reflected chance, albeit chance striking twice.

Considerable evidence indeed undergirds the claim that when it comes to positivity ratios, within bounds, higher is better. Losada and I reviewed the evidence to date in our 2005 *AP* article (Fredrickson & Losada, 2005). Beyond Losada's now-questioned prior work (Losada, 1999; Losada & Heaphy, 2004), this review included work by Gottman (1994) and Schwartz (1997). Based on decades of empirical work on the emotion patterns predictive of marital success and failure, Gottman's work famously shows that successful marriages are characterized by positivity ratios of about 5:1, whereas marriages on cascades toward dissolution have ratios of about 1:1. The lesser known work of Schwartz, rooted in Boolean algebra as well as his reformulated balanced states of mind model, finds that depression is marked by positivity ratios of less than 1:1 and that following treatment (either pharmacological or cognitive-behavioral), ratios rise to about 2:1 for those with typical remission, whereas they rise to about 4:1 for those with optimal remission (Schwartz et al., 2002). Newer empirical work continues to support the idea that, across a wide range of ages and life circumstances, people with higher positivity ratios have superior mental health and adjustment than those with lower ratios (Diehl, Hay, & Berg, 2011, discussed in more detail below; Trute, Benzies, Worthington, Reddon, & Moore, 2010).

The question newly raised by Brown and colleagues' (2013) critique is whether positivity ratios obey one or more critical tipping points, and if so, whether those critical tipping points coincide with the ones identified by Losada's mathematical work for all individuals, samples, and subgroups. Clearly, these questions merit further test. Even so, the prospect of positivity ratios being a simply linear phenomenon, in which higher is invariably better, is unlikely for two reasons.

First, as reviewed in the previous section, a wealth of evidence suggests that too much positivity is associated with less than optimal functioning. Whereas most evidence for inverted-U patterns examines effects of positive affect without simultaneous consideration of concurrent negative affect, in the discussion section of our 2005 paper (Fredrickson & Losada, 2005), Losada and I raised the question of an upper limit to the benefits of such positivity ratios. Building upon Losada's now-questionable mathematics, we suggested that a second tipping point, at positivity ratios of about 11:1, might be associated with a downturn in flourishing. Although we did not have data suitable for testing this second tipping point, we noted that such a phenomenon was consistent with the then emerging ideas that (a) problems can occur with too much positivity and (b) appropriate negativity plays an important role in human flourishing.

Although empirical tests of an upper limit on the benefits of higher positivity ratios remain scarce, one available cross-sectional study examined the effects of positivity ratios on creativity in a sample of 595 retail employees in Portugal (Rego, Sousa, Marques, & Cunha, 2012). The researchers found the classic inverted-U relation between positivity ratios (based on employee self-reports) and employee creativity (based on supervisor ratings). Higher positivity ratios predicted greater creativity up to a point, beyond which creativity took a downturn. The optimal positivity ratio for creativity in this sample was found to be 3.6:1 (Rego et al., 2012). Drawing on theorizing by Oishi and colleagues (2007), which suggested that "ultrahappy" employees may become complacent toward problems and opportunities, Rego and colleagues (2012, p. 265) concluded that a "modest level of negative affect, if combined with high levels of positive affect, may help to generate creativity," logic consistent with work by George and Zhou (2007) on the joint contributions of positive and negative affect to employee creativity. Another recent published report concurs. It examined the effects of positivity ratios in two cross-sectional studies of individuals exposed to considerable stress: One study targeted gastric cancer patients ($N = 123$, predominantly at Stage 3), and the other sampled hospital personnel exposed to missile attacks ($N = 84$). These researchers also found repeated evidence for a curvilinear relationship between positivity ratios and functioning (Shrira et al., 2011). Interestingly, the inflection point of the observed curvilinear effects coincided with a positivity ratio of about 3:1. Echoing the idea that appropriate negativity can be adaptive, these authors speculated that "with little or no [negative affect], the gravity of the situation is not acknowledged and resources are not mobilized to their full extent" (Shrira et al., 2011, p. 270).

It can be tempting to conclude from this evidence that the inflection point of this curvilinear effect is far lower than the 11:1 ratio that Losada and I put forth in 2005 (Fredrickson & Losada, 2005). Unfortunately, due to variance across studies in data reduction strategies, such a conclusion is unwarranted. For instance, unlike the approach Losada and I took, both Rego and colleagues (2012) and Shrira and colleagues (2011) inadvertently restricted the ranges of their computed positivity ratios to be within the ranges of the 7- and 4-point scales their participants used, respectively, to rate their emotional experiences. As I cautioned in the discussion section of my article with Losada (Fredrickson & Losada, 2005, p. 685), "computed positivity ratios invariably reflect the conceptual and temporal resolution of the underlying affect-measurement instruments." Given the computational differences, the safest conclusion to draw from these new data is that an inverted-U inflection point exists. Where precisely it falls remains an important target for future research that computes positivity ratios independently of scaling parameters.

A second reason to anticipate and model nonlinear effects of positivity ratios is altogether different from their now-familiar downturning, inverted-U effects. A more limited set of evidence suggests that positivity ratios may simply be inert at low levels. Specifically, in a study of the relationships that incoming university students develop with their newly assigned roommates, Waugh and Fredrickson (2006) reported that the most potent predictor of accumulating relational resources was whether or not students' positivity ratios, measured over 28 days of nightly reports, exceeded the critical ratio put forth in

Fredrickson and Losada (2005). Strikingly, for students with ratios below 2.9:1, absolutely no evidence emerged to suggest growth in relational resources: Over the span of four weeks, no changes in self–other overlap or complex understanding emerged whatsoever. By sharp contrast, among those with ratios above this same threshold, growth in relational resources was both evident and statistically significant. I've called this the "now-you-see-it-now-you-don't" effect of positivity (Fredrickson, 2009) and speculated that such nonlinearity in the effects of positivity ratios is one reason that scientific evidence for the benefits of positive emotions has been slower to emerge than has comparable evidence regarding the costs of negative emotions. That is, without consideration of critical change points, it can seem as if positive emotions have played an elaborate "shell game" with researchers, with their effects popping in and out of view at seeming random. Nonlinearity of this sort can perhaps be captured with multiphase mixed-effects models (e. g., Cudeck & Klebe, 2002), which identify and test critical change points at which growth phenomena switch from one phase to another.

The accumulation of independent evidence for the diagnostic value of positivity ratios exemplifies and bolsters two important and oft-replicated asymmetries between positive and negative affect, namely, negativity bias and positivity offset. *Negativity bias* describes the phenomenon that, in the moment of experience, a bad outcome, such as losing $20, feels more extreme and rivets more attention than does a comparably good outcome, such as gaining $20 (Baumeister, Bratslavsky, Finkenauer, & Vohs, 2001; Kahneman & Tversky, 1979; Rozin & Royzman, 2001). The less heralded yet no less important asymmetry encapsulated in the term *positivity offset* describes the probabilistic fact that most moments are mildly positive (Cacioppo, Gardner, & Berntson, 1999; Diener & Diener, 1996). Indeed, worldwide representative surveys find that a positivity offset is virtually universal, even for people who live in very difficult circumstances (Diener, Oishi, & Suh, 2013). So, whereas negativity dominates positivity in intensity, positivity dominates negativity in frequency. From these asymmetries alone we can surmise that affective parity, represented by ratios near 1:1, is unlikely to characterize mental health.

In a recent effort to illuminate the magnitude of negativity bias and therefore the "dose" of positivity needed to appropriately counteract negativity in daily life, Larsen and Prizmic (2008) reported that experience sampling data on emotions suggest that the average person has about three "good" days—defined as positivity exceeding negativity—for every "bad" day. Put differently, a single day in which negative emotion prevails has the countervailing force of three good days. Larsen and Prizmic (2008) further observed that standardized beta weights for predicting people's global reports of subjective well-being from their average daily negative versus positive affect also differ by a factor of three, suggesting that daily negativity contributes threefold more to overall well-being than does daily positivity. Uniting their own empirical observations with the evidence on positivity ratios reviewed here (i.e., Fredrickson & Losada, 2005; Gottman, 1994; Schwartz et al., 2002), Larsen and Prizmic (2008) suggested that "a good first estimate" for the affect balance necessary for minimal emotional well-being "would be the value of pi (π, or 3.14)" (p. 268).

Further evidence for the value of positivity ratios comes from a recent study that replicated the basic empirical approach of Fredrickson and Losada (2005) while extending it to examine flourishing mental health across adulthood (Diehl et al., 2011). A sample of 239 adults, representing young adults (18–39 years, $n = 81$), middle-aged adults (40–59 years, $n = 81$), and older adults (60–89 years, $n = 77$), completed daily reports of emotions for 30 days. Independent assessments were used to classify participants as languishing ($n = 65$), moderately mentally healthy ($n = 113$), or flourishing ($n = 61$), and this classification was found to be unrelated to age. Chi-square tests showed that (across ages) participants with positivity ratios lower than 2.9:1 were disproportionately languishing, whereas those with positivity ratios above 2.9:1 were disproportionately flourishing. Discriminant function analysis also revealed that, beyond other well-established predictors of mental health (i.e., education, life satisfaction, physical symptoms, and self-rated health), positivity ratios contributed significantly to discriminating groups based on their mental health status. The results of this study do, however, raise questions about the universality of the critical positivity ratio identified by Losada's mathematics. Specifically, whereas the data for young adults in Diehl and colleagues' (2011) sample mapped well onto the prediction—now made by multiple research teams based on different empirical and mathematical approaches—that the critical positivity ratio that sets flourishers apart from others is around 3:1, the positivity ratios for middle-aged and older adults were significantly higher and more variable, such that even languishing individuals in these more advanced age groups showed positivity ratios at or above 3:1. Diehl and colleagues acknowledged that these differences may reflect age, cohort, or perhaps any age-related differences in daily social or work circumstances.

In sum, then, the claim that flourishing mental health is associated with higher positivity ratios than is nonflourishing remains unchallenged. Indeed, positive potentiation—the ability of certain people to extract more positive emotions out of common, everyday events—a process evidently unique to flourishers (Catalino & Fredrickson, 2011), could well account for the differential positivity ratios between flourishers and nonflourishers. Descriptively, this means that striving to raise one's positivity ratio from a low level to a moderately high level in hopes of attaining flourishing mental health remains a reasonable and healthy goal. Indeed, the now-ample evidence for the long-range benefits of positive emotions (e.g., Catalino & Fredrickson, 2011; Cohn et al., 2009; Fredrickson et al., 2008; Kok et al., 2013; Lyubomirsky, King & Diener, 2005) assures that this advice is both on point and evidence-based. Whether the outcomes associated with positivity ratios show discontinuity and obey one or more specific change points, however, merits further test. Losa-

da's math alone no longer seems to be a steady platform from which to make that claim.

To be sure, research on the full value of positivity ratios remains in its infancy. Although in the wake of Brown and colleagues' (2013) work, this infant may seem a bit sullied, in my estimation a good scrubbing reveals a healthy baby well worth letting grow up. Losada's mathematical work, which to date he has elected not to defend, may well be the smudge that needs removing. Whereas Brown and colleagues' article revealed this smudge, my hope is that the present article effectively washes it away. Perhaps we can now toss out the muddied bath water and move on to conducting the relevant empirical and mathematical work necessary for the continued healthy development of this growing research area.

Most valuable to the maturation of this work will be longitudinal field studies and experiments that use densely repeated measures of emotions and relevant outcomes alongside pioneering dynamic mathematical and statistical models (Algoe, Fredrickson, & Chow, 2011). The interdisciplinary field of systems science is likely to be of value here (e.g., Luke & Stamatakis, 2012). Although physics, chemistry, and engineering have more experience modeling complex systems than does psychological science, human emotions are clearly dynamic, multicomponent systems that show self-sustaining upward and downward spirals sensitive to changing circumstances (e.g., Fredrickson & Joiner, 2002; Garland et al., 2010; Kok et al., 2013; Kok & Fredrickson, 2010). As such, system dynamics, network analysis, agent-based modeling, and other systems science approaches are likely to become ever more relevant to affective science and positive psychology, as they have for biology, economics, and public health (Luke & Stamatakis, 2012; Mabry, Marcus, Clark, Leischow, & Mendez, 2010). Indeed, funding initiatives at both the National Institutes of Health (Modeling Social Behavior, RFA-GM-13–006) and the National Science Foundation (Human and Social Dynamics, NSF 04–537) have already incubated systems science approaches within psychology more generally. Applying these approaches to affective science and positive psychology demands boundary-spanning collaborations. Only when scholars with nonoverlapping areas of expertise forge productive alliances can we illuminate the bigger pictures that cannot be understood from one vantage point alone. Such teamwork will be necessary to clarify how people's lives and positivity ratios change as they undertake new activities and mindsets promoting health, well-being, and flourishing.

Concluding Thoughts

As Brown and colleagues (2013) highlighted, my book *Positivity* (Fredrickson, 2009), written for a wide readership, made considerable use of the ideas presented in my 2005 *AP* article with Losada (Fredrickson & Losada, 2005). Even for this audience, however, I took precautions not to present the ratio as an unquestionable fact. "Science is never complete," I wrote. "The stakes in terms of human welfare are too high for me to rest easy in the belief that clever theory or fancy math alone can provide the answers" (Fredrickson, 2009, p. 138). To this I would add that within the trinity of theory, mathematics, and data, data are what merit our closest attention and respect. I am grateful to Brown and colleagues (2013) for spurring me to update my own thinking on positivity ratios. In doing so, I've learned that the most recent empirical evidence on the value of positivity ratios tells us quite a bit. The data say that when considering positive emotions, more is better, up to a point, although this latter caution may be limited to self-focused positive emotions. The data also say that when considering negative emotions, less is better, down to a point. Negativity can either promote healthy functioning or kill it, depending on its contextual appropriateness and dosage relative to positive emotions. Empirical evidence is thus growing to support the value of calculating positivity ratios. Even so, considerable empirical work remains to be done to better understand the dynamic and nonlinear properties of positivity ratios as well as the most appropriate algorithms for computing them.

Science, at its best, self-corrects. We may now be witnessing such self-correction in action as mathematically precise statements about positivity ratios give way to heuristic statements such as "higher is better, within bounds." While this new statement is perhaps less dramatic, it remains just as useful. Time and data will tell.

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