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On the Form of Forgiving

Michael E. McCullough

University of Miami

Lindsey M. Root

University of Miami

Jack W. Berry

Samford University

Benjamin A. Tabak

University of Miami

Giacomo Bono

WestEd

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Abstract

The authors sought to identify the mathematical function that describes the temporal course of forgiveness. Using longitudinal data from 372 people who had been recently harmed by another person, the authors tested a variety of models for monotonic decline. The logarithmic model was superior to the linear, exponential, power, hyperbolic, and exponential-power models. By 3 months post-transgression, the typical person had become 7.61 times less likely (in terms of odds) to report any given negative feeling or motivation toward his or her transgressor at any given level of intensity. The logarithmic function (which implies a psychological process yielding diminishing returns over time) corresponds to the Weber-Fechner law of stimulus-perception relations and is functionally similar to the power law underlying the psychophysical function (Stevens, 1971) and the forgetting function (Wixted & Ebbesen, 1997). New avenues for forgiveness research are proposed.

On the Form of Forgiving

Progress in the sciences—the psychological sciences included—rests on the identification of empirical regularities. In fact, the “theories-to-laws ratios” of the various sciences—the number of theories relative to the number of laws mentioned in a science’s introductory textbooks—is virtually synonymous with the maturity, status, and immediacy of that science and its knowledge base (Simonton, 2004). Within psychology, entire subfields of research on sensation, perception, and memory have arisen out of efforts to describe and formalize mathematical descriptions of seemingly simple bivariate relations, for example, the relationship between physical stimuli and their perceived sensory properties (Stevens, 1971), and the relationship between memory retention and the passage of time since learning occurred (Rubin, 1996; Wixted, 2004a, , 2004b; Wixted & Ebbesen, 1997). Basic efforts such as these often precede enormous waves of theoretical progress (Wixted, 2004b).

In the present paper, we sought to identify and describe a basic empirical regularity that is more germane to the fields of personality and social psychology than are the regularities governing sensation, perception, and memory: The relationship between forgiveness and time. Notwithstanding truisms such as “time heals all wounds,” and the laws of “habituation” and “comparative feeling” that Frijda (1988) formulated, surprisingly few scientists have explicitly examined affective change over time. There are a few exceptions, of course. For example, Hemenover (2003) tried to identify individual differences in rates of affective change over short intervals of time, and Carnelly, Wortman, Bolger, and Burke (2006) attempted to identify the best functions for describing the temporal trajectory of grief reactions. But aside from recent contributions such as these, research tells us little about the form of temporal changes in affect and motivation.

Forgiveness as a Model for Affective/Motivational Change

The concept of forgiveness provides an interesting model for considering affective and motivational change. Researchers have defined forgiveness in different ways, but all of their definitions are based on the idea that forgiveness involves temporal change. Enright, Gassin, and Wu (1992), for instance, defined forgiveness as “the overcoming of negative affect and judgment toward the offender, not by denying ourselves the right to such affect and judgment, but by endeavoring to view the offender with compassion, benevolence, and love...” (p. 101). Exline and Baumeister (2000) defined forgiveness as the “cancellation of a debt” by “the person who has been hurt or wronged” (p. 133). Finally, McCullough, Worthington, and Rachal (1997) defined forgiveness as “the set of motivational changes whereby one becomes (a) decreasingly motivated to retaliate against an offending relationship partner; (b) decreasingly motivated to maintain estrangement from the offender; and (c) increasingly motivated by conciliation and goodwill for the offender, despite the offender’s hurtful actions” (pp. 321-322).

Despite the obvious differences among such definitions, they are all based on the assumption that forgiveness involves prosocial change regarding a transgressor on the part of the transgression recipient. Most theorists concur that when people forgive, their responses (i.e., thoughts, feelings, behavioral inclinations, or actual behaviors) toward a transgressor become more positive and/or less negative. This point of consensus led McCullough, Pargament, and Thoresen (2000) to propose that *intra-individual prosocial change toward a transgressor* is a foundational and uncontroversial feature of forgiveness (McCullough & Root, 2005).

Researchers have considered the forgiveness-time relation in three different ways. Some researchers consider time by statistically controlling the amount of time since a transgression has elapsed before examining other potential correlates of forgiveness (Exline, Baumeister,

Bushman, Campbell, & Finkel, 2004; Finkel, Rusbult, Kumashiro, & Hannon, 2002; Orcutt, 2006) as a way of exerting greater statistical control over diverse experiences (for a fuller treatment of these methodological issues see McCullough & Worthington, 1999; Tsang, McCullough, & Hoyt, 2005).

Wohl and McGrath (in press) considered time by trying to understand how the perceived passage of time between a transgression and the present influences forgiveness. They discovered that experimentally increasing the perceived amount of subjective time that had passed since a transgression occurred (by manipulating the left and right anchors on a time line that moved from a point either in the recent or distant past to the present, and then asking participants to place the transgression somewhere between those two anchors), made people more forgiving (via self-report). These findings suggest that the perceived passage of time is sufficient to cause forgiveness, though the mechanisms yielding this effect are not well understood.

The third way to consider the forgiveness-time relationship is to incorporate time explicitly in how forgiveness is conceptualized and measured (McCullough, Fincham, & Tsang, 2003; McCullough & Root, 2005; Root & McCullough, in press). We have explored the idea that forgiveness as a process of change could be studied using mixed-effects (or multilevel) growth curve models in which change can be modeled as a simple linear or curvilinear function of time (McCullough, Fincham, & Tsang, 2003). In two longitudinal studies, we found that people generally experience a decline in their negative interpersonal motivations (e.g., revenge and avoidance motivation) following a transgression, but do not experience an increase in their positive motivations (although there were individual differences in rates of linear change in all of these constructs). We also found that simple two-parameter linear models fit the data better than

three-parameter models in which we permitted curvature in people's trajectories by introducing a quadratic effect for time.

However, several limitations of McCullough, Fincham, and Tsang's (2003) work made it inadequate for deriving a fully accurate description of the forgiveness-time function. First, their data sets had relatively few participants ($N = 73$ and 89 , respectively) and relatively small numbers of repeated observations per participant (i.e., no more than five repeated measures per participant). Low numbers of participants limits one's ability to predict individual differences in growth parameters and low numbers of observations within individuals limits the precision and flexibility for evaluating a wide variety of growth models (Singer & Willett, 2003). Second, we suspect that they did not measure people frequently enough within the measured intervals to capture non-linear growth processes. Third, the three self-report scales that they used to measure avoidance, revenge, and benevolence motivations were developed using classical test theory, the assumptions of which probably restricted the range of possible scores, thereby creating ceiling and floor effects that might have limited their ability to depict change faithfully. Fourth, and perhaps most importantly, they did not attempt to model forgiveness using non-linear models such as the logarithmic, exponential, and power functions that have been so useful, and ultimately, empirically fruitful for research on forgetting (e.g., Rubin, 1996; Wixted & Ebbesen, 1997).

The Present Study

In the present study, we attempted to surmount these problems by using (a) a large data set with large numbers of observations per individual that are spread out over a 100-day period following participants' transgressions; (b) a measure of forgiveness that yielded interval-level measurement and minimal restriction of range due to ceiling and floor effects; and (c) statistical

techniques that enabled us to evaluate linear models of growth as well as nonlinear ones. Having derived a wide variety of linear and nonlinear models for depicting the nature of the relations between forgiveness and time, we attempted to account for individual differences in our participants' rates of forgiveness with other known correlates of forgiveness both as a means of evaluating the construct validity of the resulting estimates of each person's rate of change *and* as a way of learning more about the factors that predict individual differences in the forgiveness function.

Method

Participants

Participants were $N = 372$ undergraduate students (74% female, 26% male) from Southern Methodist University and the University of Miami. By the time we obtained the first of the many repeated measures of forgiveness that we obtained on our participants, an average of 5.95 days ($SD = 3.13$ days; range = 0-20 days) had passed since their transgressions occurred, and more than three-quarters of participants' transgressions had occurred seven or fewer days before the first measurement point.

Data set 1. Participants were 89 students in undergraduate psychology courses (69 women, 20 men; M age = 20.44, $SD = 3.09$) at Southern Methodist University. All participants, who had incurred a transgression in the last 7 days ($M = 4.66$ days, $SD = 1.86$), received extra course credit for participating. Students who completed all five repeated measures received \$10. Data were collected by pencil and paper records that were individually distributed to participants in their introductory psychology courses approximately once every 14 days. Other procedural details are reported elsewhere (McCullough, Fincham, & Tsang, 2003, Study 2; Root & McCullough, in press, Study 1). Most transgressions were committed by girlfriends/boyfriends

(42%), friends of the same gender (23%), and friends of the other gender (15%). Smaller numbers detailed transgressions by relatives (10%), husbands/wives (3%) and “others” (8%). Participants described several types of transgressions, including betrayals of a confidence or insults by a friend (36%); neglect by a romantic partner, spouse, or ex-romantic partner (25%); infidelity by a romantic partner or spouse (13%); rejection, neglect or insult by a family member (10%); termination of a romantic relationship (7%); insults by people other than family or friends (3%); and rejection or abandonment by friend or prospective relationship partner (3%). Two participants declined to describe the specific transgression.

Data set 2. Participants were 115 students in undergraduate psychology courses (91 women, 24 men; M age = 19.76, SD = 2.61) at Southern Methodist University. Participants had encountered interpersonal transgressions within the 7 days prior to recruitment (M = 4.04 days, SD = 1.82). Data were collected by having participants visit the first author’s laboratory on up to five different occasions that were separated by approximately 14 days. Participants received up to \$20 for participating. Other procedural details are reported elsewhere (McCullough, Bono, & Root, 2007; Study 2; McCullough, Orsulak, Brandon, & Akers, 2007). Most participants described their transgressors as girlfriends or boyfriends (59%), friends of the same gender (19%), or friends of the other gender (11%). A few participants reported transgressions by relatives (10%), husbands/wives (3%) and “others” (9%). One person did not report the type of relationship involved. Participants experienced insults by a friend or betrayals of a confidence (28%); neglect by a romantic partner, spouse, or ex-romantic partner (22%); infidelity by a romantic partner or spouse (19%); rejection, neglect or insult by a family member (10%); termination of romantic relationship (11%); insults by people other than family or friends (3%);

and rejection or abandonment by a friend or prospective relationship partner (2%). Five participants did not describe the transgression.

Data set 3. Participants were 163 students in undergraduate psychology courses (112 women, 51 men) at the University of Miami. Participants had incurred interpersonal transgressions just prior to enrollment ($M = 4.37$ days prior to enrollment, $SD = 1.85$). They received extra course credit for participating and, if they completed the tasks described here and a separate laboratory session not described here, \$20. Upon enrollment, participants were given a packet of 21 daily questionnaires, and they were advised to complete one record each day for 21 consecutive days. Other procedural details are reported elsewhere (Root & McCullough, in press, Study 3). Most incurred transgressions committed by girlfriends/boyfriends (50%), friends of the same gender (19%), or relatives (13%). A smaller number of participants reported transgressions by friends of the other gender (9%), husbands/wives (1%) and “others” (8%). Participants described several types of transgressions, including infidelity by a romantic partner or spouse (29%); insults by a friend or betrayals of a confidence (20%); rejection, neglect or insult by a family member (13%); termination of a romantic relationship (13%); neglect by a romantic partner, spouse, or ex-romantic partner (10%); rejection or abandonment by a friend or prospective relationship partner (10%); and insults by people other than family or friends (5%).

Measures

Forgiveness. We conceptualize forgiveness as a process of reducing one’s negative (viz., avoidance and revenge) motivations toward a transgressor and restoring one’s positive, benevolent motivations regarding the transgressor (McCullough et al., 1997). To measure these motivational changes, in the present study we used the 18-item form of the Transgression-Related Interpersonal Motivations (TRIM) Inventory (McCullough, Root, & Cohen, 2006). The

7-item Avoidance subscale measures motivation to avoid a transgressor (e.g., “I live as if he/she doesn’t exist, isn’t around”). The 5-item Revenge subscale measures motivation to seek revenge (e.g., “I’ll make him/her pay”). Both have high internal consistency ($\alpha \geq .85$), moderate test-retest stability (e.g., 8-week test-retest $r_s \approx .50$) and evidence of construct validity (McCullough et al., 1998, 2001). Items are rated on a five-point Likert-type scale (1 = *strongly disagree* and 5 = *strongly agree*). We recently added a six-item subscale for measuring benevolence motivation (e.g., “Even though his/her actions hurt me, I have goodwill for him/her”) that also has good reliability (McCullough, Fincham, & Tsang, 2003; McCullough & Hoyt, 2002). These six items are rated on the same five-point Likert-type scale as are the 12 avoidance and revenge items.

McCullough, Root, and Cohen (2006) found that two oblique principal components could be extracted from the 18 items on the TRIM-18 (one of which represents avoidance vs. benevolence, and the other which represents revenge motivation), but here we explored the possibility that the appearance of multidimensionality belies a more basic unidimensional structure that might emerge under the Rasch (1960) model, which is a probabilistic conjoint measurement model (Fox & Jones, 1998).

We used the Rating Scale version of the Rasch model (Andrich, 1978) to explore the dimensionality and measurement characteristics of the 18 items on the TRIM. The simplest Rasch model posits that any individual’s score on a single test item on any occasion is a function of two parameters: a parameter representing the endorsability (or “difficulty”) of the item (i.e., how much or how little of a construct one would have to possess to endorse the item at a given level), and a parameter representing the individual’s standing on the psychological construct being measured on that particular occasion (Fox & Jones, 1998). The rating scale extension of the Rasch model also includes a threshold parameter for each response category in polytomous

items. Prior to the Rasch analysis, we reverse-scored the benevolence items so that high scores were indicative of less forgiveness (as was the case with the avoidance and revenge items). We used an expectation-maximization routine to estimate missing values on the TRIM items for cases missing one or two items (approximately 9% of the cases) before we conducted the Rasch analysis. For results described here, we conducted our analyses on data from 362 participants who were observed on a total of 3812 person-occasions. Item responses for all participants on all assessment occasions were fit to the Rasch model in a single analysis, which places all person measures over time on a common scale (Wright, 1996).

The TRIM items fit the Rasch model successfully: person and item separation reliabilities were 0.92 and 1.00, respectively. The fit of individual items to the Rasch model was assessed using unweighted mean-square fit statistics. These fit statistics have an expected value of 1. Fit statistics less than 1.5 contribute effectively to a measurement system, whereas fit values greater than 2 degrade measurement (Linacre, 2003). In the present sample, item fit values ranged from 0.73 to 1.55. A single unidimensional measure accounted for 83% of the item variance, with a yardstick-to-total noise ratio of 4.9:1. After accounting for variation attributable to the unidimensional measure, some structure remained in the residuals. Specifically, a single residual factor appeared to contrast the revenge items from the avoidance and benevolence items. However, modeling this structure would have led to only a small increment in variance explained (only an additional 4% after accounting for the unidimensional measure). The measure accounted for 20.9 times as much variance as did the residual component. Therefore, we concluded that the TRIM largely measures a unidimensional construct.

The item difficulties give some clue to the nature of this construct. The five revenge items were the most difficult, with the item reading “I wish something bad would happen to

him/her” scoring the highest item difficulty (i.e., the lowest endorsability). The avoidance and (reverse-scored) benevolence items were less difficult. The least difficult items were the reverse-scored benevolence item that read, “I forgive him/her for what he/she did to me” and the avoidance item that read “I don’t trust him/her.” Therefore, it stands to reason that a “moderately forgiving” person might have a low level of revenge motivation, but only a very forgiving person can also have a low level of avoidance motivation and a high level of benevolence.

We proceeded to calculate Rasch-derived measures of forgiveness for each individual on each occasion for which we had data. We omitted two participants at this stage, one of whom apparently falsified some of his or her data, and another for whom the measurement model provided a poor fit (apparently because of misunderstanding the meaning of one of the items). We transformed the scale so that zero was the lowest estimated person measure and ten units equaled one logit of difficulty. A logit, or log-odds, is a metric that permits an interval-level interpretation of the data. For every one-logit increase in one’s standing on the measure, one’s log-odds of endorsing an item at any given level of difficulty increases by a value of one. Exponentiating a logit yields an odds, so a one-logit increase in ability implies an $\exp(1) = 2.718$ increase in one’s odds of endorsing an item at a given level of ability.

Relationship-specific variables. Shortly after enrolling in the studies that led to these data, participants rated their perceptions of closeness and of commitment to the offender prior to the transgression using seven point Likert-type scales (where lower numbers imply less closeness and commitment, respectively). Participants also completed Aron, Aron, and Smollan’s (1992) Inclusion of Other in the Self (IOS) Scale. This single-item, visual analogue measure consists of seven pictures, each of which comprises two circles marked “self” and “other” that use progressively increasing degrees of overlap between the two circles to symbolize varying

degrees of closeness that someone might experience toward another person. We created a linear composite of these three measures ($\alpha = .92$), which has been correlated with forgiveness in previous work (McCullough et al., 1998).

Offense-specific variables. Participants rated the perceived painfulness of the transgression, the extent to which they attributed responsibility to the transgressor, and the extent to which they viewed the transgression as an intentional violation, on seven-point Likert-type scales (see also McCullough, Fincham, & Tsang, 2003). Participants also used two seven-point Likert-type scales to indicate the extent to which their offender apologized and made amends for the transgression. We combined these latter two items to create a scale ($\alpha = .82$).

Personality variables. Participants also rated their own personalities using the Big Five Inventory (BFI; John, Donahue, & Kentle, 1991). The BFI comprises 44 brief descriptive phrases that are prototypical markers for five broad personality dimensions: Agreeableness, Conscientiousness, Extraversion, Neuroticism, and Openness. Alpha reliabilities and test–retest reliabilities for the five subscales range from .80 to .90 (John & Srivastava, 1999). Researchers have noted that forgiving people tend to score low on measures of Neuroticism and high on measures of Agreeableness (McCullough, 2001).

Analyses

Major analyses proceeded in two steps. First, we evaluated the fit of the linear and non-linear growth models that have been commonly used to model forgetting as a function of time since learning (Wixted & Ebbesen, 1997). These models appear in Table 1.

Because our data set involved a set of repeated measures nested within individuals, they conformed to a multilevel structure. Therefore, we ran linear and nonlinear mixed-effect models using the nlme library in R (Pinheiro & Bates, 2000). Within a multilevel framework for

longitudinal data, variation in a set of repeated measures is partitioned into between-persons effects and within-persons effects. For example, one might model the variation in a set of repeated measures y for person j on occasions 1 to i as a function of an initial status and a rate of linear change (as in McCullough, Fincham, & Tsang, 2003) using the equation:

$$y_{ij} = \beta_{0j} + \beta_{1j} (\text{Time}_{ij}) + r_{ij} \quad (1)$$

where β_{0j} = person j 's initial status, or expected value on y when Time is 0, β_{1j} = the expected rate at which person j 's scores on y change as a linear function of time, and r_{ij} = a residual representing the difference between y_{ij} and the value that would be predicted on the basis of the β_{0j} and β_{1j} estimates. These residuals r_{ij} include measurement error and substantive variation in y_{ij} that might be explained with other variables that differ within person j as a function of time (Singer & Willett, 2003).

Between-persons variation in the β_{0j} and β_{1j} estimates is modeled as

$$\begin{aligned} \beta_{0j} &= \gamma_{00} + u_{0j} \text{ and} \\ \beta_{1j} &= \gamma_{10} + u_{1j} \quad (2, 3), \end{aligned}$$

where γ_{00} and γ_{10} estimate the expected initial status and rate of linear change for the entire population of individuals, respectively, and u_{0j} and u_{1j} represent person j 's deviation from those population values. Between-persons variation in u_{0j} and u_{1j} , therefore, represents variation in the extent to which people manifested a negative reaction to their transgressions immediately after the transgressions occurred and in the rates in which those motivations became less negative over the measured interval, respectively. This between-persons variation can be predicted on the basis of variables that differ across participants (e.g., differences in the nature of their relationships with the individuals who harmed them, differences in the transgressors' post-transgression behaviors, and differences in participants' personalities).

In addition to the linear within-persons model of Equation (1), we also evaluated a quadratic model by introducing a term for the squared effect of time to identify whether it was appropriate to evaluate more sophisticated non-linear models. Next we evaluated the exponential, logarithmic, power, hyperbolic, and exponential-power functions (Wixted & Ebbesen, 1997). To evaluate the relative fit of these models, we used the Bayesian Information Criterion (BIC; Pinheiro & Bates, 2000). Models yielding smaller BIC values are adjudged superior to models yielding larger BIC values.

Second, after determining the best mathematical form of the forgiveness function, we extracted person-specific estimates of initial status and forgiveness and attempted to predict the individual differences in forgiveness rates based on initial status and the relationship-specific, offense-specific, and personality variables described above.

Results

Table 2 shows means and standard deviations for major study variables. Figure 1 represents the data points from 15 randomly selected participants. The curves result from non-parametric regressions that depict people's temporal trajectories without imposing any assumptions about the growth parameters that generated them. These curves suggest that most participants experienced either significant declines in their scores over time (with diminishing returns), or else a fairly flat trajectory (suggesting relatively little decay). Both families of trajectories could be explained with two-parameter models that allow for varying initial status estimates and varying rates of decay across persons.

The Multilevel Models for Depicting Change

Table 1 provides the BIC values for each of the linear and nonlinear models we used to describe the relations between the forgiveness measure and time since the transgression. As can

be seen, a linear model which describes people's trajectories in terms of an initial status plus a constant rate of change ($BIC = 25424.57$) provides a better fit than does the "intercept-only" model ($BIC = 27164.00$). This suggests that true change occurred for some participants. A third model, in which we added the squared effect for time to permit curvature in people's trajectories, provided an even better fit ($BIC = 25318.35$), suggesting that the shape of change was not strictly linear. In this quadratic model, the term for linear change was negative (suggesting that people tended to experience forgiveness over time), but the term for quadratic change was positive (suggesting that the rate of forgiveness itself became smaller with the passage of time).

Quadratic models are not really plausible in the long run for describing a temporal trend because they imply growth without limit as time approaches infinity. Therefore, we tested a series of two-parameter nonlinear models that permit monotonic decline with diminishing returns without the problem of unbounded growth that the quadratic model implies. Of these nonlinear models, the logarithmic model (which involved the addition of 1 to the time values because the natural log is undefined at 0) provided the best fit to the data ($BIC = 25399.98$). Indeed, the other nonlinear models provided an even worse fit than did the linear model. Thus, we concluded that the best two-parameter model depicted forgiveness as linear in the log of time. Of the 326 participants for whom we could run within-subjects ordinary least squares growth models, only 19 (5.8%) of them had decay rates that were significantly larger than zero. In other words, the idea that forgiveness is produced by a decay mechanism that varies in strength across persons provided a good description for 94% of the participants in our sample.

According to the population-level parameters (or "fixed effects") of the logarithmic model, the typical people in the sample had an initial status of 60.93 and their scores declined at a rate of 4.49 units (with 10 units equal to one logit of difficulty) per log-day. In other words,

after three months (i.e., 91 days, which is coded as 92 days because logarithmic functions are undefined at zero) had passed following the transgression, the typical person in the sample would have been expected to experience a reduction of $4.49 \cdot \ln(92) = 20.3$ units, or 2.03 logits. By exponentiating 2.03, we find that after three months have passed, the typical person in our sample would have experienced a 7.61-fold reduction in their odds of endorsing any single TRIM item (all of which are scored so that higher scores equal less forgiveness) at a given level of difficulty.

The initial status and forgiveness rates varied significantly between persons ($SD = 21.03$ and 7.68 , respectively, $ps < .05$). The initial status and decay rates were significantly and negatively correlated ($r = -0.79$) such that people with higher initial scores had higher rates of logarithmic decay (see also McCullough, Fincham, & Tsang, 2003, who reported a negative correlation between initial status and rate of change).

Predicting Individual Differences in Rates of Forgiveness

Table 3 provides the results of an ordinary least squares regression analysis in which we regressed the person-specific estimates of forgiveness (expressed as rates of change with respect to the log of time) onto their initial status estimates as well as the personality variables, the relationship-specific predictors, and the offense-specific predictors. Overall, this equation predicted 68.9% of the inter-individual variation in rates of forgiveness. After controlling for the association of people's initial status estimates and their rates of logarithmic decay, the personality, relationship-specific, and offense specific variables accounted for a unique 10.6% of the variance. In particular, people who were high on Agreeableness had significantly higher rates of logarithmic decay, as did people who had higher levels of closeness/commitment to their transgressors prior to the transgression and whose transgressors made a lot of effort to apologize

and make amends for their behavior. People who evaluated their transgressions as painful and who viewed their transgressors as highly responsible for the transgression had lower rates of decay. These findings provide evidence of construct validity to our depiction of logarithmic change as forgiveness: Agreeableness, transgression painfulness, closeness/commitment, and so forth are well-known cross-sectional correlates of forgiveness (McCullough, 2001; but cf. McCullough et al., 2003, who found that high attributions of responsibility were correlated with faster rates of forgiveness).

Discussion

Forgiveness as Logarithmic Change

Forgiveness is a process of temporal change by which people's feelings and motivations toward people who have harmed them become more positive and less negative (McCullough, Fincham, & Tsang, 2003). Because forgiveness seems to be, for most people, a process of monotonic change (and because we scaled our dependent variables so that smaller values implied more forgiveness), we tested a variety of two-parameter linear and nonlinear models that can depict monotonic decay (Wixted & Ebbesen, 1997). By doing so, we discovered evidence consistent with the idea that forgiveness is a logarithmic function of time since the transgression. A logarithmic function underlies the Weber-Fechner law governing stimulus-perception relations (Fechner, 1966). Applied here, the Weber-Fechner law implies that as temporal distance from a stimulus (in this case, a transgression) increases geometrically, forgiveness increases linearly.

Although most researchers concede that the Weber-Fechner law has been superseded by the power law (Stevens, 1971) for describing most stimulus-perception relations, one implication of a logarithmic forgiveness function, as with the power function, is that time in some sense *retards* the progress of forgiveness (Wixted, 2004b; Wixted & Ebbesen, 1997). As time passes,

the rate of change becomes smaller. This can be seen by differentiating the logarithmic function with respect to time: In the first derivative, time since the offense appears in the denominator, as it does in the power and exponential-power functions (Wixted & Ebbesen, 1997).

In memory research, one common way to understand how time impedes forgetting is by invoking the concept of *consolidation* (Wixted, 2004b). Wixted, for instance, interprets the power law of forgetting as evidence for consolidation, and he invokes neuroscientific evidence suggesting that this process is largely the work of the hippocampus. Although researchers have barely scratched the surface of forgiveness in relation to the hundred years of research on the forgetting function (Rubin, 1996), it seems possible that the relatively good fit of a logarithmic forgiveness function means that people's negative feelings toward a transgressor become consolidated at the same time that they are being dissipated by another mechanism that works in the other direction, the net result of which is an ever more stubborn bolus of negative affect and motivation that is, nevertheless, ineluctably worn down by the passage of time. More fine-grained experimental research may be able to determine whether a consolidation process is responsible for the logarithmic appearance of the forgiveness function.

By interpreting the logarithmic function as the result of a process of decay plus a process of consolidation, it seems to follow that interventions for influencing forgiveness may be most effective if they are administered relatively early after transgressions have occurred because relatively little consolidation will have occurred at that point in time—just as the formation and decay of memories can be best influenced by processes that occur early in time after initial learning occurs (Wixted, 2004b). It might also be posited that “informal interventions” such as apologies, appeasement gestures, and expressions of contrition are most effective if received early after a transgression occurs. These seem like easy ideas to test through experimental and

intervention research. For example, in the current study we found that forgiveness rates were correlated with the extent to which offenders apologized and made amends within a few days after the transgression occurred. Do apologies have equally potent effects after one's feelings about the offense have had time to begin consolidating?

A second implication of a logarithmic model for the forgiveness function is the prediction, originally attributable to Jost [1897, cited in Wixted (2004a)], that if a person's feelings about two separate transgressions are equally negative at a given point in time, the transgression that happened further in the past will be forgiven less quickly than will the transgression that occurred more recently. This insight might be difficult for clinicians to believe, many of whom have told us over the years that their intuition is that people forgive quite slowly when transgressions have occurred in the recent past, but that forgiveness gets easier as people have time to put the transgression into perspective. Our findings suggest that exactly the opposite is true. A third implication of the present findings is that if two people experience the same initial level of outrage because of an offense but have different rates of forgiveness, then the difference in their levels of forgiveness at any point in time will become even larger as time passes.

A fourth and final implication of a logarithmic forgiveness function is that the proportionate increase in a stimulus needed to produce a noticeable change in perception at a given background level of the stimulus is constant across all possible background levels. In other words, if someone who reaches a certain level of forgiveness 10 days after a transgression needs to wait another five days to experience a noticeable increase in forgiveness (i.e., after a 50% increase in time), then the same person who reaches a certain level of forgiveness after 100 days will have to wait 50 more days to reach a noticeable increase in forgiveness (i.e., after another 50% increase in time). Applying the Weber-Fechner law to forgiveness, then, implies that people

will perceive themselves to make relatively large strides in forgiveness early in the process. As the transgression recedes further and further into the past, however, ever larger amounts of time must pass to obtain similar progress in forgiveness. Whether these implications are correct remains to be evaluated, but explicit tests of these implications would go far in providing further evidence for the logarithmic model of forgiveness that these data suggest.

How Much Change over Time?

By interpreting the parameters resulting from our logarithmic model, it appears that the types of people whom we studied tended to make rather remarkable progress in forgiving: Within three months, the typical person in this study became 7.61 times less “able” to endorse a negatively worded item (at any given level of intensity) regarding his or her transgressor. For example, over three months, it became 7.61 times more difficult for the typical person in our sample to “strongly agree” that he or she wanted to see his or her transgressor “hurt and miserable.” Stated in this fashion, we think most readers will concede that a lot goes on within the first few months following a transgression (at least within the context of the types of transgressions we have studied here). Indeed (if the logarithmic function is correct), someone would have to wait approximately 23 years before they obtained the second 2.03-logit reduction through the processes that generated the first 2.03-logit reduction during the first three months.

Construct Validity for Forgiveness as Logarithmic Change

We found that people high in Big Five Agreeableness had higher rates of logarithmic decay than did their less agreeable counterparts. In addition, people were more forgiving of people to whom they felt close and committed prior to the transgression. Also, as might be expected, transgressions that were perceived to be painful or for which the transgressor was held responsible were associated with less forgiveness. Finally, people whose transgressors made an

effort to apologize and make amends for their behavior experienced relatively fast progress in forgiving (McCullough, Worthington, & Rachal, 1997). In the context of the present study, these findings lend confidence to our interpretation of longitudinal change in our self-report measure as a process of “forgiveness,” and they also lend credence to previous conclusions drawn from cross-sectional and two-wave longitudinal studies regarding the correlates of forgiveness (Finkel, Rusbult, Kumashiro, & Hannon, 2002; McCullough & Hoyt, 2002; McCullough, Worthington, & Rachal, 1997).

Limitations and Future Directions

A limitation of the present study is that the harms people experienced were quite heterogeneous (ranging, as they did, from insults to parental rejection to sexual infidelity), and we were not able to control for all of the ways in which these experiences differed across persons. Importantly, we were unable to control for the nature of people’s interactions with their transgressors following the transgression. Later acts of apology and contrition, for example, might have distorted the forgiveness process away from the natural decay process that we were trying to observe; conversely, negative interactions with their transgressions probably exerted effects in the opposite direction. Indeed, the fact that approximately 6% of participants became significantly less forgiving over time suggests that events going on in people’s lives were influencing their forgiveness trajectories in ways that we could not control.

Even though people reported that their transgressions were, in general, quite painful (4.02 on a 0-6 scale, where 3 = *somewhat painful* and 6 = *the worst pain I ever felt*), they were obviously much less severe than the sorts of harms that have been studied in other forgiveness research (e.g., sexual abuse, intimate partner violence, etc.). Whether these results would generalize to a more severe set of interpersonal harms is unknown. Future work would benefit

from a more intensive look at naturally occurring, more severe, and more uniform “transgressions” (e.g., job layoffs, sexual assault, loss of a loved one to homicide). At the very least, it seems likely that the population averages for the control parameter would be much lower (implying slower rates of decay) than the rates we discovered in this present study.

Finally, we think it would be useful to explore whether our results generalize to other methods with which forgiveness might be measured (e.g., implicit, behavioral, and biological measures). Relatedly, it would be most useful to know whether the individual differences in rates of forgiveness that we have observed in this study are correlated with individual differences in the measures of social behavior, health, psychological well-being, and relationship functioning that have been associated with forgiveness in previous cross-sectional and experimental work (e.g., Finkel, Rusbult, Kumashiro, & Hannon, 2002; Karremans & Van Lange, 2004; e.g., Karremans, Van Lange, & Holland, 2005; Karremans, Van Lange, Ouwerkerk, & Kluwer, 2003; Witvliet, Ludwig, & Vander Laan, 2001).

Conclusion

The logarithmic model we have discussed herein has a mechanistic interpretation: That a process or combination of processes creates decay in people’s negative representations of a transgressor, but that this process becomes less efficient over time. Exactly *what* those processes are remains to be evaluated. Throughout this paper, we have referred occasionally to memory research, and it is possible that a more explicit integration of memory research with forgiveness theorizing would be fruitful. Perhaps the processes responsible for forgiveness and the processes responsible for forgetting have more in common than scientists have heretofore appreciated. For example, if the negative cues that stimulate people to feel avoidant and vengeful toward their transgressors become less salient over time, it seems likely that forgiveness would result.

Similarly, if *some* of those cues become stronger through rehearsal (e.g., rumination), thereby generating a consolidation of the memory of the offense, it seems like this countervailing memory process might produce the diminishing returns that these data reveal.

On the other hand, it is possible that the resemblance of the “forgiveness curve” to the “forgetting curve” is purely coincidental. Perhaps, if we had scaled our forgiveness variable so that higher scores implied more forgiveness (so that scores gradually increased with the passage of time) we would have made more effort to tie our results to concepts such as growth, recovery, or resilience. But irrespectively of whether a decay metaphor or a growth metaphor is ultimately most apt, we think that new theorizing about forgiveness that incorporates mechanisms that can produce such changes, and studies that attempt to identify such mechanisms empirically, might do much to elucidate the forgiveness process. At the very least, we hope this paper will be viewed alongside other recent efforts (e.g., Carnelly, Wortman, Bolger, & Burke, 2006; Hemenover, 2003) to model affective change and to explore the mechanisms that create it.

Author Notes

Michael McCullough, Lindsey M. Root, and Benjamin A. Tabak, University of Miami, Jack W. Berry, Samford University, Giacomo Bono, WestEd. Correspondence regarding this article may be sent to Michael McCullough, Department of Psychology, University of Miami, PO Box 248185, Coral Gables, FL 33124-0751. E-mail: mikem@miami.edu. This research was supported by National Institute of Mental Health Grant R01MH071258 and support from the Center for the Study of Law and Religion at Emory University and the John Templeton Foundation. Portions of this paper were presented at the 2007 Social Psychology Winter Conference in Park City, UT. We are grateful to Kathleen Vohs for providing feedback on an earlier version of this article.

Table 1

Candidate Equations for the Forgiveness Function, plus the Bayesian Information Criterion (BIC) Values that Resulted for Each Model

Function	Equation	Bayesian Information Criterion (BIC)
Intercept Only	$y_{ij} = \beta_{0j} + r_{ij}$	27164.00
Linear (Initial Status + Slope)	$y_{ij} = \beta_{0j} + \beta_{1j}(\text{Time}_{ij}) + r_{ij}$	25424.57
Quadratic	$y_{ij} = \beta_{0j} + \beta_{1j}(\text{Time}_{ij}) + \beta_{2j}(\text{Time}_{ij})^2 + r_{ij}$	25318.35
Exponential	$y_{ij} = \beta_{0j} * \exp(-\beta_{1j} * \text{Time}_{ij})$	25659.12
Logarithmic	$y_{ij} = \beta_{0j} + \beta_{1j} * \ln(\text{Time}_{ij}) + r_{ij}$	25399.98
Power	$y_{ij} = \beta_{0j} * \text{Time}^{-\beta_{1j}} + r_{ij}$	25822.16
Hyperbolic	$y_{ij} = 1/(\beta_{0j} + \beta_{1j} * \text{Time}_{ij}) + r_{ij}$	26953.45
Exponential-Power	$y_{ij} = \beta_{0j} * \exp(-2 * \beta_{1j} * \text{sqrt}(\text{Time}_{ij})) + r_{ij}$	25668.12

Table 2

Means and Standard Deviations for Major Study Variables

Variable	Mean	SD
Rasch Derived TRIM Scores ^a	51.09	15.00
Openness ^b	3.73	0.62
Conscientiousness ^b	3.67	0.68
Extraversion ^b	3.70	0.74
Neuroticism ^b	3.01	0.84
Agreeableness ^b	3.87	0.65
Closeness/Commitment ^c	3.02	1.94
Transgression Painfulness ^c	4.02	1.28
Responsibility Attribution ^c	4.93	1.37
Intentionality Attribution ^c	3.23	1.93
Apology/Making Amends ^c	2.25	1.82

^a $N = 3812$ (because multiple observations were nested within individuals). ^b $N = 361$, ^c $N = 368$.

Table 3

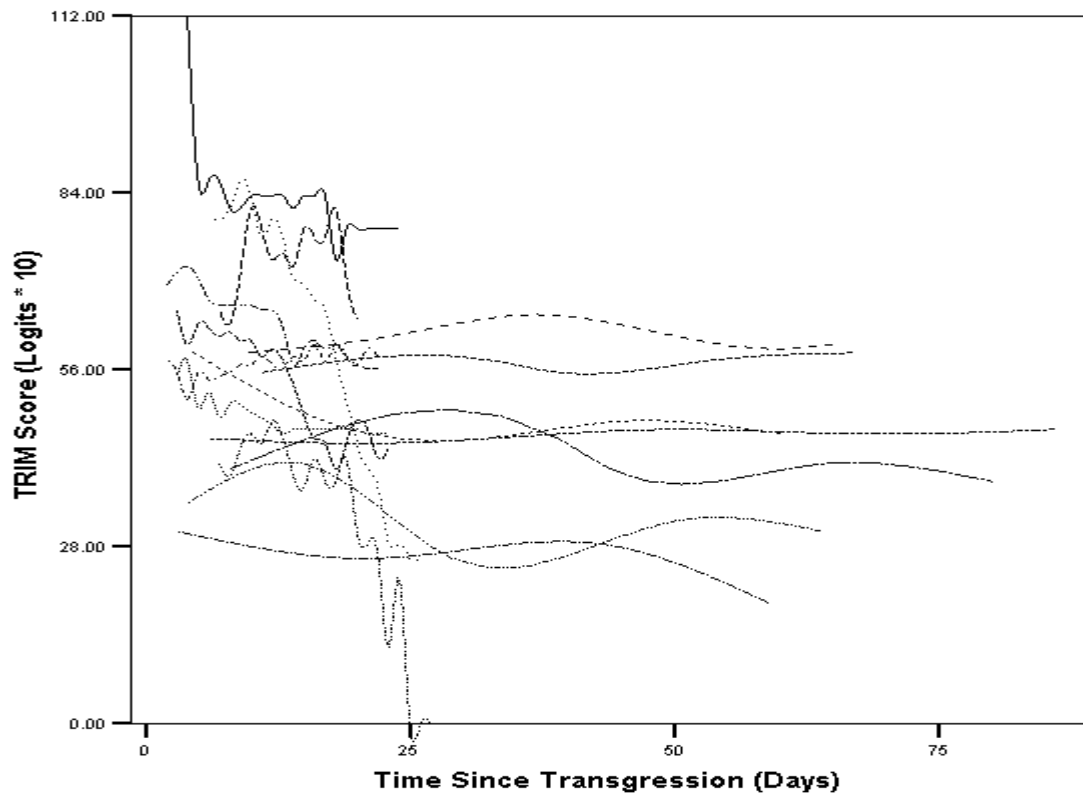
Regression of Between-Persons Differences in Forgiveness (Rate of Logarithmic Decay) on Personality, Relationship-Specific, and Offense-Specific Variables

Predictor	Coefficient	Standard Error	Standardized β
Initial Status	0.33	0.01	0.91***
Openness	0.17	0.36	0.02
Conscientiousness	0.51	0.34	0.05
Extraversion	0.19	0.31	0.02
Neuroticism	-0.10	0.28	-0.01
Agreeableness	0.80	0.36	0.07*
Closeness/Commitment	0.79	0.13	0.22***
Transgression Painfulness	-0.39	0.19	-0.07*
Responsibility Attribution	-.56	0.16	-0.11**
Intentionality Attribution	-0.22	0.12	-0.06
Apology/Making Amends	0.46	0.14	0.12**

Note. $N = 354$. * $p < .05$. ** $p < .01$. *** $p < .001$.

Figure Legend

Figure 1. Nonparametric Trajectory Plots for 15 Randomly Selected Cases (with > 2 Observations per Case).



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