relevant for revenge/forgiveness, but may also affect the proximate mechanisms outlined in the target article, namely WTRs. Can the relation between self-control, forgiveness, and revenge be understood by the adaptationist model? Here we suggest that self-control may work together with evolved psychological mechanisms (e.g., WTRs) to affect revenge and forgiveness.

Specifically, individual differences in self-control may aid our understanding of *monitored* WTRs. People who monitor their behavior in relation to goals during social interactions, thereby exerting self-control, may be more thoughtful about how their own and other's current behavior may affect future outcomes. Another possibility is that self-control is used to compare other's perceived WTRs to one's own WTR, and this process may affect revenge and forgiveness. Although previous research suggests that self-control may enable people to inhibit their desire for revenge in order to maintain valuable social relations, as we discuss below, self-control can also enable people to become more vengeful. Other traits may relate to individual differences in the calibration of *intrinsic* WTRs (such as social value orientations; see Balliet et al. 2009). Importantly, both features of personality that affect monitored and intrinsic WTRs may interact to affect revenge and forgiveness.

Recently, Balliet et al. (2011a) measured intentions of revenge in response to a partner's initial transgression during an iterated prisoner's dilemma (and maximizing difference game). They found that trait self-control negatively related to revenge in response to their partner's defection, but only amongst individuals who were less concerned for others' outcomes, relative to their own outcomes (i.e., low intrinsic WTRs). In this experimental context, participants were thought to be interacting for several trials of the dilemma. One implication of this finding is that self-control may affect calculating concern for anonymous others, and especially in situations when another has an ability to respond and punish one's behavior. Certainly, in the context of each iterated game, mutual cooperation is in the long-term self-interest for both parties. Thus, self-control may be a general ability that works by adjusting (monitored) WTRs to manage social relations and achieve long-term outcomes for the individual. A second implication is that the effect of self-control on revenge may depend on a person's intrinsic WTR.

An unexpected finding in recent work is that positive intrinsic WTRs can lead to stronger revenge motivation in response to a perceived transgression, but only when people have the time and exert self-control to think about the costs and benefits of revenge (Balliet et al. 2011a; Perunovic & Holmes 2008). Perhaps high intrinsic WTRs establish expectations of social behavior that are easily violated, and self-control may initiate a comparison between own and an other's perceived WTRs that may subsequently encourage revenge in an attempt to get the other to recalibrate their monitored WTR to reach an equilibrium with their own. Yet, for individuals who have a low intrinsic WTR, the use of self-control may result in attempts to display an increase in their own WTR toward the other. Interestingly, in both accounts self-control may encourage strategies to reach an equilibrium between one's own and the other's WTR.

A second finding not easily explained by existing theories is that punishment more effectively increases cooperation when punishments are costly to deliver (Balliet et al. 2011b). Prior theorizing suggests that reduced costs of punishment make punishment more effective at promoting cooperation. Yet, this finding may indicate the importance of others' perceived WTRs for revenge and forgiveness. Not only do people possess their own WTR, but also cognitive mechanisms disposed toward understanding others' WTRs, and these hold important implications for both own intrinsic *and* monitored WTRs. Perhaps costly punishments communicate that punishment is delivered out of concern for the relationship or group and so may be more effective by simultaneously increasing the transgressor's own intrinsic WTR as well as the monitored WTR.

As we reflected on the ability of an adaptationist perspective to guide research on revenge and forgiveness, we noticed in several instances that this perspective could be meaningfully related to conclusions from our own research and is able provide clues to some previously puzzling findings. Specifically, trait self-control and trait concern for others may affect forgiveness by the calibration of monitored and intrinsic WTRs, respectively – a possibility that deserves future research attention. Overall, we are excited about the possibility of this model directing future research. Managing social relations certainly provided an abundance of challenges in our ancestral environment that were directly relevant to survival and reproduction. Taking revenge to deter harm and forgiving others to maintain vital social relations are likely two important ingredients that have enabled humans to successfully navigate the social environment.

## Pathways to abnormal revenge and forgiveness

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**Abstract:** The target article's important point is easily misunderstood to claim that all revenge is adaptive. Revenge and forgiveness can overstretch (or understretch) the bounds of utility due to misperceptions, minimization of costly errors, a breakdown within our evolved revenge systems, or natural genetic and developmental variation. Together, these factors can compound to produce highly abnormal instances of revenge and forgiveness.

In the target article, McCullough et al. do an admirable job of arguing that revenge is not a disease, and instead may be an adaption to prevent exploitation. This approach is long overdue in many social sciences, as it moves away from pejorative preconceptions about behaviours we don't like. As with any adaptive explanation for behaviour, there is a high risk of the authors' argument being misunderstood to claim that all instances of revenge should be adaptive. Such misunderstandings regularly occur with other evolutionary explanations of human social behaviour. As such, the authors' argument requires extension to examine when revenge and forgiveness will overstretch (or understretch) the bounds of utility, and why.

A complete explanation of revenge and forgiveness will include errors of absence as well as errors of excess. While there are popularized cases of ridiculous revenge, we often overlook the excessive "lack of revenge" or excessive forgiveness. These are the things that fill books like *Chicken Soup for the Soul*. They are potentially equally maladaptive, but we don't see them as "errors" because we "like" this behaviour (see also Wakefield 1992). There is likely an optimal level of revenge and forgiveness for any situation. Too little revenge is an insufficient deterrent, but too much revenge invites further retaliation (Barclay 2008). Too little forgiveness prevents reparation of a relationship, but too much forgiveness invites future exploitation (Axelrod 1984). Finding the optimal level of revenge involves "brinksmanship" (Daly & Wilson 1988), a difficult game when people have imperfect information about the world or about others' past and future intentions (e.g., Todd 2001). Because of such constraints, no evolved psychological mechanism is expected to produce optimal results in every single instance, but is expected to be adaptive on average (Haselton & Buss 2000; Nesse 2005; Barclay 2011). The following are some causes of excessive or insufficient

revenge or forgiveness, and when combined in one individual, they could result in markedly abnormal behaviour indeed.

**Misperceptions of costs and benefits.** To produce adaptive levels of revenge and forgiveness, our brains must use environmental cues of the costs and benefits. Assessing these costs and benefits is no small task, as one must assess one's strength relative to a transgressor (and possibly an audience), audience presence and characteristics, one's need, the risk, the relationship value, and a host of other factors. Naturally, there is error associated with assessing any of these (Barclay 2008). Sometimes these errors will balance out, but when they don't, they will compound to produce more revenge or forgiveness than is optimal. Statistically speaking, these misperceptions alone will cause deviations from optimality that are normally distributed about the optimum, with most individuals near optimality but with some individuals displaying excessively high or low revenge or forgiveness.

**Misperceptions of others' actions.** The optimal level of revenge and forgiveness likely depends on others' intentions, both in terms of the reasons for their past actions and their intended future behaviour. Assessing such intentions is a mind-reading game, and is also prone to error. "Rules of thumb" based on past experience will only sometimes be right, and will sometimes overestimate hostility. Based on this, we might predict that people who are better at reading others' intentions will produce more optimal levels of revenge and forgiveness.

**Minimizing costly errors.** Different errors have different costs, and natural selection has presumably designed our emotions so that we avoid committing more costly or more frequent errors (Haselton & Buss 2000; Nesse 2005). If being too vengeful is more costly than being insufficiently vengeful, then our revenge systems should be biased towards producing less revenge than is "needed," and vice versa. A similar argument holds for forgiveness. Which is more costly, excessive or insufficient revenge (or forgiveness)? This is probably an empirical question. In fact, the answer may vary in different social environments depending on the frequency and importance of exploitation (bias towards excessive retaliation) and long-term cooperation (bias towards excessive forgiveness). By focusing on the costs and frequencies of these different errors, we can predict when we will observe excessive vengeance or excessive forgiveness.

**Genetic or development noise variation.** The target article outlines a number of tasks performed by our revenge and forgiveness systems, each of which involves many steps. As with any complex trait, each of these sub-tasks will be affected by multiple genes and environmental influences. Because these influences can combine in different combinations, it will cause natural variation about an optimum for each sub-task, resulting in some individuals in the tail ends of excessive revenge.

**Pathologies within the revenge systems.** Although the target article suggests that revenge is not a "disease," it does leave open the possibility of genuine diseases *within our evolved revenge systems*. Some individuals might indeed have something "broken" in the brain areas responsible for assessing costs, benefits, and intentions, or for producing an appropriate level of revenge. For example, if a (subconscious) assessment of costs tends to inhibit revenge, then anything that damages the brain's inhibitory systems will prevent this inhibition and will result in excessive revenge. Also, if someone is insensitive to costs or punishment in general (e.g., psychopaths), then there will be nothing to lower their vengefulness down to optimal levels. In other words, the capacity for revenge is not pathological, nor is the acting on that capacity, but there can be pathologies associated with expressing that capacity. It is these pathologies that probably produce the types of revenge and forgiveness that make newspaper headlines (Barclay 2008).

These are but some of the potential causes of abnormal levels of revenge and forgiveness. Some will result in normally distributed variation in revenge and forgiveness, whereas others will cause systematic biases towards excess (e.g., pathologies, error

management). Altogether, they show how not every instance of revenge will be beneficial, nor will every instance of forgiveness. Thus, we can extend the framework that McCullough et al. provide to make predictions about "abnormal" levels of revenge and forgiveness.

# The cultural shaping of revenge

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**Abstract:** There are interesting parallelisms between McCullough et al.'s article and studies of revenge presented by French legal anthropologist Raymond Verdier, particularly as regards the discussion of the increasing likelihood of revenge with increasing social distance. Additionally, the observation that many peoples speak of revenge in the language of debt and repayment, links it with exchanges of benefits as well as costs.

Substantial parts of this interesting target article by three psychologists, McCullough, Kurzban, and Tabak (McCullough et al.), are strikingly congruent with studies of revenge conducted by anthropologists over the last three decades. Among the most important publications in this arena are the four volumes edited by French legal anthropologist Raymond Verdier and his collaborators (Verdier 1981a; 1986; Verdier & Poly 1984; cf. Courtois 1984). In his introduction to that work, Verdier (1981b) points out that in many (perhaps most) societies vengeance is spoken of in terms of debt and repayment, the vocabulary in which people talk about the owing and paying of goods and services – and most importantly, the same terms in which the exchange of women as brides is discussed. Indeed, one of the most common means of terminating an actual or potential blood feud is for the family or lineage of the killer to turn over one of its daughters as a wife to the family or lineage of the homicide victim, the woman's life-giving capacity being taken as compensation for the life than was taken. This perspective potentially amplifies the applicability of the Welfare Tradeoff Ratio (WTR) to include all fitness relevant exchanges, comprehending benefits as well as costs in a single calculation.

Another area of convergence arises from the authors' remark that "we expect revenge to be less likely in the context of kin, people with whom one has an ongoing exchange relationship (…), friends and allies (…), and long term mates" (target article, sect. 4.1, para. 3). Verdier (1981b; 2008) distinguishes three increasingly distant categories of social relations – *identity, adversity* (by which he means that the actors on the poles of the relationship are adversaries, but not usually permanent enemies), and *hostility* – each marked by a characteristic form of retribution. (These categories map rather well to the three spheres of reciprocity – generalized, balanced, and negative – proposed by Sahlins (1972) to classify the varieties of material exchange.) Within identity, the first and closest category of social relations (e.g., the family, the clan), violent revenge is forbidden. To kill or injure someone in that tight circle would only be to compound the initial injury to oneself. Retribution is characteristically left to the workings of supernatural forces.

It is in the second category, adversity, (e.g., different clans within the same tribe, neighboring tribes that intermarry) that the cultural elaboration of revenge flourishes, often with elaborate rules stipulating what constitutes an injury calling for revenge, who ought (or must) take revenge, who is eligible and who is ineligible as a target, and where and when and how it is permissible to take revenge, and what sort of revenge is mandated. The typical goal in this realm of adversity is to achieve a balance of injuries,