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Understanding Impulsive Aggression: Angry Rumination and Reduced Self-Control Capacity Are Mechanisms Underlying the Provocation–Aggression Relationship

Thomas F. Denson[1], William C. Pedersen[2], Malte Friese[3], Aryun Hahm[2], and Lynette Roberts[1]

Abstract

Interpersonal provocation is a common and robust antecedent to aggression. Four studies identified angry rumination and reduced self-control as mechanisms underlying the provocation–aggression relationship. Following provocation, participants demonstrated decreased self-control on an unpleasant task relative to a control condition (Study 1). When provoked, rumination reduced self-control and increased aggression. This effect was mediated by reduced self-control capacity (Study 2). State rumination following provocation, but not anger per se, mediated the effect of trait rumination on aggression (Study 3). Bolstering self-regulatory resources by consuming a glucose beverage improved performance on a measure of inhibitory control following rumination (Study 4). These findings suggest that rumination following an anger-inducing provocation reduces self-control and increases aggression. Bolstering self-regulatory resources may reduce this adverse effect.

Keywords

anger, aggression, angry rumination, self-control, glucose, self-regulation

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Anger is a common antecedent of aggressive behavior, and uncontrolled anger can lead to aggression and violence. Evolutionary theory suggests that in our ancestral past, aggression was a risky but often effective solution to survival-related problems faced by our ancestors (cf. Buss, 2005). However, it was not until the late 18th century that Americans came to value regulating anger in the interest of promoting greater social harmony (Stearns & Stearns, 1986). In the modern world, there are serious negative consequences for those who display anger and engage in aggressive behavior. They include social disapproval, moral stigma, and legal difficulties. In most circumstances, the costs will outweigh potential benefits. Although there may be specific instances when we are motivated to experience anger (Scherer & Tannenbaum, 1986; Tamir, Mitchell, & Gross, 2008), because of the risk of incurring the high costs associated with displays of anger and aggression, individuals are typically motivated to regulate angry thoughts, feelings, and aggressive behavior (Stearns & Stearns, 1986; Tice & Baumeister, 1993).

Anger-inducing interpersonal provocation has been described as "perhaps the most important single cause of human aggression" (Anderson & Bushman, 2002, p. 37). Accordingly, research suggests that anger regulation is a common response to provocation. For instance, within seconds of being provoked, activity increases in brain regions associated with controlled top-down emotion regulation (Denson, Pedersen, Ronquillo, & Nandy, 2009). Moreover, angry feelings and associated physiological arousal tend to dissipate within 10 to 15 min, which suggests that individuals are typically capable of effective anger regulation (Doob & Climie, 1972; Fridhandler & Averill, 1982; Tyson, 1998). Nonetheless, the many acts of impulsive, anger-driven aggression that are observed in daily life suggest that individuals sometimes struggle to resist aggressive urges. Indeed, impulsive aggression is most

[1]University of New South Wales, Sydney, Australia
[2]California State University, Long Beach, CA, USA
[3]University of Basel, Basel, Switzerland

Corresponding Author:
Thomas F. Denson, University of New South Wales, School of Psychology, Sydney, NSW 2052, Australia
Email: t.denson@unsw.edu.au

often due to the inability to inhibit our evolved predisposition toward aggression when angered (MacDonald, 2008). This notion is consistent with neuroscientific perspectives of aggressive behavior in which more recently evolved, prefrontal regions are thought to exert top-down control over angry feelings and aggressive urges generated by limbic and subcortical regions (e.g., Davidson, Putnam, & Larson, 2000; Denson, 2011; Raine, 2008; Siever, 2008). Thus, when viewed in this light, aggression following a provocation can be thought of as a failure of self-control.

Although individuals are typically motivated to regulate angry affect and aggressive urges, the fact that they are not always able to effectively do so suggests the presence of additional mechanisms. One possibility explored in the research described here is that the manner in which individuals regulate angry feelings may paradoxically increase aggression by reducing self-control. Indeed, not all forms of anger regulation are effective in reducing anger and aggressive behavior. Gross and colleagues distinguish between *antecedent-focused* and *response-focused* emotion regulation strategies (Gross, 2001). Antecedent-focused emotion regulation strategies are believed to be the most effective in reducing anger and aggression because they occur before the initiation of a full-blown anger response. The most widely studied antecedent-focused strategy is cognitive reappraisal, in which individuals interpret a potential emotional episode in an objective, non-emotional manner before the elicitation of an intense emotional response (Gross, 2001). Response-focused strategies involve managing the anger response after the anger experience has already begun. These include emotional suppression (i.e., attempting to suppress the intensity of the emotional experience) and angry rumination, which consists of reliving the anger-inducing event, focusing on angry thoughts and feelings, and planning revenge (Caprara, 1986; Denson, Pedersen, & Miller, 2006; Sukhodolsky, Golub, & Cromwell, 2001).

Mediating Mechanisms: Angry Rumination and Reduced Self-Control

The present research focused on one common anger regulation strategy in particular: angry rumination (Caprara, 1986; Sukhodolsky et al., 2001). Relative to distraction, angry rumination following a provocation increases aggression (Bushman, 2002; Caprara, 1986), even toward those who had nothing to do with the original provocation (Bushman, Bonacci, Pedersen, Vasquez, & Miller, 2005; Denson et al., 2006; Denson et al., 2011). Recent social psychological theories offer explanations for how rumination augments aggression. According to the general aggression model (GAM; Anderson & Bushman, 2002; DeWall & Anderson, 2010), person and situation factors interact to influence one's present internal state (i.e., angry affect, aggressive cognition, and physiological arousal). In the context of anger, each time a person thinks about a provoking incident, rumination maintains or increases each of these three routes to aggression (Pedersen et al., in press). This increase in aggressive routes is thought to impair the capacity to thoughtfully reappraise the situation, which thereby increases the likelihood of impulsive aggression and decreases the likelihood of refraining from aggression.

A recent metatheory known as I^3 (pronounced "I-cubed") theory places emphasis on the role of self-control failure as a cause of aggression (Slotter & Finkel, 2011). Specifically, I^3 theory posits that instigating triggers, impelling forces, and inhibiting forces determine aggressive behavior. In the presence of an instigating trigger (e.g., provocation), aggression occurs when impelling forces overpower inhibiting forces. Consistent with both the GAM and I^3 theory, rumination can be conceptualized as exerting both impelling and disinhibiting effects. The anger, aggressive cognition, and physiological arousal might be considered impelling forces, but we suspect that regulating these impelling forces decreases self-control capacity (i.e., an inhibiting force).

Because angry rumination is characterized by aversive, intrusive thoughts accompanied by angry affect, we propose that rumination requires the recruitment of three self-regulatory processes: (a) managing the intensity of the anger experience, (b) suppressing angry thoughts, and (c) inhibiting urges to act on aggressive impulses. These three components can be conceptualized as emotion regulation, thought suppression, and acts of behavioral volition, respectively. From research unrelated to aggression, it is known that each of these processes consumes self-control resources (see Baumeister, Vohs, & Tice, 2007; Hagger, Wood, Stiff, & Chatzisarantis, 2010). Because angry rumination likely triggers all three resource-depleting processes, we suspect that its effects on the failure to control aggression may be particularly pernicious. Thus, we propose that the self-regulatory effort exerted when ruminating about an anger-inducing interpersonal provocation reduces self-control and thereby increases aggression.

Recent findings provide initial support for the hypothesis that resource depletion might underlie the link between rumination and increased aggression. Experimentation within the framework of the strength model of self-control has found that emotion regulation is costly in terms of self-regulatory resources (Baumeister, Bratslavsky, Muraven, & Tice, 1998; Hagger et al., 2010). The strength model suggests that executive functioning is a limited yet renewable resource (Baumeister et al., 2007). Thus, a prior act of volition will temporarily deplete these resources, which increases the likelihood that individuals will be less able to control their subsequent behavior, urges, and emotions. In this manner, depletion increases risk of impulsive behavior such as retaliatory aggression. Indeed, experimental evidence confirms that when depleted and subsequently provoked, aggression is more severe than when not depleted even when the

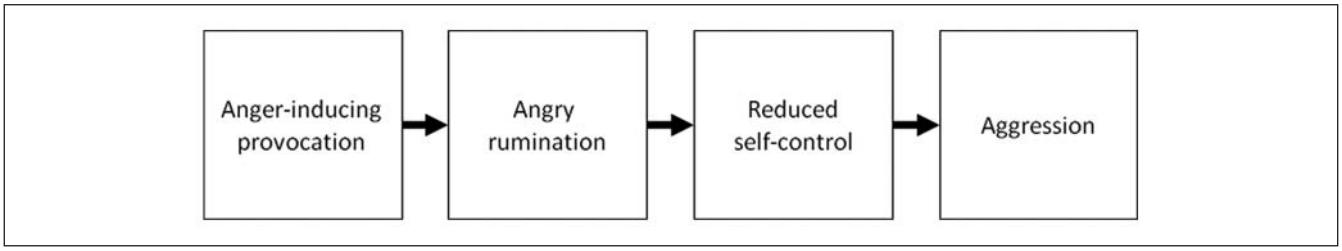

Figure 1. Temporal model showing intervening mechanisms of the relationship between provocation-induced anger and aggressive behavior

Note: When an anger-inducing provocation is followed by rumination, self-regulatory effort exerted during rumination reduces self-control and increases the likelihood and severity of aggression.

initial source of the depletion is unrelated to anger (DeWall, Baumeister, Stillman, & Gailliot, 2007; Finkel, DeWall, Slotter, Oaten, & Foshee, 2009; Stucke & Baumeister, 2006).

Conversely, bolstering executive control decreases aggression (Denson, von Hippel, Kemp, & Teo, 2010; Finkel et al., 2009). Acute glucose consumption is particularly relevant in this regard. To engage in an act of self-control, sufficient glucose must be available to the brain (Gailliot, 2008; Gailliot & Baumeister, 2007). Research suggests that glucose consumption can improve executive control capacity when depleted (Denson et al., 2010; DeWall, Baumeister, Gailliot, & Maner, 2008; Gailliot et al., 2007; Gailliot, Peruche, Plant, & Baumeister, 2009). For instance, Gailliot et al. (2007) found that when participants were depleted by being asked to control their visual attention, consuming a glucose beverage improved performance on the Stroop color-naming task, which is a measure of inhibitory control.

Overview of the Present Research

Figure 1 presents a temporal model of the relationship between provocation and aggressive behavior. We suggest that anger-inducing provocation increases aggression because provocation often leads to angry rumination, which induces self-regulation. The depletion induced by the recruitment of these self-regulatory processes during rumination increases the likelihood and severity of subsequent aggressive behavior because it weakens the ability to control aggressive tendencies. The present research tested these notions in four studies. In Study 1, we sought to demonstrate a direct link between provocation and reduced self-control. To this end, participants were insulted and given the opportunity to briefly engage in spontaneous anger regulation. We suspected that the mental effort exerted in response to this provocation would reduce self-regulatory capacity in that provoked participants would persist less on an unpleasant task than unprovoked participants (e.g., Baumeister et al., 1998). To examine the effects of angry rumination on depletion more directly, in Study 2 we manipulated this form of response-focused anger regulation. Specifically, Study 2 tested the possibility that within a single experiment, angry rumination would temporarily reduce self-control and thereby augment aggressive behavior. Study 3 investigated the mediating effects of anger and spontaneous rumination on the relationship between trait rumination and aggression. Furthermore, because glucose has been implicated as the energy source underlying self-control (Gailliot & Baumeister, 2007; Gailliot et al., 2007), Study 4 investigated the novel possibility that relative to placebo, consumption of a glucose-rich beverage would bolster self-regulatory capacity and thereby provide a buffer against the depleting effects of angry rumination as assessed by performance on a measure of inhibitory control.

Study 1

If the anger regulation and angry rumination in particular that follow interpersonal provocation can reduce general self-control capacity, we should expect to see an effect of provocation on a domain entirely unrelated to aggressive behavior. We tested this hypothesis in Study 1. Specifically, participants were either insulted or not by a fictitious participant and were then asked to exert willpower on a subsequent unpleasant task. Because rumination is a common response to provocation (e.g., Konečni, 1974; Sukhodolsky et al., 2001), we expected that even this brief anger experience would be sufficient to elicit self-regulatory depletion, as participants would presumably engage in spontaneous angry rumination and attempt to stop doing so.

Method

Participants and design. A total of 58 participants responded to an advertisement on the University of New South Wales (UNSW) careers website for laboratory research investigating social interaction, perseverance, and performance. They received AUD$15 in exchange for participation. Participants were randomly assigned to one of two experimental conditions (provocation, no provocation). Data from 4 participants were excluded from the final analyses due to suspicion about

the provocation procedure. This left a final sample of 54 participants (34 women; 69% Asian, 19% White, 13% Other). The distribution of men and women did not differ as a function of condition, $\chi^2(1) = 0.02$, $p = .88$.

Materials and Procedure

Provocation manipulation. Participants were asked to prepare a 2-min speech based on talking points provided by the experimenter (e.g., future plans, university experience), which they would later present via a bogus web conference to a participant ostensibly in the laboratory down the hall. In reality, the web conference was prerecorded. To make this deception more realistic, the experimenter began the web conference with a series of simple instructions for a sex-matched actor, timed to ensure that the instructions given by the experimenter and the responses from the bogus participant coincided. The experimenter then instructed the participant and the actor not to interrupt each other during the other's speech, which helped ensure that the participant did not discover this deception. The actor always spoke first for 2-min, followed by the actual participant's 2-min speech. Participants were then told that they were to evaluate their partner's speech and vice versa via a single online chat message. All participants then received insulting or neutral feedback, ostensibly from the confederate. Participants in the provocation condition received feedback stating "Your speech was juvenile and boring. A waste of my time listening to you," whereas participants in the no-provocation condition received feedback stating "Your speech sounds reasonable." Participants were left alone for approximately 3 min following the feedback. This provocation procedure has been used in past research (Denson et al., 2010; Memedovic, Grisham, Denson, & Moulds, 2010).

State self-control. Participants were then asked to take part in an ostensibly unrelated tasting test that involved consuming bad-tasting drinks containing vinegar. Participants were encouraged to consume as many cups as they could, with a monetary incentive of 10 Australian cents per cup drunk. The drink, which was a modified version of that used in previous studies (e.g., Baumeister, DeWall, Ciarocco, & Twenge, 2005), consisted of 10% vinegar, 5% Cottee's unsweetened lemon drink,[1] and 85% water by volume. Each cup contained 30 ml of the drink. The total number of 30-ml drinks consumed by the participant was used as the measure of state self-control. The reasoning is that to obtain the reward, monetary or otherwise, one must exert self-control to drink as much of the bad-tasting drink as possible.

Manipulation check and debriefing. Participants rated the degree to which they experienced each of seven anger-related emotions as a result of the provocation: angry, hostile, scornful, grouchy, annoyed, upset, and offended (1 = *not at all*, 7 = *extremely so*; $\alpha = .94$). Finally, participants were probed for suspicion, thanked, debriefed, and paid.

Results and Discussion

Participants in the provocation condition reported feeling more angry ($M = 2.86$, $SD = 1.49$) following the interaction with the confederate than participants in the no-provocation condition ($M = 1.28$, $SD = 0.48$), $F(1, 52) = 29.28$, $p < .001$, $\eta^2 = .36$, suggesting an effective manipulation. Most importantly, provoked participants drank fewer cups ($M = 7.25$, $SD = 5.60$) of the unpleasant beverage than nonprovoked participants ($M = 11.17$, $SD = 6.13$), $F(1, 52) = 5.95$, $p = .02$, $\eta^2 = .10$, suggesting that anger regulation immediately following the provocation depleted self-regulatory capacity.

Study 1 demonstrated the effect of provocation on self-regulatory depletion. Specifically, angered participants showed reduced self-control strength on a subsequent task unrelated to aggressive behavior. To our knowledge, this is the first such finding. However, this initial study was limited in the extent to which we can conclude that the self-regulatory processes recruited as a result of angry rumination caused this depletion effect. Specifically, participants were not instructed on how to manage their emotional reactions to the provocation. Thus, individual differences in emotion regulation strategies other than rumination following the provocation may have played a role. Therefore, Study 2 experimentally induced participants to ruminate or engage in distraction following provocation.

Study 2

In Study 2 we examined the extent to which reduced self-control would mediate the aggression-augmenting effect of angry rumination. Specifically, participants were provoked by the experimenter or not and then induced to ruminate or engage in distraction for 20 min. State depletion was assessed via self-report, after which participants were given the opportunity to aggress against the experimenter. Relative to distraction, we expected that rumination would decrease state self-control and increase aggression when participants were provoked. Furthermore, we expected that reduced self-control would mediate the interactive effect of provocation and rumination on aggressive behavior.

Method

Participants and design. Two hundred undergraduates from California State University, Long Beach participated for course credit. Thirteen participants were removed due to suspicion, leaving a total of 187 participants ($M_{age} = 19.02$, $SD_{age} = 1.50$). Participants were randomly assigned to one of four conditions in a 2 (provocation, no provocation) × 2 (rumination, distraction) between-participants design. Men and women were equally distributed across the conditions, $\chi^2(3) = 2.34$, $p = .51$.

Materials and Procedure

Provocation manipulation. Participants received a list of 15 anagrams. In the provocation condition, 11 of the anagrams were difficult. After 4.5 min, the research assistant took the anagram answer sheet for scoring and gave the participant a computer printout showing that most previous participants had gotten nearly all of the anagrams correct. A few minutes later, the experimenter entered with the score, told participants that their performance was unsatisfactory, and insulted the participant in an irritated tone of voice: "We should probably just start all over, but to be perfectly honest with you, I don't want to waste my time." In the no-provocation condition, participants were given easy anagrams and told that their performance was average. This manipulation has successfully increased anger and aggression in past experiments (Bushman et al., 2005; Denson et al., 2006; Vasquez, Denson, Pedersen, Stenstrom, & Miller, 2005).[2]

Rumination manipulation. Participants were informed that the next part of the experiment involved an academic writing task and that a topic had been randomly selected for the participant to write about. In the rumination condition, participants were asked to write about their experience in the experiment thus far. Suggested points included "Write about who you have interacted with in the experiment up to this point" and "Write about the emotional reactions you have had in the experiment." Participants in the distraction condition were asked to describe the layout of their university campus. Participants in both conditions wrote for 20 min. These manipulations have been used effectively in prior research (Bushman et al., 2005; Denson et al., 2006; Denson, Fabiansson, Creswell, & Pedersen, 2009; Denson, Pedersen, et al., 2009; Pedersen et al., in press).

State self-control. The 10-item State Self-Control Capacity Scale (α = .85; Twenge, Muraven, & Tice, 2004) assessed levels of depletion in response to the experimental manipulations (e.g., "I feel mentally exhausted"; 1 = *not true*, 7 = *very true*). The measure has been used in prior research and is sensitive to depletion manipulations (DeWall et al., 2007; Gailliot, Schmeichel, & Baumeister, 2006; Twenge et al., 2004).

Aggression. Participants were given a form written on university letterhead, which explained that the Department of Psychology was soliciting input from participants in the hiring of student research assistants. It indicated that these were coveted positions in the department because they looked good on students' resumes and offered a good salary. Allegedly, the department had received far more applications than they had positions and therefore would like student input in the hiring process. The form explained that the experimenter in the current study had applied for this position and participants were asked to evaluate this individual on five items ostensibly to be used in hiring decisions (α = .89). One item assessed how strongly they recommended the experimenter for the position. The remaining items assessed their evaluation of the experimenter on four dimensions: likeable, friendly, competent, and intelligent (1 = *strongly agree*, 7 = *strongly disagree*). Participants were asked not to place their name on the evaluation. Furthermore, they placed the evaluation in an envelope and deposited it in a box to be picked up by a department staff member. Aggression is typically defined as behavior intended to harm another person (e.g., Anderson & Bushman, 2002). By giving a negative evaluation, participants could intentionally harm the experimenter's chance to obtain the highly coveted assistantship. This previously used measure (e.g., Pedersen, Gonzales, & Miller, 2000) yields the same theoretically predicted results as physical measures of aggression such as painful blasts of white noise and placing a person's hand in painfully cold water (e.g., Bushman et al., 2005; Vasquez et al., 2005).

Provocation manipulation check. Participants rated the degree to which they experienced angry affect as a result of the insult (i.e., angry, irritable, annoyed; 1 = *definitely not*, 4 = *definitely*; α = .82).

Rumination manipulation check. Participants rated *how often* and *how strongly* they thought about the social interaction task while they were writing the essay (α = .80; 1 = *not at all*, 7 = *very often*/*very strongly*). The experimenter then debriefed the participant.[3]

Results and Discussion

Manipulation checks. Participants in the provocation condition ($M = 2.22$, $SD = 0.93$) reported more anger regarding feedback on the anagram task than did those in the no-provocation condition ($M = 1.47$, $SD = 0.75$), $F(1, 185) = 35.59$, $p < .001$, $\eta^2 = .16$. Participants in the rumination condition reported thinking more about the provocation during the writing task ($M = 4.25$, $SD = 1.71$) than did those in the distraction condition ($M = 2.28$, $SD = 1.57$), $F(1, 171) = 61.81$, $p < .001$, $\eta^2 = .27$. These results suggest effective provocation and rumination manipulations.

State self-control. A 2 (provocation, no provocation) × 2 (rumination, distraction) between-participants ANOVA revealed a main effect of provocation, $F(1, 181) = 8.83$, $p = .003$, $\eta^2 = .05$, such that provoked participants reported feeling more depleted than nonprovoked participants. However, this was qualified by the expected Provocation × Rumination interaction, $F(1, 181) = 5.74$, $p = .02$, $\eta^2 = .03$ (see Figure 2). Simple effects analyses revealed that when provoked, rumination reduced state self-control, $F(1, 181) = 4.40$, $p = .04$, $\eta^2 = .04$, whereas no significant differences emerged for nonprovoked participants, $F(1, 181) = 1.73$, $p = .19$, $\eta^2 = .02$. (Although not significant, unexpectedly self-control was directionally greater in the rumination than distraction condition.) Furthermore, a contrast comparing the provocation/rumination condition with the remaining conditions (+3, −1, −1, −1) revealed significantly reduced self-control in the

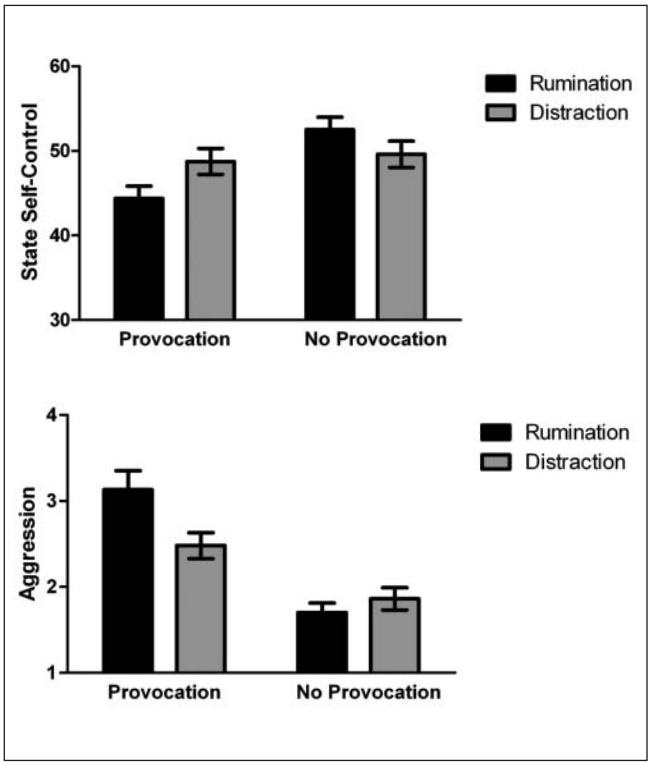

Figure 2. Means and standard errors of state self-control and aggression as a function of provocation and rumination from Study 2

Note: Higher values represent more self-control and aggression, respectively. Values range from 7 to 70 for self-control and 1 to 7 for aggression.

former condition, $t(181) = -3.52$, $p = .001$, $d = -.57$. Contrast residuals were not significant (Levin & Neumann, 1999), suggesting that the contrast captured all of the significant between-group variance, $F(2, 736) = 1.66$, $p > .10$. There was no main effect of rumination, $F < 1$.

Aggression. The results for the aggression measure paralleled those of the state self-control measure. Specifically, a 2 (provocation, no provocation) × 2 (rumination, distraction) between-participants ANOVA revealed a main effect of provocation, $F(1, 183) = 37.23$, $p < .001$, $\eta^2 = .17$, such that provoked participants were more aggressive than nonprovoked participants. However, this was qualified by the expected Provocation × Rumination interaction, $F(1, 183) = 5.84$, $p = .02$, $\eta^2 = .03$ (see Figure 2). Simple effects analyses revealed that when provoked, rumination increased aggression, $F(1, 183) = 7.99$, $p = .005$, $\eta^2 = .05$, whereas no differences emerged for nonprovoked participants, $F < 1$. Furthermore, a contrast comparing the provocation/rumination condition with the remaining conditions (+3, −1, −1, −1) revealed significantly increased aggression in the former condition, $t(183) = 6.00$, $p < .001$, $d = .94$. Contrast residuals were significant, $F(2, 744) = 5.70$, $p < .05$.[4] There was no main effect of rumination, $F(1, 183) = 2.15$, $p = .14$.

Mediation analysis. Because rumination both reduced self-control and increased aggression when angered, we conducted a causal steps mediation analysis (Baron & Kenny, 1986) to determine whether reduced state self-control mediated the effects of provocation and rumination on aggression (see Figure 3). To adequately test for the effect of the Provocation × Rumination interaction, we partialed out the main effects of provocation and rumination from their product term and used this residual as the net interaction effect in the following analyses.

At the first step, the residualized Provocation × Rumination interaction term predicted increased aggression, $t(183) = 2.20$, $p = .03$. This interaction also predicted decreased state self-control, $t(183) = -2.32$, $p = .02$. State self-control was inversely related to aggression such that lower levels of self-control were associated with increased aggression, $t(183) = -5.26$, $p < .001$. Finally, the effect of self-control remained significant even when controlling for the interaction between provocation and rumination, $t(182) = -4.95$, $p < .001$, whereas the effect of the interaction on self-control was no longer significant, $t(182) = 1.53$, $p = .13$. Furthermore, Preacher and Hayes's (2004) bootstrap test of indirect effects confirmed that state self-control mediated the effect of the Provocation × Rumination interaction on aggression, indirect effect estimate (IE) = 0.30, 95% CI [0.05, 0.61].[5]

Study 2 found that when angered, subsequent rumination reduced self-control capacity and increased aggression relative to distraction. Moreover, this reduction in self-control mediated the effect of angry rumination on aggressive behavior. We also replicated the main effect of provocation found in Study 1 with a different measure of state depletion. These findings highlight the harmful effects of angry rumination in augmenting aggression via a temporary reduction in self-control.

Study 3

Because our experimental procedures instructed participants to ruminate and angry rumination in daily life occurs spontaneously rather than in response to instructions to ruminate, Study 3 investigated the effect of rumination on aggression in an ecologically valid manner. Our theorizing also suggests that rumination and not anger per se induces self-regulatory depletion and subsequent aggression. Thus, we tested these notions by examining the effects of trait angry rumination on spontaneous rumination, angry affect, and subsequent aggression. We expected that state rumination—but not angry affect—would mediate the effect of trait rumination on aggression.

Method

Participants. A total of 93 UNSW undergraduates (M_{age} = 20.34, SD_{age} = 5.42; 68% women) participated as part of a course requirement.

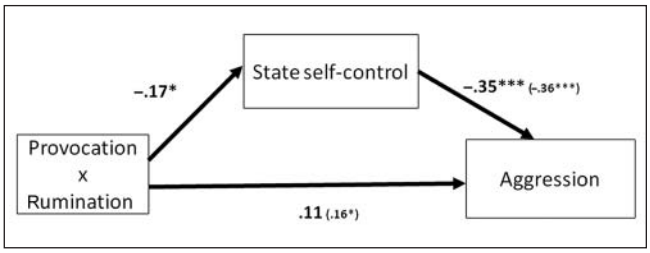

Figure 3. State self-control partially mediates the effect of rumination on aggression in Study 2
Note: Parameter estimates are standardized coefficients. Values in parentheses are zero-order correlations.
*$p < .05$. ***$p < .001$.

Materials and procedure. Participants were told they were participating in a study on cognitive performance. Participants first completed the 10-item Angry Rumination subscale of the Displaced Aggression Questionnaire (Denson et al., 2006). The subscale assesses individual differences in the tendency to ruminate about anger-inducing events (e.g., "When angry, I tend to focus on my thoughts and feelings for a long period of time"; 1 = *very uncharacteristic of me*, 7 = *very characteristic of me*; α = .92; $M = 3.81$, $SD = 1.26$). Participants also completed a 10-item bogus personality questionnaire to allay suspicion.

Participants then completed the anagram task from Study 2 and were subsequently provoked in the same manner as in that study. A few minutes later, the experimenter reentered the room and asked the participant to complete a student research assistant evaluation form, which was modified from Study 2. The key difference was that the evaluation form contained three additional items assessing the extent to which participants ruminated about the provocation (e.g., "I can't stop thinking about how rude the experimenter was"; α = .54; $M = 3.15$, $SD = 1.13$). These items were embedded among distracter items (e.g., "I feel comfortable with the experimenter"). Participants completed the measure of angry affect from Study 1 (α = .90; $M = 2.63$, $SD = 1.27$) and the aggression items used in Study 2(α = .82; $M = 5.12$, $SD = 0.96$). Participants placed the forms in a sealed envelope and deposited them in a lockbox ostensibly to be collected by the department administration.

Results and Discussion

Table 1 shows the correlations between the measures. As expected, trait rumination was significantly and positively related to anger, state rumination, and aggressive behavior. The more participants reported ruminating and being angered, the more aggressive they were. We conducted a mediation analysis with multiple mediators (Preacher & Hayes, 2008) by simultaneously examining the two possible mediators of trait rumination on aggression: angry affect and state rumination. Thus, at the critical step to test mediation, we simultaneously entered trait rumination, state rumination, and angry affect in predicting aggression. Only state rumination remained a strong predictor of aggressive behavior (see Figure 4). Specifically, when controlling for trait rumination, the effect of state rumination remained strongly related to aggression, $t(80) = 5.76$, $p < .001$, whereas the effect of trait rumination was reduced, $t(80) = 2.19$, $p = .03$, and angry affect was no longer a significant predictor of aggression, $t(80) = 1.35$, $p = .18$. Although the relationship between trait rumination and aggression remained significant, a comparison of regression coefficients revealed that state rumination was a stronger predictor of aggression than trait rumination, $F(1, 80) = 7.73$, $p = .007$. Moreover, Preacher and Hayes's (2008) bootstrap test of multiple mediators revealed that state rumination mediated the effect of trait rumination on aggression, $IE = 0.12$, 95% CI [0.03, 0.24], but not self-reported angry affect, $IE = 0.04$, 95% CI [–0.01, 0.10]. These data suggest that state rumination, and not angry affect, mediated the effect of trait rumination on aggressive behavior.

Table 1. Correlations Between the Variables in Study 3

	Trait rumination	State rumination	Angry affect
State rumination	.28**		
Angry affect	.39***	.47***	
Aggression	.35**	.67***	.45***

**$p < .01$. ***$p < .001$.

Study 4

Study 4 examined rumination-induced depletion from a novel perspective. Specifically, we examined the effect of glucose in bolstering executive control within the context of angry rumination. Research suggests that glucose consumption can improve self-control capacity when depleted, including performance on the Stroop color-naming task (DeWall et al., 2008; Gailliot et al., 2007, 2009). Thus, we directly manipulated a proposed mediator—self-regulatory resources—by testing the hypothesis that bolstering self-control capacity by consuming a glucose-rich beverage would provide a buffer against the depleting effect of rumination on inhibitory control. In a double-blind study, participants consumed either glucose or a placebo, were provoked, and engaged in rumination or distraction. We assessed inhibitory control with the Stroop color-naming task before the manipulations and following the rumination manipulation. We expected that glucose would improve performance relative to placebo following a period of angry rumination but not distraction.

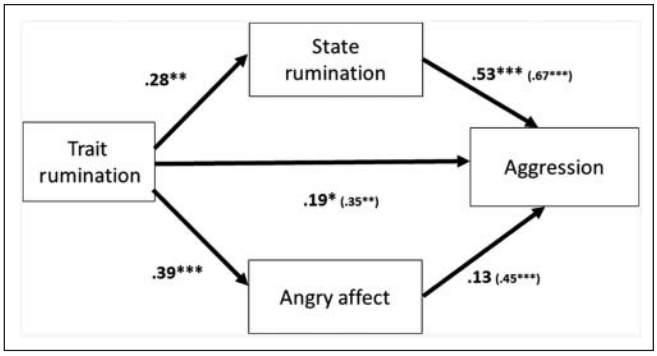

Figure 4. State rumination, but not angry affect, mediated the effect of trait rumination on aggression in Study 3
Note: Parameter estimates are standardized coefficients. Values in parentheses are zero-order correlations.
*$p < .05$. **$p < .01$. ***$p < .001$.

Method

Participants and design. A total of 139 UNSW undergraduates participated as part of a course requirement or in exchange for AUD$15. Data from 8 participants were removed from analyses: 5 due to suspicion about the provocation, 1 due to computer malfunction, and 2 identified as outliers using Tukey's (1977) boxplot procedure (1 in the placebo/distraction and 1 in the glucose/rumination condition). This left a total sample of 131 (M_{age} = 20.37, SD_{age} = 3.62; 66 men). Participants were randomly assigned to one of four conditions in a 2 (glucose, placebo) × 2 (rumination, distraction) between-participants design. Gender did not differ as a function of condition, $\chi^2(3) = 0.28$, $p = .96$. Following past research, participants were instructed to fast from food and drink (except for water) for 3 hr before the experiment to stabilize blood glucose levels (Gailliot et al., 2007). No participants reported a glucose-related disorder.

Materials and Procedure

Upon arrival to the laboratory, participants were told that they were participating in a study that was investigating the relationships between glucose consumption, cognitive performance, and social impression formation.

Inhibitory control. Before the experimental manipulations, participants were administered the paper version of the Stroop color-naming task as a baseline measure of inhibitory capacity. The Stroop color-naming task consisted of three pages of 100 items, each in a matrix of 5 × 20 items. The first stage of the test was the "word" page where participants were required to read out loud as fast as they could a list of words (*red, blue* or *green*) printed in black ink. In the second stage, "color" page, participants read out the color of each item, written as "XXXX" in red, green, or blue ink. Finally in the third stage, "color-word" page, participants had to inhibit the tendency to read the word and instead say the color the word is written in, as the color of the font was incongruent with the written word. For example, the word *red* printed in blue ink. The Stroop was administered and scored following standardized procedures described in the Stroop manual (Golden & Freshwater, 2002). All three phases were restricted to a time frame of 45 s and were timed with a stopwatch. Following the instructions for the paper version of the Stroop, response latencies were not used as dependent measures. Rather, the numbers of correct responses given in the 45-s periods were used to calculate standardized interference *T* scores. Higher values indicate better inhibitory control (i.e., less interference). A number of laboratory experiments confirm that the Stroop task is a sensitive measure of self-control depletion (Gailliot et al., 2007; Richeson & Shelton, 2003; von Hippel & Gonsalkorale, 2005). There were no differences between groups in Stroop performance at baseline, $F(3, 126) = 1.66$, $p = .18$.

Double-blind glucose manipulation. Participants were given a 350-ml lemonade drink containing either 50 g of sugar (glucose condition; Cottee's Lemon Crush) or a sugar substitute containing a negligible amount of sugar (2.4 g) that provided a real sugar taste (placebo condition; Cottee's no added sugar Lemon Crush). All participants were told they received a sugar drink and the experimenter was blind to glucose condition.

Provocation and rumination. All participants were then provoked and assigned to either the rumination or distraction condition. The provocation procedure was identical to Study 1 and the rumination manipulation was identical to Study 2.

Second Stroop task. Participants were then given a second Stroop test. Because of practice, there was an overall improvement from baseline, $F(1, 128) = 27.96$, $p < .001$. We therefore created a difference score for each participant by subtracting the baseline *T* scores from the postmanipulation *T* scores. Thus, higher values on this difference score represent greater improvement in inhibitory control. Participants completed the second Stroop task approximately 25 min following the onset of rumination, which provided ample time for the glucose to be metabolized (Benton & Owens, 1993; Gailliot et al., 2007).

Manipulation checks. Participants completed two manipulation checks. The first asked participants how enjoyable they found the drink (1 = *not at all*, 7 = *very much*) to determine whether there were differences in subjective liking for the beverages. Participants also completed the same rumination manipulation checks as those used in Study 2 (α = .88). Finally, participants were probed for suspicion, thanked, and debriefed.

Results and Discussion

Manipulation checks. Participants in the glucose and placebo conditions did not differ in the extent to which they

liked the beverage, $F < 1$. Participants in the rumination condition reported thinking about the provocation more than participants in the distraction condition ($M_{rumination} = 4.05$, $SD_{rumination} = 1.66$; $M_{distraction} = 2.78$, $SD_{distraction} = 1.56$), $F(1, 126) = 19.92$, $p < .001$, $\eta^2 = .14$. These data suggest effective manipulations.

Inhibitory control. A 2 (rumination, distraction) × 2 (glucose, placebo) between-participants ANOVA revealed a significant interaction, $F(1, 125) = 5.60$, $p = .02$, $\eta^2 = .04$. Figure 5 presents these data. Our primary hypothesis was that among participants who ruminated, glucose would improve Stroop performance relative to placebo. Indeed a follow-up test confirmed that when participants engaged in angry rumination, Stroop performance was significantly better in the glucose condition than in the placebo condition, $F(1, 59) = 3.69$, $p = .03$, one-tailed, $\eta^2 = .06$. Among participants in the placebo condition, those induced to ruminate displayed marginally worse performance on the Stroop than participants in the distraction condition, suggesting a depletion effect, $F(1, 64) = 2.56$, $p = .06$, one-tailed, $\eta^2 = .06$. When participants engaged in distraction, there was no difference in Stroop performance as a function of beverage condition, $F(1, 66) = 2.38$, $p = .13$, $\eta^2 = .04$. Although unexpected, among those in the glucose condition, participants in the rumination condition performed marginally better than participants in the distraction condition, $F(1, 61) = 3.02$, $p = .09$, $\eta^2 = .05$. These data suggest that bolstering self-regulatory resources via glucose consumption before a bout of angry rumination increased inhibitory control as reflected by improved performance on the Stroop task relative to placebo. This finding further highlights the direct role of self-regulatory strength as a mechanism underlying the aversive effects of angry rumination in the aftermath of a provocation.

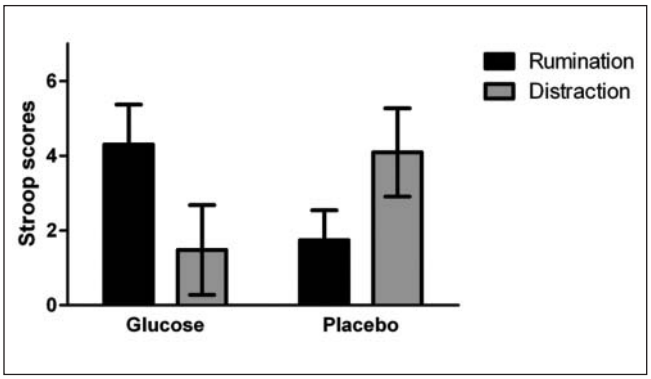

Figure 5. Stroop performance as a function of rumination or distraction and beverage condition in Study 4
Note: Higher scores represent greater inhibitory control.

General Discussion

It has long been known that anger-inducing interpersonal provocation is a powerful elicitor of aggression (Anderson & Bushman, 2002; Bettencourt & Miller, 1996). The present research increases our understanding of the psychological mechanisms responsible for this robust effect. Our results implicate angry rumination and reduced self-control induced by rumination as mechanisms that mediate the provocation–aggression relationship. The results of these four studies are consistent with the proposed temporal framework that specified that rumination following an anger-inducing provocation reduces self-control and increases the likelihood and severity of aggression (see Figure 1).

Study 1 found that just a few minutes after experiencing an interpersonal provocation, participants showed lower self-regulatory capacity than participants who were not provoked. Although we suspected that a number of participants engaged in angry rumination following the provocation, we directly manipulated this form of postevent anger regulation in subsequent studies. Study 2 found that when angered, rumination reduced self-control capacity and increased aggression relative to distraction. Moreover, this reduction in self-control mediated the effect of angry rumination on aggressive behavior. Separate lines of inquiry have found that rumination augments aggression, as does the temporary depletion of self-regulatory capacity (Bushman, 2002; Bushman et al., 2005; Caprara, 1986; DeWall et al., 2007; Finkel et al., 2009; Stucke & Baumeister, 2006). The present findings bridge these two lines of research. Study 3 found that within an individual difference perspective, spontaneous rumination, but not anger experience per se, mediated the effect of trait rumination on provocation-induced aggression. Finally, by boosting the energy available for self-control, Study 4 found that relative to placebo, glucose bolstered inhibitory control (i.e., Stroop performance) following angry rumination.

In addition to the strength model of self-control, our data are consistent with recent social psychological aggression theories. Self-control has long been of interest to aggression researchers, and most models highlight its importance (albeit to varying degrees). I^3 theory places particular emphasis on the role of self-control failure (Slotter & Finkel, 2011). Consistent with I^3 theory, by depleting self-control capability (an inhibiting force), trying to stop ruminating can increase aggression. Similarly, the GAM (Anderson & Bushman, 2002) suggests that each time a person thinks about a provoking incident, rumination maintains or increases angry affect, aggressive cognition, and physiological arousal, which is thought to impair the capacity to thoughtfully reappraise the situation. This impaired capacity thereby increases the likelihood of impulsive aggression and decreases the likelihood of refraining from aggression. According to the GAM, if one possesses sufficient cognitive resources, thoughtful reappraisal can result in nonaggressive action (Anderson & Bushman, 2002). Our data suggest that the self-regulatory processes

invoked when ruminating make it less likely that sufficient cognitive resources will be available for thoughtful reappraisal. On the bright side, the results of Study 4 suggest acute glucose consumption might provide a buffer against the depleting consequences of angry rumination.

Together with the strength model of self-control, the GAM and I^3 theory provide a coherent conceptual framework for understanding the findings observed in the present research. The strength model specifies sufficient resources (likely in the form of glucose availability in the prefrontal cortex) as the basis of self-control. This notion is consistent with neuroscientific data and theory as well as behavioral experimentation (cf. Denson, 2011; Denson et al., 2010; DeWall et al., 2007; Gailliot et al., 2007; Raine, 2008). When resources are depleted by self-regulatory processes recruited as a result of angry rumination, inhibiting forces as specified by the I^3 model are weak, which make it unlikely that individuals who have been ruminating will be able to thoughtfully reappraise a provoking situation and/or reduce the GAM's three routes to aggression (i.e., angry affect, cognition, and arousal). As such, impelling factors specified by I^3 theory are more likely to become important determinants of impulsive aggression. The present understanding represents a conceptual advance beyond associative network metaphors to more observable phenomena with a neurophysiological basis in understanding risk for impulsive aggression.

Our results also speak to the role of distraction as a nondepleting response-focused anger regulation strategy. At least within the relatively short time frame of our laboratory studies, relative to rumination, distraction did not deplete self-regulatory capacity or increase aggression. Future research could manipulate additional emotion regulation strategies that might prove effective alternatives to rumination. For instance, when thinking about angry memories, cognitive reappraisal reduces angry affect and sympathetic nervous system activity relative to rumination (Ray, Wilhelm, & Gross, 2008). Additional work could also examine how self-control in other domains unrelated to aggression such as impulsive eating and drinking is influenced following a period of angry rumination.

For the sake of internal validity, our experiments were conducted within the confines of the laboratory with a very specific population. Future work might investigate the role of provocation, rumination, and self-regulatory depletion in augmenting and reducing aggression among individuals known to have compromised self-control capacity (e.g., violent offenders). For instance, low blood glucose has been linked with criminality (Gailliot & Baumeister, 2007). Thus, individuals with chronic glucose disorders (e.g., diabetes, glucose-6-phosphate dehydrogenase deficiency) might be especially prone to aggression following a period of angry rumination.

The present research was limited in some aspects. In Study 1, we did not actually assess the extent to which participants ruminated. Doing so would have allowed us to more directly examine the effect of rumination in augmenting depletion. Study 3 addressed this issue more directly. Study 2 relied on a self-report measure of depletion rather than a behavioral measure. Although separate behavioral measures would have been ideal, including a more complicated behavioral measure before the aggression measure might have allowed time for participants to "cool off," thereby reducing the impact of our experimental manipulations (for a discussion of order effects in aggression research, see Lindsay & Anderson, 2000). Study 4 did not contain a measure of blood glucose to assess change from baseline. However, this is unlikely to threaten the validity of our findings as research has demonstrated that the dose of glucose we used can reliably increase blood glucose levels within minutes (e.g., Benton & Owens, 1993).

Our research highlights rumination and the self-regulatory depletion it induces as important psychological mechanisms underlying provocation-induced aggression. Interventions designed to bolster self-control capacity might prove beneficial in reducing the psychological and physical harm associated with provocation and subsequent angry rumination. Bolstering self-control via acute glucose administration appears especially promising in this regard. Glucose can improve self-control in a number of domains (Gailliot et al., 2007), and initial work found that glucose reduces aggression following provocation among those high in trait aggression (Denson et al., 2010). Self-control training could also be beneficial in reducing provoked aggression as research demonstrates that such training can reduce aggressive intentions within the context of intimate partner violence (Finkel et al., 2009).

In sum, the reported studies highlight two mechanisms underpinning the provocation–aggression relationship. They therefore contribute to understanding why individuals sometimes have difficulty controlling anger-driven responses to provocation.

Authors' Note

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Notes

1. Cottee's Lemon Crush is a sweet Australian beverage similar to American lemonade.

2. Provocation was confounded with anagram task difficulty. To rule out the possibility that the difficult anagrams might have induced depletion or anger, we administered the same sets of anagrams (difficult vs. easy from the provocation and no-provocation conditions, respectively) to 49 introductory psychology students in small groups. Participants then completed the state self-control scale ($\alpha = .86$) and a mood scale consisting of seven anger-related items ($\alpha = .73$). Participants were asked to rate how they were feeling "right now" (i.e., immediately after the anagrams). There was absolutely no difference between the difficult and easy anagrams on either state anger, $F(1, 47) = 0.03$, $p = .87$, $\eta^2 = .001$, or depletion, $F(1, 45) = 0.02$, $p = .88$, $\eta^2 = .001$. Furthermore, there are several prior studies showing that when both provoked and nonprovoked participants are given the difficult anagrams, increased anger is observed only in the provocation condition (Denson, Pedersen, & Miller, 2006, Study 1; Vasquez, Denson, Pedersen, Stenstrom, & Miller, 2005). Thus, we can rule out the possibility that anagram difficulty produced the observed effects in Study 2.
3. Two blind research assistants coded the written responses from the writing task in the rumination condition to determine the number of words devoted to (a) the experimenter's negative remarks, (b) task difficulty, and (c) anagram performance. Participants wrote more about the experimenter's remarks than either task difficulty, $t(95) = 3.11$, $p = .003$, or anagram performance, $t(95) = 2.09$, $p = .04$. Moreover only the number of words devoted to the experimenter's nasty remarks was correlated with reduced self-control capacity, $r = -.30$, $p = .003$, and increased aggression, $r = .31$, $p = .002$. This further precludes the possibility that anagram difficulty was responsible for our observed effects and supports the hypothesis that angry rumination is responsible for reduced self-control and increased aggression.
4. The significant residual was due to the slightly elevated aggression in the provocation/distraction condition relative to the no-provocation condition. Indeed, a +3, +1, −2, −2 contrast revealed no significant contrast residuals, $F < 1$.
5. The mediation remained significant even when the main effects were not partialed out, although the path from the interaction term to aggression remained marginally significant ($p = .06$) when controlling for state self-control.

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