Psychology of Addictive Behaviors

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BRIEF REPORT

Caffeine Expectancies but Not Caffeine Reduce Depletion-Induced Aggression

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Caffeine is the most widely consumed central nervous system stimulant in the world, yet little is known about its effects on aggressive behavior. Individuals often consume caffeine to increase energy and ward off mental depletion. Because mental depletion increases aggression when people are provoked, caffeine might reduce aggression by ameliorating the negative effects of depletion. In 2 experiments, participants consumed a 200-mg caffeine tablet or a placebo, were mentally depleted or not, and then provoked and given the opportunity to retaliate with a blast of white noise. Results showed that consuming a placebo reduced aggression relative to both caffeine (Experiments 1 and 2) and a no-pill control condition (Experiment 2). These data suggest that expectancies about the effects of caffeine in the absence of the pharmacological effects of the drug can reduce aggression when mentally depleted.

Keywords: aggression, caffeine, depletion, placebo effect, expectancies

Although much research has examined the cognitive effects of caffeine (Snel, Lorist, & Tieges, 2004), the limited work examining its effects on human aggression is equivocal. A meta-analysis comparing caffeine to placebo found a nonsignificant mean effect size but large variability (Bushman, 1993). This variability suggests the presence of moderating variables that can increase or decrease the caffeine–aggression relationship. One possible moderator is derived from the strength model of self-regulation (Baumeister, Vohs, & Tice, 2007). According to this model, exerting self-control relies on executive control capacity, which can be temporarily depleted. In a typical paradigm, participants engage in an initial act of self-control (e.g., a Stroop task) and subsequently complete a second measure of self-control (e.g., a difficult anagram task). Performance on the second task is typically reduced (Hagger, Wood, Stiff, & Chatzisarantis, 2010). Once depleted and provoked, individuals are less able to control aggressive impulses, which makes aggression more likely (DeWall, Baumeister, Stillman, & Gailliot, 2007). The present research examined the influence of caffeine and caffeine expectancies on depletion-induced aggression.

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A number of factors that reduce the self-control deficits associated with depletion have been identified (Hagger et al., 2010). For instance, consuming glucose-rich beverages improves executive control following depletion (Gailliot et al., 2007) and reduces aggression (Denson, von Hippel, Kemp, & Teo, 2010). Paralleling the glucose effects, caffeine can also augment alertness and executive control, especially when mentally fatigued (Kenemans, Wieleman, Zeegers, & Verbaten, 1999; Snel et al., 2004). Such effects could translate into decreased aggression.

However, caffeine also increases subjective and physiological arousal, including increased blood pressure, cortisol, and epinephrine. Zillmann's (1983) excitation transfer theory, which has recently been integrated into the general aggression model, suggests that arousal produced by nonaggressive sources (e.g., caffeine) can be misattributed to the effects of a provocation (DeWall & Anderson, 2011). Thus, participants given caffeine and then insulted may interpret the physiological arousal as caused by the insult rather than the caffeine. Such arousal might be interpreted as a cue to retaliate against the provocateur. If so, caffeine should augment aggression relative to placebo and arousal should predict aggression for participants given caffeine but not placebo.

In summary, one possibility is that caffeine consumption can attenuate the effects of depletion-induced aggression by temporarily restoring executive control. A second possibility derived from excitation transfer theory suggests that participants given caffeine should misattribute their arousal to the provocation, which would increase aggression. However, if participants show improved executive control and arousal-induced aggression, a third possibility is that these effects may cancel each other.

When studying the behavioral effects of drugs, it is important to disentangle the pharmacological effects of the drug from

expectancies about the drug's effects (Rohsenow & Marlatt, 1981). Similar to alcohol expectancies (Bègue et al., 2009), individuals also have expectancies about caffeine. These expectancies consist of increased alertness, energy, attention, and arousal, but also increased calmness and well-being (Flaten, Aasli, & Blumenthal, 2003; Heinz, Kassel, & Smith, 2009). Furthermore, individuals likely hold expectancies about caffeine that are context dependent. Although research has not examined this notion with caffeine, expectancies regarding other drugs differ as a function of situational context (e.g., Wall, McKee, Hinson, & Goldstein, 2001). Because caffeine is often used to enhance mental alertness, expectancies might exert especially strong behavioral effects within the context of demanding mental activity. However, the relative lack of physiological arousal among participants given placebo relative to caffeine should not induce excitation transfer. Thus, for participants given placebo, positive expectancies about caffeine's facilitation of alertness should give participants a "cognitive boost" in the depletion condition, thereby reducing the depleting effects of the task. The "boost" may include increased motivation to engage in self-control, as improved energy is a common caffeine expectancy, and motivation can ameliorate the adverse effects of depletion (Hagger et al., 2010). However, such a change in subjective state is likely to depend on the presence of demanding mental activity (i.e., depletion). In the absence of demanding mental activity, increased motivation and energy may be superfluous.

Experiment 1

Method

Participants and design. A total of 113 undergraduates from the University of New South Wales participated in a study ostensibly investigating the effects of caffeine on impression formation and executive functioning. One participant reported noncompliance with a 48-hr washout period. Inclusion criteria included drinking less than 1 cup of coffee per day due to concerns about withdrawal symptoms (Griffiths et al., 1990). Data were excluded because of suspicion that the provocation was fabricated ($n = 6$) or software failure ($n = 10$), leaving a final sample of 96 participants (38 men) who were randomly assigned to one of four conditions in a 2 (caffeine, placebo) $\times$ 2 (depletion, no-depletion) between-participants design. Men and women were equally distributed across the four conditions, $\chi^2(3) = 0.47$, $p = .93$.

Materials and procedure.

Baseline affect. The items *energized*, *excited*, *jittery*, *alert*, and *vigorous* constituted a stimulation subscale ($\alpha = .63$) and *irritable*, *hostile*, and *annoyed* constituted an anger subscale ($\alpha = .72$; 1 = *not at all*, 7 = *extremely so*). The two subscales were uncorrelated, $r = .17$, $p = .11$.

Caffeine manipulation. Participants in the caffeine condition received a 200-mg caffeine tablet. Those in the placebo condition received a sucrose tablet (containing <1 g sucrose) administered from the same clearly labeled bottle as the caffeine tablets in order to appear as if they were actually receiving caffeine. Participants were told that they were receiving a dose equivalent to drinking 2 cups of coffee. Because caffeine absorption reaches 99% in approximately 45 min (Lorist & Tops, 2003), participants were asked to return 45 min later.

Second affect measure. Participants completed the second mood questionnaire upon return to the laboratory: stimulation, $\alpha = .79$; angry affect, $\alpha = .79$.

Depletion manipulation. Participants were presented with a page of text and asked to cross out all 398 instances of the letter *e*. Participants were then presented with a second text. In the no-depletion condition, they were given the same instructions as the first text. In the depletion condition, participants were asked not to cross out the *e* only if it was followed by a vowel or if the *e* appeared in a word with a vowel appearing two letters before the *e*. This task required participants in the depletion condition to exert self-control by breaking a learned behavior (Hagger et al., 2010). A manipulation check indicated how much more difficult the second task was than the first (0 = *no difference at all*, 5 = *extremely more difficult*).

Provocation procedure. Participants were given 10 min to prepare a 2-min speech based on talking points provided by the experimenter (e.g., life goals, travel plans), which they would later present via a web conference to a bogus participant. In reality, the web conference was prerecorded. After the speech, participants were provoked through insulting feedback ostensibly written by the fictitious participant: "Your speech was juvenile and boring. Overall, a very disappointing speech coming from a Uni student. A waste of my time listening to you." This procedure successfully has increased anger and aggression in prior research (Denson et al., 2010; Memedovic, Grisham, Denson, & Moulds, 2010).

Aggression paradigm. As part of the study's focus on cognitive functioning, participants were told that they were to play a reaction time task and to win the task, they had to be the fastest to click the mouse when the color of a small box on the screen changed from yellow to red. Aggressive behavior was operationalized as the mean intensity and duration of a blast of white noise participants selected to deliver to the bogus participant during a modernized single-trial version of the Taylor (1967) Aggression Paradigm (TAP; e.g., Bushman, 1995; Denson et al., 2010). The noise levels ranged from 1 (60 dB) to 10 (105 dB), and durations ranged from 0 (0.5 s) to 10 (1.75 s). A nonaggressive 0 dB option was also included. Extensive research supports the validity of the TAP; individuals who report engaging in aggression and violence outside the laboratory behave more aggressively in studies using the TAP (Anderson & Bushman, 1997; Bernstein, Richardson, & Hammock, 1987; Carlson, Marcus-Newhall, & Miller, 1989; Giancola & Chermack, 1998; Giancola & Parrott, 2008; Giancola & Zeichner, 1995; Hammock & Richardson, 1992).

Third affect measure. Participants rated their mood following the TAP for the third time: stimulation, $\alpha = .80$; angry affect, $\alpha = .72$. They were then probed for suspicion and debriefed.

Results and Discussion

Manipulation checks. Participants in the depletion condition ($M = 3.89$, $SD = 1.63$) reported that the second *e* task was more difficult than did participants in the no-depletion condition ($M = 2.13$, $SD = 1.86$), $F(1, 33) = 9.02$, $p = .01$, $\eta^2 = .22$, suggesting

an effective depletion manipulation.[1] At baseline, there was no difference in angry affect across conditions, $F < 1$; however, there was an increase in self-reported anger from baseline, suggesting an effective provocation procedure ($M_{baseline} = 1.38$, $SD_{baseline} = 1.07$; $M_{Time\ 3} = 2.86$, $SD_{Time\ 3} = 1.60$), $F(1, 95) = 75.72$, $p = .01$, $\eta^2 = .44$. There was no difference in self-reported stimulation between caffeine and placebo at baseline, $F < 1$. When participants returned to the laboratory, they reported an increase in feelings of stimulation ($M_{baseline} = 2.88$, $SD_{baseline} = 0.89$; $M_{Time\ 2} = 3.48$, $SD_{Time\ 2} = 1.16$), $F(1, 95) = 34.11$, $p < .001$, $\eta^2 = .26$. The magnitude of this increase in stimulation was comparable in the caffeine and placebo conditions, $F < 1$, suggesting effective caffeine and placebo procedures. With the exception of a marginally significant Depletion × Gender interaction ($p = .06$), gender did not influence aggressive behavior. Thus, the remaining analyses were collapsed across gender.[2]

Aggression. A 2 (depletion, no-depletion) × 2 (caffeine, placebo) between-participants analysis of variance (ANOVA) on the noise blast level that participants selected for their opponent revealed a Drug × Depletion interaction, $F(1, 92) = 5.84$, $p = .02$, $\eta^2 = .06$ (see Figure 1). Simple effects analyses revealed that when participants were depleted, those who consumed the placebo were marginally less aggressive than those who consumed caffeine, $F(1, 45) = 3.22$, $p = .08$, $\eta^2 = .07$. No differences were found between caffeine and placebo when participants were not depleted. Among participants given placebo, those who were depleted did not reliably differ in aggression from participants who were not depleted ($p = .33$). Participants given caffeine were more aggressive when depleted than when not depleted, $F(1, 46) = 7.17$, $p = .01$, $\eta^2 = .14$.

Affect and excitation transfer. Consistent with excitation transfer theory, self-reported stimulation was correlated with increased aggression in the caffeine condition, $r = .32$, $p = .03$, but not in the placebo condition, $r = .11$, $p = .47$, suggesting that arousal induced by the caffeine may have been misattributed to the provocateur and thereby increased aggression. The 2 (caffeine, placebo) × 2 (depletion, no-depletion) ANOVA revealed a main effect of drug, suggesting that participants who had consumed caffeine felt more stimulated at the third assessment ($M = 3.86$, $SD = 1.12$) than participants who had consumed the placebo ($M = 3.41$, $SD = 1.12$), $F(1, 92) = 4.12$, $p = .05$, $\eta^2 = .04$.[3] The ANOVA revealed no main effects or interaction on angry affect at the third assessment (Fs < 1), suggesting that differences in aggressive behavior were not due to differences in anger induced by the manipulations.

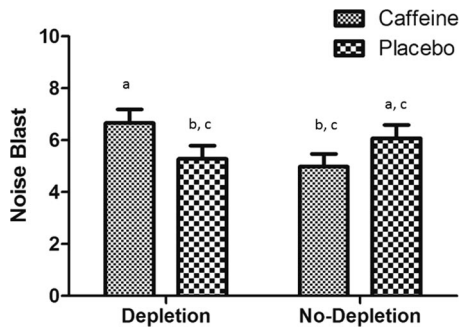

Figure 1. Means and standard errors for aggressive behavior as a function of the drug and depletion manipulations in Experiment 1. Possible values range from 0 to 10. Columns with different letters differ from each other at $p < .08$.

Experiment 2

Experiment 1 found differential levels of depletion-induced aggression following caffeine or placebo consumption. Although we propose that the placebo reduced aggression relative to caffeine when depleted, in the absence of a no-pill control condition, the direction of these effects is unclear. Experiment 2 remedied this. We expected that the control condition would replicate prior work showing the aggression-inducing effects of depletion, which would serve as a baseline for judging the effects of caffeine and placebo on aggressive behavior within the context of mental depletion. We also included a measure of general positive and negative affect to determine whether the observed effects were due to changes in well-being (Silverman & Griffiths, 1992).

Method

Participants and design. A total of 133 undergraduates from the University of New South Wales participated. The cover story was identical to that of Experiment 1. Nine participants' data were removed because of suspicion regarding the provocation manipulation, leaving a total of 124 participants (63 men; $M_{age} = 19.75$ years, $SD = 2.12$). All participants reported compliance with the 48-hr washout period and were randomly assigned to conditions in a 2 (depletion, no-depletion) × 3 (caffeine, placebo, no-pill control) between-participants design. Men and women were equally distributed across the six conditions, $\chi^2(5) = 0.28$, $p = .99$.

Materials and procedure. The caffeine and placebo procedures were the same as in Experiment 1, as was the depletion manipulation. Control participants who did not receive a pill were able to immediately proceed with the experiment. Prior to the depletion manipulation, participants in all conditions rated how they were currently feeling with a mood adjective checklist consisting of 24 items measuring positive affect (e.g., happy; $\alpha = .81$), general negative affect (e.g., sad; $\alpha = .91$), and the three angry affect items from Experiment 1 ($\alpha = .85$; 1 = *not at all*, 7 = *extremely so*). Participants completed the same provocation procedure and aggression paradigm from Experiment 1 and then reported on their mood as a result of the video conference using the checklist: positive affect, $\alpha = .81$; negative affect, $\alpha = .81$; and

[1] The first 66 participants did not receive the manipulation check; however, a meta-analysis found that this procedure induces depletion (see Hagger et al.'s 2010 meta-analysis).

[2] Even when controlling for gender, the Drug × Depletion interaction remained significant, $F(1, 90) = 5.46$, $p = .02$, $\eta^2 = .06$.

[3] Because the effects of caffeine and social stress on arousal are additive (al'Absi & Lovallo, 2004), this heightened stimulation at the end of the experiment likely reflects this notion. Indeed, there was a marginal Time × Drug interaction, $F(1, 94) = 2.75$, $p = .10$, $\eta^2 = .03$. Specifically, in the placebo condition, stimulation stayed steady from Time 2 to Time 3, $t(47) < 1$, $p = .99$, but increased in the caffeine condition, $t(47) = 2.58$, $p = .013$, likely due to the stressful interpersonal encounter with the provocateur.

angry affect, $\alpha = .93$. Finally, the experimenter probed for suspicion and debriefed participants.

Results and Discussion

Manipulation checks. Participants in the depletion condition reported that the second *e* task was significantly more difficult than the first to a greater extent ($M = 3.57$, $SD = 0.96$) than did participants in the no-depletion condition ($M = 1.27$, $SD = 1.57$), $F(1, 122) = 106.70$, $p < .001$, $\eta^2 = .47$, suggesting an effective depletion manipulation. Anger increased from baseline, $F(1, 89) = 37.64$, $p < .001$, $\eta^2 = .30$, suggesting an effective provocation procedure. There was no main effect of gender or interactions with the experimental manipulations on aggressive behavior. Thus, analyses were collapsed across gender.

Aggression. A 2 (depletion, no-depletion) × 3 (caffeine, placebo, no-pill) ANOVA on noise blast intensity revealed a main effect of drug condition, $F(2, 116) = 3.09$, $p = .05$, $\eta^2 = .05$, which was qualified by the Drug × Depletion interaction, $F(2, 116) = 4.52$, $p = .01$, $\eta^2 = .07$ (see Figure 2).[4,5] Replicating prior work (DeWall et al., 2007), a follow-up test revealed that participants in the no-pill condition were more aggressive when depleted compared with nondepleted participants, $F(1, 40) = 4.54$, $p = .04$, $\eta^2 = .10$. Replicating Experiment 1, depleted participants who consumed placebo were less aggressive than depleted participants who consumed caffeine, $F(1, 40) = 4.99$, $p = .03$, $\eta^2 = .11$. It is important to note that depleted participants given placebo were less aggressive than depleted participants not given a pill, $F(1, 40) = 9.18$, $p = .004$, $\eta^2 = .19$, suggesting that caffeine expectancies can reduce depletion-induced aggression. Participants who consumed caffeine and were depleted were as aggressive as those in the depletion/no-pill condition, $F < 1$, suggesting that caffeine does not decrease depletion-induced aggression. When not depleted, participants given caffeine were more aggressive than participants not given a pill, $F(1, 36) = 7.79$, $p = .008$, $\eta^2 = .18$, suggesting an excitation transfer effect. Replicating Experiment 1, among nondepleted participants, levels of aggression for those given the placebo did not differ from those in the caffeine condition, $F < 1$.

Affect. A 3 (caffeine, placebo, no-pill) × 2 (depletion, no-depletion) ANOVA revealed no significant main effects or interaction on angry affect after provocation, confirming that differences in aggressive behavior were not due to differences in anger induced by the experimental manipulations. Furthermore, although there was no change in negative affect from the first assessment to the second ($F < 1$), there was a general decrease in positive affect across time in all conditions ($M_{\text{Time 1}} = 3.55$, $SD_{\text{Time 1}} = 1.02$; $M_{\text{Time 2}} = 2.98$, $SD_{\text{Time 2}} = 1.03$), $F(1, 83) = 28.23$, $p < .001$, $\eta^2 = .25$. Affect was uncorrelated with aggression.

Experiment 2 replicated and extended Experiment 1 by demonstrating that consuming a placebo reduced depletion-induced aggression, whereas caffeine had no such ameliorative effect. When given a placebo, depleted participants were less aggressive than depleted participants given caffeine or no pill at all. By contrast, participants in the control condition showed the typical pattern of depletion-augmented aggression (e.g., DeWall et al., 2007).

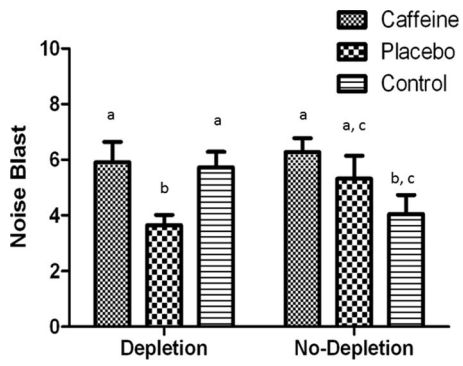

Figure 2. Means and standard errors for aggressive behavior as a function of the drug and depletion manipulations in Experiment 2. Possible values range from 0 to 10. Columns with different letters differ from each other at $p < .05$.

General Discussion

Relative to caffeine, consuming a pill that is believed to contain caffeine prior to engaging in demanding mental activity reduced provoked aggression. The primary result is clear across the two experiments: Caffeine led to greater aggression than placebo in the depletion conditions and no difference from placebo in the no-depletion conditions. The mean effect size for the difference in aggression between caffeine and placebo when depleted was $\eta^2 = .09$, which is moderate to large in magnitude (Cohen, 1988) and is a reduction in aggression comparable in size to the aggression-inducing effect of alcohol (Bushman, 1993). Thus, our results help specify when caffeine expectancies are capable of reducing aggressive behavior. There was, however, an unexpected difference between the two studies in that there was an effect of depletion in Experiment 1, but not Experiment 2, among participants who consumed caffeine: In the caffeine conditions in Experiment 1, depleted participants were more aggressive than nondepleted participants. It is not clear why this effect emerged in Experiment 1 but not Experiment 2.

Experiment 2 introduced a no-pill control condition. Caffeine increased aggression relative to no pill only when not depleted. Thus, caffeine had no additional effect on aggression beyond that of depletion. These results clarify the findings of Experiment 1 by demonstrating that caffeine does not increase aggression when depleted, but rather that the placebo reduces aggression when depleted. In contrast, caffeine led to an increase in aggression when not depleted, which is consistent with excitation transfer theory (although the lack of an aggression-augmenting effect of caffeine in the no-depletion condition in Experiment 1 clearly suggests a need for additional research). As such, arousal rather than executive control mechanisms may best account for the aggression-augmenting effects of caffeine.

[4] Tukey's (1977) boxplot procedure identified two outliers, whose data were excluded from analysis. With outliers included, the main effect of drug condition was no longer significant, $p = .12$, but the Drug × Depletion interaction remained reliable, $p = .03$.

[5] Duration also showed the same pattern of results as intensity, and the two were highly correlated, $r = .69$, $p < .01$, but the interaction with the average was only marginally significant, $p = .08$. We therefore relied on intensity for our analyses.

One likely mechanism for these findings is that caffeine expectancies provided a cognitive boost that increased motivation and energy. Another complementary possibility is that depletion increased the strength of caffeine expectancies. When depleted, participants given the placebo may have felt as if they were able to ward off the effects of depletion because of increased positive expectations about the drug's effect in this regard. Future research assessing the strength of expectancies could be informative in addressing this mechanism.

The present research was limited in some aspects. Including physiological measures of arousal could help determine whether subjective or physiological arousal independently contributes to the effects observed here. We selected our participants based on limited caffeine use and requested a washout period to isolate the effects of the drug and expectancies, but this choice limits the generalizability of our findings. The extent of caffeine consumption or withdrawal symptoms may moderate the effects observed here. Despite these limitations, the present research suggests that caffeine is not effective in reducing depletion-induced aggression. Rather our results suggest that caffeine placebos can effectively reduce aggression when people are mentally depleted. The combined results of both experiments suggest that caffeine leaves depletion-induced aggression untouched and that placebo lowers it.

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