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THE ROLE OF REWARD SENSITIVITY IN THE PERPETRATION OF REACTIVE AND PROACTIVE AGGRESSION

by

OLIVIA SUBRAMANI

Under the Direction of Dominic Parrott, PhD

ABSTRACT

Research has implicated reward sensitivity as one potential shared mechanism underlying reactive and proactive aggression. The current study examined the effect of reward sensitivity, assessed multi-modally through a behavioral task and self-report, on the perpetration of reactive and proactive aggression assessed via a laboratory paradigm. Participants were 184 undergraduate men and women. Hierarchical linear regression revealed positive main effect of reward sensitivity on aggression that did not differ according to condition. This finding offers initial evidence for reward sensitivity as a common etiological correlate of reactive and proactive aggression. And supports future research on shared risk factors that could be targeted to reduce both reactive and proactive aggression.

INDEX WORDS: Reward sensitivity, Reactive aggression, Proactive aggression

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Doctor of Philosophy

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1 INTRODUCTION

Aggression is a serious public health problem that substantially impacts society through a variety of adverse economic, psychosocial, and health consequences (Centers for Disease Control and Prevention, 2016; Sumner et al., 2015). Such pervasive costs to society have led to efforts to identify both risk factors for perpetration of aggression and possible points of intervention that span a range of scientific disciplines. One worthwhile approach is the examination of biologically based risk factors for aggression. A rich scientific literature has identified predispositions to observable variation in behavior, such as perpetration of physical aggression, that are directly rooted in neurobiological mechanisms (Beauchaine & McNulty, 2013; Patrick, Venables, Hicks, Nelson, & Kramer, 2013). A larger call within the field is to examine such biobehavioral constructs and variation in observable behavior in laboratory settings (Insel et al., 2010; Patrick & Hajcak, 2016). Biobehavioral constructs reflect heritable individual differences in biological processes that are directly tied to variation in behavior. Reward sensitivity, one such biobehavioral mechanism, has received strong empirical support as a risk marker for perpetration of aggression (Chester et al., 2016; Derefinko, DeWall, Metze, Walsh, & Lynam, 2011; Seo, Patrick, & Kennealy, 2008). Reward sensitivity varies as a function of individual differences in the experience of stimuli as rewarding. Consistent with other biobehavioral constructs, reward sensitivity was developed, conceptualized, and refined from a neurobiological perspective (Gray, 1981, Fowles, 1980) and is thus well-suited for examinations of biologically-based risk markers for aggression. Individuals high in reward sensitivity may be more susceptible to the rewarding aspects of risky behaviors like aggression and are thus more motivated to engage in these behaviors despite the associated risks.

A key aim of this study was to examine the role (or roles) that reward sensitivity plays in motivating aggressive behavior. Indeed, although intent to cause proximal harm is a necessary component of aggression (Berkowitz, 1993; Baron & Richardson, 1994), motivations for causing harm vary across individuals and situations. For physical aggression, for example, researchers commonly use a two-factor model that distinguishes between reactive and proactive motivations (e.g., Berkowitz, 1993; Tedeschi & Felson, 1994). *Reactive aggression* is perpetrated in response to perceived provocation with the primary goal of hurting someone. *Proactive aggression* is perpetrated in service of obtaining a primary goal other than hurting someone. It is of note that researchers have used interchangeably the terms *functions* and *motivations* in reference to reactive and proactive aggression (e.g., Little, Brauner, Jones, Nock, & Hawley, 2003; Parrott & Giancola, 2008). In the current review and study, we use the term *motivation*. Unlike the term *function*, the term *motivation* refers to an individual's expectation about the consequences or function of a behavior rather than actual consequences of a behavior.

Although reward sensitivity has been studied as a risk factor for both reactive and proactive aggression, this literature contains several notable gaps. First, despite support for reward sensitivity as a multidimensional construct that can be assessed through multiple units of analysis (e.g., genetic, behavioral, self-report; Cuthbert & Insel, 2013; Insel et al., 2010), studies that examine the association between reward sensitivity and aggressive behavior have largely employed only one measurement modality to assess reward sensitivity. Second, researchers have generally examined reactive and proactive aggression in isolation, precluding direct comparison of how reward sensitivity relates to each. Third, the few studies that have directly compared associations with reward sensitivity between reactive and proactive aggression have relied exclusively on self-report measures of aggression.

Although there are well-recognized advantages of self-report methods (e.g., external validity, content validity), there are some notable limitations as well (e.g., social desirability bias, weaker construct validity) (Giancola & Parrott, 2008; Lobbestael, 2015; Patrick et al., 2013). These limitations are particularly salient when the intended construct is aggressive behavior. In response to these limitations, the field has pushed for studies that examine the association between biobehavioral constructs, such as reward sensitivity, and variation in observable behavior, like physical aggression (Insel et al., 2010). Although researchers have heeded this call, utilization of behavioral measures of proactive aggression have been largely characterized by poor construct validity.

Together, these limitations have partially contributed to discordance in the literature. One line of research has focused on the role of reward sensitivity in the perpetration of reactive aggression (e.g., Harmon-Jones, 2003a). In contrast, a second line of research has focused on comparisons between reactive and proactive aggression and has identified reward sensitivity as a differential correlate of proactive aggression. Since reactive and proactive aggression are highly correlated, it is likely that these distinct motivations share common underlying etiological processes. Examination of reward sensitivity as a potential shared etiological mechanism could contribute to the integration of two seemingly disparate literatures and have practical implications for interventions that reduce both reactive and proactive aggression. As such, the aim of the proposed study is to examine the effect of reward sensitivity, assessed multi-modally through a behavioral task and self-report, on the perpetration of reactive and proactive aggression assessed via a laboratory paradigm.

1.1 Reinforcement Sensitivity Theory

Although reward sensitivity has been examined through a variety of lenses, this review will focus on the construct of reward sensitivity in the context of Reinforcement Sensitivity Theory, as this perspective has been most extensively referenced in the aggression literature. Importantly, this theory lends itself to multiple units of analysis (e.g., self-report, behavioral, neurobiological) and has clear underpinnings in neurobiology. Reinforcement Sensitivity Theory (RST; Corr, 2008; Gray & McNaughton, 2000) is a conceptualization of personality based on individual differences in neurobiological responses to environmental cues. According to this theory, three motivational systems underlie individual differences in behavior: The Behavioral Inhibition System (BIS), the Behavioral Activation/Approach System (BAS), and the Fight-Flight-Freeze System (FFFS). This review will focus on the BAS, the appetitive system that underlies sensitivity to and pursuit of unconditioned and conditioned reward. The BAS facilitates behavioral approach toward rewards and positive affect in response to rewards. A rich scientific literature supports the idea that the BAS is the motivational system that is primarily responsible for perpetration of aggression (Harmon-Jones & Sigelman, 2001; Wingrove & Bond, 1998).

Behavioral Activation System and reactive aggression. Researchers have typically demonstrated associations between the BAS and reactive aggression using one of two primary units of analysis. First, self-reported BAS Sensitivity on the BIS/BAS Scales (Carver & White, 1994) has been associated with reactive aggression as assessed by self-report (Harmon-Jones, 2003a; Smits & Kuppens, 2005) and behavioral methods (Seibert, Miller, Pryor, Reidy, & Zeichner, 2010). Second, researchers have identified a potential neurobiological marker of the BAS using electroencephalographic (EEG) methods. The *Motivational Directional Model* of frontal asymmetry states that greater left than right cortical activity is related to approach motivations (i.e., BAS) whereas greater right than left cortical activity is related to withdrawal motivations (i.e., BIS) (Coan & Allen, 2004; Harmon-Jones, 2003b). Accordingly, greater left frontal cortical activity has been consistently associated with reactive aggression (Harmon-Jones & Sigelman, 2001; Peterson, Shackman, & Harmon-Jones, 2008). Peterson and colleagues (2008) provided evidence for a causal link between the BAS and reactive aggression by inducing asymmetric left frontal cortical activity with contralateral hand contractions and measuring subsequent aggression on a laboratory paradigm. Individuals who contracted their right hand showed higher left frontal cortical activity and in turn were more aggressive. Additionally, Harmon-Jones and Peterson (2008) found that trait levels of the BAS only predicted aggression in participants who engaged in a behavioral approach task prior to the aggression paradigm. Together, these findings highlight the proximal and causal role of reward sensitivity in the perpetration of reactive aggression.

Behavioral Activation System and proactive aggression. In contrast to the large theoretical and empirical literature on reactive aggression, few studies of adults have utilized RST to examine the role of reward sensitivity in the perpetration of proactive aggression. However, a rich child and adolescent literature has focused on sensitivity to positive reinforcement as a putative mechanism that facilitates proactive, but not reactive aggression (Bandura, 1986; Tuvblad, Raine, Zheng, & Baker, 2009). In fact, researchers who examine the development of aggressive behavior in children have referred to proactive aggression as “a reinforcement-shaped form of aggression” (Merk et al., 2005, p. 200) and “reward-focused” aggression (Frey et al., 2016 p. 1).

Despite the paucity of literature that directly examines the role of the BAS in the perpetration of proactive aggression, a line of research focused on the link between psychopathy and proactive aggression provides a useful framework. According to Blair’s (2005) integrated emotion systems (IES) model, the association between psychopathy and proactive aggression may arise from a disruption in the amygdala, an area of the brain involved in forming connections between behavioral responses and reinforcement (i.e., operant conditioning). A failure to register the full aversive value of stimuli (i.e., punishment), combined with intact ability to form connections between responses and rewarding stimuli, characterizes this disruption. The presence of such asymmetry is posited to increase the likelihood of seeking reinforcement without considering negative consequences of the behavior. This neurobiological process has similarities to the construct of the BAS and fits with prior literature showing intact BAS reactivity and impaired BIS reactivity in psychopathy (Fowles, 1980).

Pertinent to the current study, self-report measures of the BAS (e.g., the BIS/BAS scales) have been associated with the interpersonal/affective aspects of psychopathy thought to contribute to premeditated, instrumental aggression (i.e., proactive aggression) (Broerman, Ross, & Corr, 2014; Hughes, Moore, Morris, & Corr, 2012). Importantly, the fact that these studies relied on data from non-psychopathic samples suggests the BAS may serve as a mechanism underlying proactive aggression in the general population. While a link between reward sensitivity and proactive aggression and proactive-aggression promoting traits has been tentatively established, it is unclear if the BAS is more strongly (or weakly) associated with proactive than reactive aggression.

Delay Discounting. Although not explicitly situated within Reinforcement Sensitivity Theory, research supports the idea that delay discounting, or the tendency to seek immediate, lesser rewards in lieu of delayed, greater rewards, is a central dysfunction related to a variety of maladaptive behaviors (Bickel & Johnson, 2003; Reynolds, 2006). In the current review and study, delay discounting is considered a facet of the broader construct of reward sensitivity that specifically captures the effect of time on reward valuation. Perpetration of aggression often exposes one to a variety of negative consequences such as bodily injury, arrest, or loss of a relationship. However, immediately-reinforcing factors likely serve to facilitate an aggressive response, despite the possibility of negative consequences. In support of this premise, delay discounting on a monetary choice paradigm has been associated with self-reported aggression (Total Score on Reactive-proactive aggression questionnaire; Miller, Lynam, & Jones, 2008). Similarly, Moore and Foreman-Peck (2009) found that delay discounting on a decision-making task was associated with self-reported perpetration of aggression. Although this study assessed both instrumental and reactive aggression, all individuals who reported perpetrating reactive aggression also reported perpetrating instrumental aggression. Thus, aggression was collapsed across motivation, precluding examination of the unique associations between delay discounting and reactive and proactive aggression.

Pertinent literature suggests the construct of delay discounting might be a key component facilitating reactive aggression. Heightened negative affect (e.g., anger) facilitates behaviors (e.g., physical aggression, substance use) that function to alleviate negative affect immediately, without consideration of the long-term consequences of those behaviors (Lynam & Miller, 2004; Miller, Flory, Lynam, & Leukefeld, 2003). Not surprisingly, negative urgency, which is defined as the tendency to lash out impulsively in the context of negative affect, is especially predictive of reactive physical aggression (Berg, Latzman, Bliwise, & Lilienfeld, 2015; Carlson, Pritchard, & Dominelli, 2013; Miller et al., 2003; Miller, Zeichner, & Wilson, 2012). In other words, reactive aggression could serve as a behavioral mechanism intended to reduce negative affect in the short-term without appropriate consideration of long-term consequences.

While the literature indicates that the tendency to seek immediate gratification could be a foundational component of reward sensitivity that facilitates reactive aggression, there is little evidence to support the idea that this process is relevant to the prediction of proactive aggression. Indeed, delay discounting stands in stark contrast to the conceptualization of proactive aggression as emotion-free and premeditated. Thus, it is possible that this aspect of reward sensitivity is associated with reactive, but not proactive, aggression. To test this possibility, the current study measured participants' preference for immediate rewards over delayed, but greater rewards, utilizing a behavioral delay-discounting task (Beauchaine & McNulty, 2013; de Wit, Flory, Acheson, McCloskey, & Manuck, 2007).

1.2 Theoretical Integration

Despite support for the pivotal role of reward sensitivity in the perpetration of reactive aggression, research dedicated to parsing distinct correlates of reactive and proactive aggression has focused more heavily on reward sensitivity as a distinct correlate of proactive aggression (Bandura, 1986; Merk et al., 2005; Tuvblad, Raine, Zheng, & Baker, 2009). Given the correlation between reactive and proactive aggression, it is likely that these subtypes share common etiological mechanisms. Consistent with the field's shift toward examining core processes underlying phenotypically different behaviors, this study advances reward sensitivity as a potential shared mechanism. Few studies have directly examined the differential role of reward sensitivity in perpetration of reactive and proactive aggression. The two studies that have directly compared reactive and proactive aggression resulted in mixed findings. Miller, Zeichner, & Wilson (2012) found that BAS Fun Seeking was positively associated with proactive, but not reactive, aggression. Lobbestael Cousijn, Brugman, and Wiers (2016) found that behavioral approach toward attack scenes and positive pictures was associated with reactive, but not proactive, aggression. Of note, both studies used self-report measures of reactive and proactive aggression. One of several ways to address these mixed results is to manipulate motivation for aggression within an experimental paradigm. This approach allows for isolation of and comparison of the associations between reward sensitivity and reactive and proactive aggression, respectively.

1.3 Limitations of Current Experimental Paradigms

Researchers have employed experimental paradigms that allow for more objective measurements of aggressive behavior. Such paradigms also facilitate drawing conclusions about the temporal role of risk factors of aggression. The Taylor Aggression Paradigm (TAP; Taylor, 1967) and its variants are commonly used to measure reactive aggression in a controlled laboratory setting. In this task, participants believe they are engaging in a reaction time task against another participant. They are told that the winner of each trial can administer an aversive stimulus (e.g., electric shock or noise blast) to their ostensible opponent. Participants can choose from a range of different stimulus intensities to administer to their opponent. Aggression is typically operationalized as the average intensity of the aversive stimulus that is chosen. In reality, there is no opponent and the winner of each trial and the intensity of the aversive stimulus the participant receives is predetermined. This allows for manipulation of the level of provocation the participant receives, which is essential for measuring reactive aggression. It also allows for the measurement of unprovoked aggression (i.e., the participant's aggression during a block of trials prior receiving the "opponent's" administration of a shock or noise blast) or aggression under low provocation (e.g., the participant's aggression during a block of trials in which the "opponent" administers very low-level shocks or noise blasts).

Not surprisingly, researchers have capitalized on this paradigm to examine the reactive-proactive dichotomy. However, these laboratory studies often conflate proactive aggression with unprovoked aggression. For example, Dambacher and colleagues (2015) found that stimulation of the right hemisphere of the brain led to decreases in proactive aggression. However, they operationalized proactive aggression as noise blasts (i.e., an aversive stimulus) given to the ostensible opponent on the first 7 trials *before the participant received provocation*. Since aggression on this task was not incentivized by some goal other than harming someone, these trials measured unprovoked – *but not proactive* – aggression.

Similarly, Brugman and colleagues (2015) examined the effect of biases in social information processing on reactive and proactive aggression. They found that attention bias to anger words was more strongly associated with subsequent perpetration of reactive, relative to proactive, aggression. Again, the authors operationalized proactive aggression as the average intensity of noise blasts administered *before the participant received provocation* (i.e., unprovoked aggression). Although participants were told that noise blasts would interfere with their opponent's performance on the next trial there was no monetary incentive for winning the trial. The only explicit incentive for winning would be to avoid receiving a noise blast. Thus, aggression on this task was more akin to defensive behavior than to proactive aggression.

Bobadilla, Wampler, and Taylor (2012) utilized a variant of the TAP to examine differential personality and physiological correlates of reactive and proactive aggression. Again, proactive aggression was operationalized as aggression perpetrated before the participant received provocation. In this case, the authors appeared to acknowledge the limited construct validity of their operationalization, stating, "Further studies of psychological factors that affect unprovoked aggression as a result of external conditions such as the pursuit of rewards are needed" (pg. 470). Most recently, Chen (2018) sought to examine the effect of transcranial stimulation of brain regions implicated in aggression on reactive and proactive aggression. Proactive aggression was operationalized as aggression on unprovoked trials and this was not acknowledged as a study limitation. Collectively, these examples indicate that, at times, conclusions have been drawn about the relation between distinct risk factors and proactive aggression based on questionable operational definitions of laboratory-based proactive aggression.

With few exceptions (e.g., Nouvion, Cherek, Lane, Tcheremissine, & Lieving, 2007; Reidy, Zeichner, Miller, & Martinez, 2007), laboratory-based studies have not used a valid operational definition and behavioral measurement of proactive aggression. Of direct relevance to the present investigation, Reidy and colleagues (2007) examined the role of psychopathic traits in perpetration of reactive and proactive aggression. In this study, male participants engaged in a variant of the TAP in which they were told that delivering an electric shock to their male opponent could interfere with his performance on the competitive reaction time task. Since the winner of each trial received a monetary reward, aggression against the opponent was incentivized. Importantly, this study included a "hostile/reactive" aggression condition, allowing for examination of differential correlates of proactive and reactive aggression. Consistent with the aforementioned studies (Broerman, Ross, & Corr, 2014; Hughes et al. 2012), proactive aggression was associated with interpersonal/affective traits of psychopathy (i.e., Factor 1), but not with social deviance traits of psychopathy (i.e., Factor 2). In contrast, reactive aggression was associated with both interpersonal/affective traits and social deviance traits. However, the interpersonal/affective traits emerged as the only unique predictor in a regression analysis. Pertinent to the current study, these findings implicate Factor 1 interpersonal/affective traits of psychopathy, which have been associated with the BAS (Broerman et al., 2014; Hughes et al., 2012), as a potential common correlate of proactive and reactive aggression. However, the strength of association was not compared directly.

Recognizing that effective intervention hinges on valid empirical research, a handful of researchers have called for experimental studies that examine putative risk markers based on clear and valid measures of reactive and proactive aggression (Lobbestael, Cima, & Lemmens, 2015; Waltes et al., 2015). The current study sought to heed this call by utilizing a well-validated laboratory aggression paradigm that manipulates motivation for aggression. Importantly, in the proactive aggression condition, aggressive behavior was explicitly incentivized by a monetary reward.

1.4 Overview of the Current Study and Hypotheses

The current study sought to examine the associations between reward sensitivity and reactive and proactive aggression using multiple units of analysis. Specifically, we utilized a multi-modal approach (i.e., self-report and behavioral) to measure reward sensitivity, with the intention of gaining a more comprehensive assessment of this biobehavioral construct. Reactive and proactive aggression were measured behaviorally via a laboratory aggression paradigm. Participants were randomly assigned to one of two aggression conditions (i.e., reactive and proactive). Aggression was operationalized as the intensity and duration of shocks participants delivered to their ostensible opponent. It is possible that the correlation between reactive and proactive aggression reflects one's general tendency to engage in aggressive behavior. In order to isolate reactive and proactive motivations from one's general tendency to be aggressive, all participants engaged in a block of unprovoked trials (i.e., an unprovoked condition) of the aggression paradigm before completing the paradigm in their assigned condition.

Although little research directly compares associations between the BAS and reactive and proactive aggression, related literatures support the advancement of several hypotheses. Theory and empirical evidence support the role of the BAS and delay discounting in perpetration of reactive aggression. In addition, while only one study has demonstrated a link between the BAS and proactive aggression (Miller, Zeichner, & Wilson, 2012), the extant literature has long implicated reward sensitivity in the development of proactive aggression (Bandura, 1986; Frey et al., 2016). Based on the reviewed literature, the following hypotheses are advanced:**Hypothesis 1.** Consistent with literature that has centered on reward sensitivity as a risk marker for perpetration of aggression in general, a positive association between reward sensitivity and aggression was expected.

Hypothesis 2. The extant literature has provided ample evidence for an association between reward sensitivity and reactive aggression. Although not situated within Reinforcement Sensitivity Theory per se, the literature has also invoked reward sensitivity as a risk factor for proactive aggression. Since reward sensitivity is a broad biobehavioral construct that underlies a variety of risky behaviors, we predict that the positive association between reward sensitivity and laboratory-based aggression will not significantly differ by condition. This hypothesis is consistent with reward sensitivity as a mechanism common to reactive and proactive aggression.

Hypothesis 3. Delay discounting is the tendency to pursue immediate gratification in spite of longer-term negative consequences. In the reactive aggression condition, one longer-term consequence of administering strong shocks to one's opponent is the possibility of retaliation. In the proactive condition, the longer-term consequence of administering strong shocks to one's opponent is less clear. Due to the difference in salience of long-term consequences, a significant Delay Discounting x Condition interaction is expected. We predict that the association between delay discounting and laboratory-based aggression will be significantly more positive in the reactive, relative to the proactive, condition.

2 EXPERIMENT

2.1 Participants and Recruitment

Participants were 202 undergraduates (101 men and 101 women) aged 18-30. Prior to data collection, a power analysis (Erdfelder et al., 1996) was used to estimate a sample size that would provide adequate power to detect a Reward Sensitivity x Aggression Condition interaction effect, which requires the most power of the potential effects of interest. Parameters of the power analysis were alpha = .05 and power = .80 f^2 = .08. A small to medium effect size was chosen, based on research that has identified a small to medium-sized interaction (*d* = .38) between a self-report measure related to reward sensitivity (Levenson Self-Report Psychopathy Scale Factor 2, LSRP F2) and aggression motivation on a laboratory aggression paradigm (Reidy et al., 2007).

Participants were recruited via the Georgia State University's SONA System, an online tool for recruiting undergraduate students enrolled in Introduction to Psychology courses. Students responded via an online scheduling system to a research study entitled, "An Examination of Personality and Reaction Time." Only participants who reported being at least 18 years of age during a prescreening questionnaire on SONA were eligible to participate. Participants completed a battery of questionnaires and a laboratory aggression paradigm. All participants received course credit for their time.

Of the 202 participants who completed the study, 14 (7%) were not deceived (see below). In addition, there was an equipment malfunction for one (0.5%) participant, two participants (1%) withdrew from participation after providing informed consent, and one participant had difficulty understanding the questionnaire (1%). Removal of these participants resulted in a final sample of 184 participants. Participants ranged in age from 18 to 28 years (M = 19.31, SD = 1.86). The sample consisted of individuals who self-identified as African American (39.1%), Caucasian (28.8%), Asian (22.4%), American Indian (1.1 %), and more than one race (8.2%). Ninety-eight percent of the sample had never been married.

2.2 Experimental Design

The present study used a mixed experimental correlational design and included one between-subjects independent variable (aggression condition: reactive, proactive) and one continuous predictor (reward sensitivity composite). Participants were randomly assigned to either the reactive or proactive aggression condition. Reward sensitivity was assessed via self-report and a behavioral task (See Reward Composite section below).

2.3 Materials

Demographic form. This form comprises questions about participants' age, gender, race, ethnicity, highest level of education, and income level.

The BIS/BAS Scales (Carver & White, 1994). This 20-item, self-report measure assesses the behavioral inhibition and behavioral activation systems, situated within Reinforcement Sensitivity Theory (Gray, 1981). For the current study, the 13-item Behavioral Activation (BAS) scale served as an indicator of reward sensitivity. This scale assesses participants' disposition toward approaching rewards and experiencing positive affect in response to rewards. Participants rate items on a scale of 1 (*strongly agree*) to 4 (*strongly disagree)*, with lower scores reflecting higher behavioral activation (total score range: 13-52). For clarity, items were reverse coded, such that higher scores reflect higher behavioral activation. Sample items include: "When good things happen to me, it affects me strongly", "When I'm doing well at something, I love to keep at it", and "I crave excitement and new sensations." The BAS has been shown to have high validity and reliability (*α* = .81, Hayden et al., 2008). In the present sample, the alpha reliability coefficient for the total scale was .79.

Sensitivity to Punishment and Sensitivity to Reward Questionnaire (SPSRQ; Sensitivity to Reward subscale; Torrubia, Avila, Molto, & Caseras, 2001). This 48-item self-report measure measures the behavioral inhibition and behavioral activation systems. For the current study, the 24-item SPSRQ Sensitivity to Reward scale (SPSRQ-SR) served as an indicator of reward sensitivity. This scale measures dispositional behavioral approach toward specific rewards (e.g., money, sex, social power). Participants rate items on a yes/no scale, with higher scores (i.e., more "yes" responses) reflecting higher behavioral activation (total score range: 0-24). Sample items include: "Are you interested in money to the point of being able to do risky jobs?" and "Would you like to be a socially powerful person?" The SPSRQ-SR scale has been shown to have high validity, as well as good reliability in both men (*α* = .78) and women (*α* = .75) (Torrubia et al., 2001). In the present sample, the alpha reliability coefficient for the scale was .73.

2.3.1 Monetary Choice Questionnaire (Kirby, Petry, & Bickel, 1999).

This 27-item questionnaire available in the PhenX Toolkit assesses delay discounting. For each item, participants choose between smaller/immediate and larger/delayed monetary rewards. Sample items include: "Would you prefer $54 today, or $55 in 117 days?" and "Would you prefer $14 today, or $25 in 19 days?" The protocol is scored by calculating where the participant's answers fall amid reference discounting curves, with placement amid steeper curves indicating greater preference for immediate reward. The variable of interest is an estimate of the participant's discounting constant "k" at the point of indifference, or the point at which participants change between choosing delayed and immediate rewards. The Monetary Choice Questionnaire Automated Scorer (Kaplan et al., 2014) was used to calculate each participant's discounting "k.", with higher scores reflecting greater preference for immediate reward.

Scores on the MCQ correlate with those on other measures of delay discounting (Epstein et al., 2003) and reliably distinguish between clinical and nonclinical groups (see MacKillop et al., 2011 for review). The Monetary Choice Questionnaire Automated Scorer also provides a measure of consistency across trials. Exclusion of data is recommended when consistency is below 80% (Gray, Amlung, Palmer, & MacKillop, 2016). In the current study, all participants exceeded 80% consistency. The Monetary Choice Questionnaire Automated Scorer does not calculate discounting scores for participants that skip one or more items. In the current study, 21 participants skipped one or more items and were thus excluded from analyses involving the MCQ (i.e., Hypothesis 3). The MCQ is considered to be a behavioral task, because it measures current decision-making. This is distinguishable from self-report measures that ask participants to report on themselves and/or past behavior (Odum, 2011).

Response Choice Aggression Paradigm (RCAP; Zeichner, Frey, Parrott, & Butryn, 1999). T The RCAP was used to assess direct physical aggression. Coulbourn Instruments (Allentown, PA) developed the hardware for the task and Vibranz Creative Group (Lexington, KY) developed the computer software. In the RCAP, participants compete in a reaction time task, in which they administer electrical shocks to and received shocks from a "fictitious" opponent (for more information, see "Deception Manipulation" below). Participants are seated at a table in a small room, facing a computer screen and keyboard. They are instructed that they can administer shocks that vary in intensity using the computer's number keys ["1" (labeled "low") through "10" (labeled "high"). The duration of the shock administered depends on how long participants depress the selected key. Participants receive visual feedback on the computer monitor indicating both whether they “won” or “lost” a trial and the shock level selected and received.

The RCAP differs from other aggression paradigms (e.g., the Taylor Aggression Paradigm; Taylor, 1967) in that it gives participants the option to refrain from administering shocks on each trial. In addition, participants have the option to administer a shock regardless of whether they win or lose a trial. This additional response option allows for greater *external validity* of a laboratory aggression paradigm (i.e., the ability to refrain from retaliating against provocation, as is the case in “real word” scenarios), while still preserving an *internally valid* measure of physical aggression (i.e., administration of electric shocks to another person). Of importance to the present study, the RCAP’s option to participants – and ostensibly the opponent – to refrain from administering any shocks allows for the inclusion of a *no provocation* condition. No such condition is possible in the traditional Taylor Aggression Paradigm (Taylor, 1967), because it requires participants to administer a shock following every winning trial. Inclusion of a no provocation condition with the RCAP has been successfully implemented in past research (e.g., Reidy, Zeichner, & Martinez, 2008; Reidy, Zeichner, & Seibert, 2011).

In the current study, average shock intensity was computed by dividing the sum of selected shock intensities by the total number of trials. Average shock duration was computed by dividing the sum of selected shock durations by the total number of trials. Of note, a “0” was entered for shock intensity and shock duration on trials in which the participant did not administer a shock. *RCAP physical aggression* was defined as the sum of standardized scores for the average intensity and duration of shocks selected. This operationalization was selected because previous research has demonstrated that shock intensity and shock duration are highly correlated and are both encompassed by a more general construct of direct, physical aggression (e.g., Carlson, Marcus-Newhall, & Miller, 1989; Gallagher & Parrott, 2011). The RCAP and other similar shock-based laboratory paradigms have been repeatedly shown to be safe and valid measures of aggressive behavior (e.g., Zeichner, Parrott, & Frey, 2003; Parrott, Miller, & Hudepohl, 2015).

2.4 Deception Manipulation

To disguise the true aims of the study, participants were given a fictitious cover story. They were told that the purpose of the study was to examine reaction time under competitive conditions. Further, participants were informed that they would undergo a pain threshold test prior to the reaction time task. Immediately before assessment of their pain thresholds, participants were able to hear their opponent's responses over an intercom system. The "opponent's" voice was pre-recorded by male and female confederates, and participants heard the voice matched to their own gender. All participants heard the same experimenter-confederate verbal exchange. Prior research has confirmed the success of this deception manipulation (Parrott & Zeichner, 2005; Parrott & Giancola, 2004).

2.5 Experimental Manipulation

The RCAP consisted of 36 trials. All participants completed 12 trials in which they won and lost an equal number of trials and did not receive shocks from their "opponent" on any trial. All participants then completed 24 trials of the RCAP within their respective experimental conditions. Participants assigned to the reactive aggression condition received high physical provocation from their opponent on all losing trials. Specifically, participants received shocks that were one second in duration and ranged from 95% (a "9") to 100% (a "10") of the highest tolerated shock intensity.

Following the unprovoked trials, participants assigned to the proactive aggression condition were informed that they would receive $1 for each trial won and thus could earn between $0 and $24, depending on their performance. Critically, they were informed that receipt of higher intensity shocks could interfere with the opponent's performance, making it more likely that the participant would win the trial. Together, these components served to incentivize aggression. Participants in the proactive aggression condition won a disproportionate number of trials (i.e., 16 of 24 trials) to maintain the perception of the utility of electric shocks on interfering with the opponent's performance. Participants in the proactive aggression condition received shocks on 4 of the 8 losing trials that were one second in duration and ranged from 55% (a "1") to 60% (a "2") of the highest tolerated shock intensity.

In sum, the reactive aggression condition included strong provocation without a monetary incentive tied to aggression on the task. In contrast, the proactive aggression condition included a monetary incentive for aggressive behavior without strong provocation. This manipulation created two contexts that elicited largely reactive or proactive motivations. In doing so, it afforded a novel test of the association between reward sensitivity and reactive, relative to proactive, aggression.

2.6 Procedure

Participants presented to the laboratory where they were greeted by an experimenter and provided informed consent. Participants were told the fictitious cover story and were informed that their opponent's room was adjacent to their room. Participants were seated at a desk facing a computer. After providing informed consent, participants completed the questionnaire battery on a computer using Qualtrics, an online survey administrator (Qualtrics, Provo, UT). The experimenter provided instructions on how to operate the computer program that administers the questionnaire battery and was available to answer any questions during the session.

Upon completion of the questionnaire battery, participants then received instructions for the RCAP. During the RCAP, participants in both the proactive and reactive conditions were instructed that shortly after the words “Get Ready” appeared on the computer screen, the words “Press the Spacebar” would appear, at which time they would press, and hold down, the spacebar. Following this, the words “Release the Spacebar” would appear, at which time they would release the spacebar as quickly as possible. A “win” would be signaled by the words “You Won.” and a “loss” would be signaled by the words “You Lost.” Participants were told that following each trial they would be informed whether they won or lost and would be given a choice to administer a shock to their opponent. If they chose to administer a shock, they would select from 10 different shock intensities.

To account for individual differences in sensitivity to electric shock, participants underwent an assessment of their subjective pain ratings before the start of the RCAP. This procedure was conducted while participants were seated in the testing room and the experimenter was in an adjacent control room. They communicated through an intercom. Assessment of participants’ pain thresholds were accomplished via administration of 1-sec electric shocks in an increasing stepwise intensity from the lowest available shock setting, which was imperceptible, until the shocks reached a reportedly painful level. All shocks were administered through two electrodes that were attached to the index and middle fingers of the non-dominant hand using Velcro straps. Participants were asked to inform the experimenter when the shocks were “first detectable” and then when they reached a “painful” level. The overall pain threshold procedure lasted approximately 2-3 minutes.

Next, participants began the first block of the RCAP trials (i.e., unprovoked condition). The sequence of RCAP trials was the same for all participants. This sequence consisted of 12 trials in which participants lost and won an equal number of trials. Participants did not receive shocks from their "opponent" on any trials. This task took approximately 5 minutes.

Following the unprovoked trials, participants in the proactive condition were told that they would receive $1 for each trial they won. Further, they were informed that shocks might interfere with their opponent's performance on subsequent trials. This instruction incentivized their use of aggression, as administering shocks would maximize their likelihood to win trials and, therefore, money. Participants in the reactive condition did not receive these instructions. Instead, they were informed that the second block of the reaction time task was identical to the first. Participants then engaged in the second block of the RCAP. A randomly generated win/loss sequence was predetermined and incorporated into the computer program that executed the task. As noted above, participants in the reactive aggression condition received an equal number of "9" and "10's" after the 12 losing trials, whereas participants in the proactive aggression condition did not receive shocks on the first 4 losing trials and received an equal number of "1" and "2's" on the remaining 4 losing trials.

A specially designed "volt meter" and the illumination of one of the 10 "shock lights" [ranging from 1 (low) to 10 (high)] on the computer screen signaled to the participant the shock that s/he or the opponent selected. A computer controlled the initiation of trials, administration of shocks to participants, and recording of their responses. Again, the purpose of the competitive task was to lead participants to believe that they were engaging in an adversarial interaction with another individual. This task took approximately 10 minutes.

Debriefing and compensation. For aggression data to be valid, it must be demonstrated that participants believed that they were competing against another individual on a “reaction time” task and that this task was not a measure of aggression. This was determined by the administration of a brief verbal interview prior to the debriefing of participants. Specifically, participants were asked whether or not they thought the task was a good measure of reaction time. Additionally, participants were then asked to describe their impression of their opponent and whether they thought he/she was reasonable during the reaction time task. Participants were also asked if they believed that their administering electric shocks served to slow their opponent’s reaction time (See Appendix D).

Participants then received a thorough verbal and written debriefing. During debriefing, participants were told that the purpose of the study was to measure the association between reward sensitivity and physical aggression, and whether this effect differs according to motivation for aggression. Participants were told that at no time during the procedure did they actually administer an electric shock to anyone, and that their responses were “normal” and consistent with those of others in the study. To minimize participants’ distress of being deceived by manipulations, they were told that 95% of the participants in these types of projects are similarly deceived. They were also informed that they were not told, at the beginning of the study, that the RCAP measures aggression, because many people artificially alter their responses if they are aware of this information. The experimenter then addressed any comments or concerns. Participants were thanked for their time and compensated through the SONA system.

2.7 Analytic Plan

Computation of the Reward Sensitivity composite. We used a cross-domain approach (i.e., self-report and behavioral performance) to measure the construct of reward sensitivity. In the current sample, scores on the BAS and the SPSRSQ-SR scale (SR) were significantly correlated (r = .36, p < .001). In contrast, the discounting variable (k) on the MCQ was not significantly correlated with scores on either BAS (r = .08, p = .33) or the SPSRSQ-SR scale (r = .06, p = .49). Although measures within a given modality (i.e., two self-report measures) are expected to correlate more robustly with one another than with measures from a different modality (in this case, a self-report measure and a behavioral task) (Campbell & Fiske, 1959), a cross-domain approach to measuring a construct hinges on common variance among all measures. Given the lack of significant correlations between the MCQ and the self-report measures, respectively, we excluded the MCQ from the composite. The composite reward sensitivity variable was computed by adding the standardized z-scores of the BAS and SPSRSQ-SR scales.

Centering and coding of predictor variables Dummy coding was used to standardize the categorical variables of gender and aggression condition (Aiken & West, 1991). Men were coded as “0” and women were coded as “1.” The proactive condition was coded as “0” and the reactive condition was coded as “1.” The continuous predictor variable (i.e., the reward composite) was mean centered by subtracting the sample mean of the composite index from each participant’s composite index. According to Aiken and West (1991), mean centering first-order continuous variables is advantageous for both statistical and substantive reasons. Most importantly, this procedure reduces multicollinearity between the interaction and lower-order terms and improves the interpretability of regression equations. Further, the computation of interactions with raw scores yields incorrect regression coefficients because they are not scale invariant.

The interaction term was calculated by obtaining the cross-product of the mean-centered reward sensitivity variable and the dummy coded aggression condition variable. When using this procedure, it is important to interpret the unstandardized, and not the standardized, regression solution. As such, the parameter estimates for the interaction effect are reported as unstandardized *b*s. In contrast, estimates of main effects are reported as standardized *β*s.

Hierarchical linear regression. To test study hypotheses, two hierarchical linear models were computed with RCAP physical aggression as the dependent variable. The first model was used to test Hypotheses 1 and 2, and the second model was used to test Hypothesis 3. To control for any variation in RCAP physical aggression due to gender or baseline levels of laboratory-based aggression (i.e., not due to experimental manipulation of motivation for aggression), RCAP physical aggression on the unprovoked trials and gender were entered as covariates in the first step of both models. In step 2 of the first model, the main effects of the reward sensitivity composite and aggression condition were entered. In step 3 of the first model, the Reward Sensitivity x Condition interaction term was entered. In step 2 of the second model, the main effects of delay discounting (*k*) and aggression condition were entered. In step 3 of the second model, the Delay Discounting x Condition interaction term was entered.

Explication of interaction terms was conducted according to well-established procedures (Aiken & West, 1991; Cohen, Cohen, West, & Aiken, 2003). Specifically, regression coefficients for simple effects were examined to determine whether they were significantly different from zero. These analyses determined the associations between the continuous predictor (i.e., reward sensitivity and delay discounting, respectively) and RCAP aggression in the proactive and reactive conditions.

3 RESULTS

3.1 Manipulation Checks

Aggression task check. Prior to debriefing, participants were interviewed to confirm their belief that they were competing against another participant on a "reaction time" task and that this task was not a measure of aggression. First, participants were asked whether or not they thought the task was a good measure of reaction time. Second, they were asked about their overall impression of their "opponent." The main criteria for exclusion were participants' beliefs that they were not actually competing against another person or that the task was a measure of aggression. Of the 202 participants, 12 (6%) indicated that the task was not a measure of reaction time and/or that they were not actually competing against another participant. Participants were also asked to indicate how likely they thought it was that administration of shocks interfered with their opponent's reaction time. In the proactive condition, the main criterion for exclusion was participants' belief that the experimenter fabricated the task instructions. An additional two (1%) participants were excluded for this reason. In the reactive condition, any answer was acceptable because there was no incentive to win trials.

3.2 Preliminary analyses

Random group assignment was expected to produce an equal distribution of pertinent demographic and dispositional variables across experimental groups (Whitley & Kite, 2013). To confirm this assumption, we conducted an independent *t*-test with aggression condition as a between subjects variable and the reward sensitivity variable and unprovoked aggression as the dependent variables. Individuals in the proactive condition reported significantly higher levels of reward sensitivity (M = .42, SD = 1.61) than individuals in the reactive condition (M = -.43, SD = 1.59), $t(182)$ = 3.56, $p < .001$. No significant group difference emerged for unprovoked aggression (see Table 1). A chi-square analysis did not detect significant group differences in gender, racial composition, ethnicity, or marital status. Likewise, no significant differences emerged for age and years of education. As such, subsequent analyses did not control for these variables. The correlation between mean shock intensity and mean shock duration was computed across experimental conditions. Overall mean shock intensity and overall mean shock duration during the unprovoked trails were significantly correlated, $r = .75$, $p < .001$. Overall mean shock intensity and overall mean shock duration across both aggression conditions were also significantly correlated, $r = .67$, $p < .001$. The correlation coefficient in the proactive condition ($r = .78$, $p < .001$) was slightly more positive than, but not significantly different from, the correlation coefficient in the reactive condition ($r = .64$, $p < .001$).

Thirty-seven participants chose not to administer any shocks during the competition. A chi-square analysis determined that the proportion of aggressive responders did not differ between the experimental groups (see Table 2). Individuals who administered shocks reported significantly higher levels of reward sensitivity (composite SR score) ($M = 1.50$, $SD = .17$) than individuals who did not administer shocks ($M = 1.41$, $SD = .14$), $t(182) = 3.15$, $p < .01$, $d = .58$. Analyses did not yield evidence of any other differences between these groups (see Table 3 for comparison of pertinent variables between participants who administered shocks vs. participants who did not administer shocks).

It was important to examine whether there was a difference in aggression between unprovoked trials and the 12 unprovoked trials following instructions about the incentive in the proactive condition. Because the last 12 trials in the proactive condition included minimal provocation from the ostensible opponent, it was also important to examine whether there was a change in aggression from the first 12 incentivized, but unprovoked, trials to the last incentivized, but minimally provoked, 12 trials. To address these aims, two repeated measures

ANOVAs were conducted with trial block (i.e., unprovoked, first 12, last 12) as the independent variable and shock intensity and shock duration, respectively, as the dependent variables.

In the proactive condition, participants administered shocks significantly higher in intensity during the first 12 incentivized, but unprovoked, trials of the RCAP (M = 1.57, SD = .27) than during the non-incentivized, unprovoked trials (M = 1.01, SD =.17), p = .003, d = 2.49. Likewise, participants administered shocks significantly longer in duration during the first 12 incentivized, but unprovoked, trials of the RCAP (M = 577.57, SD = 1345.58) than during the non-incentivized, unprovoked trials (M = 286.10, SD = 600.10), p = .02, d = .28. There was no difference in shock intensity and duration between the first 12 incentivized, but unprovoked, trials and the last 12 incentivized, but minimally provoked, trials on the RCAP. Collectively, these findings indicated that introduction of an incentive, but not minimal provocation, significantly increased aggressive responding (see Table 4).

Based on previous research that has shown a large effect of provocation on laboratory-based aggression (Anderson & Bushman, 1997; Bettencourt & Miller, 1996), we expected an increase in aggression following the introduction of high provocation during the first 12 trials of the RCAP in the reactive condition. To confirm, two repeated measures ANOVAs were conducted with trial block (i.e., unprovoked, first 12, last 12) as the independent variable and shock intensity and shock duration as the dependent variables, respectively. As expected, participants administered shocks significantly higher in intensity during the first 12 provoked trials of the RCAP (M = 2.92, SD = .25) than during the unprovoked trials of the RCAP (M = 1.10, SD = .19), p < .001 , d = 8.20. Likewise, participants administered shocks significantly longer in duration during the first 12 provoked trials of the RCAP (M = 523.15, SD = 997.58) than during the unprovoked trials (M = 377.17, SD = 933.43), p = .036, d = .15 (see Table 4).

The correlations among measures of reward sensitivity and aggression in the proactive and reactive conditions, respectively, are presented in Table 5.

3.3 Hierarchical Linear Regression

Model 1: Reward sensitivity. The first step in the model was significant, $R^2 = .58$, F (2, 181) = 125.53, $p < .001$. Physical aggression during the unprovoked trials was positively associated with physical aggression during the main RCAP trials ($\beta = .77$, $p <.001$). Gender was not associated with physical aggression ($\beta = .056$, $p = .26$). The second step of the model was also significant, $\Delta R^2 = .03$, F (4, 179) = 69.23, $p < .001$. Consistent with Hypothesis 1, a significant main effect of reward sensitivity ($\beta = .12$, $p = .015$) was detected. The third step of the model was significant, $\Delta R^2 = .03$, F (5, 178) = 69.23, $p < .001$, but a Reward Composite x Aggression Condition interaction was not detected, ($b = -.092$, $p = .61$). Consistent with Hypothesis 2, this indicated that the effect of reward sensitivity on aggression did not significantly differ between the reactive and proactive conditions.

Although analyses did not yield evidence of a significant interaction, simple slopes were computed in order to determine the observed effect size of reward sensitivity on physical aggression within each condition. Examination of simple slopes revealed small effect sizes for the relation between reward sensitivity and physical aggression among participants in both the proactive ($\beta = .15$, $p = .03$) and reactive conditions ($\beta = .097$, $p = .18$) (see Table 6).

Given that unprovoked aggression accounted for a large portion of the variance of aggression during the main RCAP trials ($\beta = .77$, $p <.001$), and the bivariate relation between unprovoked aggression and the reward composite was significant and positive ($r = .21$, $p = .005$), it was of interest to examine the effect of reward sensitivity when unprovoked aggression was not controlled for in the model. The pattern of results was largely the same (see Table 7).

However, the main effect of the reward composite on aggression (β = .28, p <.001) was larger than in the *a priori* model which controlled for unprovoked aggression (β = .12, p = .015). This effect size is consistent with the size of the bivariate correlation between the reward composite and aggression (r = .23, p = .002).

Model 2: Delay discounting. Due to the exclusion of MCQ data from 21 participants who skipped one or more items, the sample size for this analysis was 160. The first step in the model was significant, R^2 = .59, F (2, 160) = 116.27, p < .001. Physical aggression during the unprovoked trials was positively associated with physical aggression on the main RCAP trials (β = .78, p < .001). Gender was not associated with physical aggression (β = .035, p = .50). The second step of the model did not add significantly more variance than the first step, ΔR^2= .008, p = .21. There was no main effect of delay discounting (β = .004, p = .93). Inconsistent with Hypothesis 3, a Delay Discounting x Aggression Condition interaction was not detected (b = .101, p = .60) (see Table 8). These results indicated that delay discounting was not associated with reactive or proactive aggression.

Post-Hoc Analyses. We took the approach of measuring the overall construct of the behavioral activation system in models defined a priori. However, there are facets of this construct that might more precisely reflect reward sensitivity and concomitant outcomes, such as aggression. We thus re-ran analyses from Hypothesis 1 and 2, substituting BAS Reward Responsiveness, which reflects one's sensitivity to rewarding stimuli, for the Reward Composite. Contrary to our original findings, there was no main effect of Reward Responsiveness (β = .017 p = .72). A Reward Responsiveness x Aggression Condition interaction was not detected (b = -.077, p = .68) (see Table 9). These results failed to offer support for the notion that reward responsiveness, relative to the broader construct of behavioral activation, more closely implicated in perpetration of reactive and proactive aggression. Since combining two measures of a construct can increase measurement error, we also re-ran analyses from Hypothesis 1 and 2 using the Sensitivity to Reward scale in lieu of the reward composite. The pattern of results largely mirrors those when using the reward composite as the measure of reward sensitivity. Specifically, there was a main effect of Sensitivity to Reward ((β = .15 p = .002) and this effect was not qualified by a Sensitive to Reward x Condition interaction (b = -.13, p = .46) (see Table 10).

4 CONCLUSIONS

The primary aim of this study was to examine reward sensitivity as a potential shared mechanism of reactive and proactive aggression. In addressing this aim, we sought to capitalize on methodological advances to improve measurement of the constructs of reward sensitivity and proactive aggression. Specifically, we sought to measure reward sensitivity cross-modally, as this approach purportedly captures more variance in a construct than do approaches that rely on single indicators (Yancey, Venables, & Patrick, 2016). We also sought to improve on the construct validity of previous behavioral measurements of proactive aggression by directly incentivizing harmful behavior toward an ostensible other. Importantly, we measured and controlled for baseline aggression (i.e., non-incentivized and not provoked). Inclusion of these controls allowed for isolation of motivations for aggression from aggressive behavior in general.

4.1 Primary Aim

In Hypothesis 1, we posited that reward sensitivity would be positively associated with aggression across motivational conditions. Consistent with this hypothesis, analyses detected a positive and significant main effect of reward sensitivity on aggression that was small in size (β = .12). This finding is noteworthy for two reasons. First, it was detected after controlling for aggression on the unprovoked trials, which accounted for a large portion of variance in aggression on the main trials (β = .77). Second, there was a small-to-medium bivariate association between the reward composite and unprovoked aggression (*r* = .21), which was not a substantially larger effect than after controlling for the effect of unprovoked aggression.

Taken together, these findings suggest the relation between reward sensitivity and aggression is not completely attributable to unprovoked aggression. That is, even in the face of the large effect of unprovoked aggression, there is still a small, reliable effect of reward sensitivity on aggression. This finding is consistent with research on the genetic and neurobiological underpinnings of aggressive behavior that has converged on heightened reward sensitivity as an important risk factor for aggression (e.g., Chester et al., 2016; Harmon-Jones & Sigelman, 2001).

In Hypothesis 2, we posited that the association between reward sensitivity and aggression would not differ between the proactive and reactive conditions. Consistent with this hypothesis, analyses did not detect a significant Reward Composite x Aggression Condition interaction; thus, no significant difference was observed in the relation between reward sensitivity aggression in the proactive (β = .15) and reactive (β = .097) conditions. This finding offers initial evidence that reward sensitivity, conceptualized within Reinforcement Sensitivity Theory (Corr, 2008; Gray & McNaughton, 2000), is a common etiological correlate of reactive and proactive aggression. This finding is also consistent with the rich theoretical and empirical literature that identifies the behavioral activation system as the motivational system responsible for a variety of maladaptive behaviors, and pertinently, reactive aggression.

While varying indicators of reward sensitivity have been broadly implicated in the literature on the development of proactive aggression, the current finding suggests further examination of the role of the behavioral activation system in perpetration of proactive aggression is warranted. Although this finding contradicts extant literature on differential correlates of reactive and proactive aggression, it fits with the contemporary call within the field to study biobehavioral mechanisms, including individual differences in approach motivation, that underlie phenotypically different behaviors (Beauchaine & Zisner, 2017; Cuthbert, 2014). More specifically, the current study contributes to recent literature that has examined behavioral approach as a mechanism underlying typologically different risky behaviors such as aggression (Kemp, Sadeh, & Baskin-Sommers, 2019).

Results did not support Hypothesis 3, which posited that delay discounting would be show a stronger positive association with reactive than proactive aggression. Unexpectedly, we did not detect a main effect of delay discounting on aggression. This finding is inconsistent with previous research that reported a positive correlation between delay discounting and self-reported aggression (Miller, Lynam, & Jones, 2008; Moore & Foreman-Peck, 2009). Notably, however, studies that have utilized laboratory aggression paradigms to examine the association between delay discounting and aggression have resulted in mixed findings. A series of studies, for example, found that violent parolees displayed significantly higher rates of delay discounting than nonviolent parolees (Cherek & Lane, 1999; Cherek, Moeller, Dougherty, & Rhoades, 1997). In contrast, delay discounting was not related to reactive aggression on a laboratory paradigm in a clinical sample of adolescents with and without past suicide attempts (Bridge et al., 2015).

4.2 Methodological Considerations and Future Directions

Reward Sensitivity. A major methodological aim of the present study was to use a cross-modal approach to measuring reward sensitivity. This approach was based on an emerging body of research that advocates for extraction of a latent variable from the shared variance of cross-modal measures as a more accurate measurement of a construct than a single indicator (Patrick et al., 2013; Yancey, Venables, & Patrick, 2016). However, in the current study, scores on the behavioral measure of reward sensitivity (i.e., delay discounting (*k*) on the MCQ) were not correlated with scores on either self-report measure of reward sensitivity (i.e., BAS and SRSSPQ-SR) or with the composite score of these self-report measures. We were thus unable to develop a reward sensitivity composite using a cross-modal approach. Instead, we used a reward sensitivity variable that was a composite of two measures within a single domain: self-report.

It is important to consider potential explanations for the lack of association between behavior on the Monetary Choice Questionnaire and self-report on the Behavioral Activation and Sensitivity to Reward scales. First, the psychometric concept of method variance should be considered. As previously noted, indicators within a modality (e.g., two self-report measures) should correlate more strongly than indicators from different modalities (e.g., a self-report and behavioral measure). Further, latent variables extracted from each modality are expected to correlate more strongly with one another than are single indicators across domains This is because latent variables are considered a more “pure” measurement of the intended construct (Patrick et al., 2013). Since we only included one behavioral task, we could not extract a latent variable in this domain. To address this limitation, future studies could use multiple behavioral tasks that have been shown to cohere both theoretically and empirically. The RDoC matrix provides a useful framework in which to consider behavioral indicators of reward sensitivity that cohere theoretically and empirically.

Second, limitations in the construct validity of the MCQ could have obscured the expected association between delay discounting and self-report measures of reward sensitivity. The MCQ’s use of financial decision-making as a proxy for measuring delay discounting limits the content validity of the MCQ. That is, financial decision-making is only one application of the larger construct of delay discounting. In addition, delay discounting tasks have been primarily used as a behavioral measure of impulsivity. However, delay discounting tasks show limited overlap with state and trait measures of impulsivity (Cyders & Coskunpinar, 2011; Reynolds, Penfold, & Patak, 2008), whether they are self-report (Cyders & Coskunpinar, 2011; Reynolds et al., 2008) or behavioral in format (Nguyen, Brooks, Bruno, & Peacock, 2018). Instead, delay discounting tasks show small correlations with more specific lower-order components of broad traits (e.g., the deliberation subscale of NEO-PI-R conscientiousness) (Miller, Lynam, & Jones, 2008).

Pertinent to the current study, delay discounting is considered an indicator of reward valuation, which is a component of the broader construct of reward sensitivity. It is possible that this behavioral measure of delay discounting correlates with self-report measures of more specific components of the broad trait of reward sensitivity. Despite notable limitations in construct validity, delay discounting tasks have shown predictive validity for discriminating clinical and non-clinical samples. For instance, individuals with ADHD show elevated rates of delay discounting (Beauchaine, Ben-David, & Sela, 2017). Pertinently, theoretical and empirical research has invoked an overactive BAS as a primary mechanism underlying ADHD (e.g., Nigg, 2001; Pironti, Lai, Muller, Bullmore, & Sahakia, 2016).

Although delay discounting on the MCQ was not associated with aggression in the current study, a rich theoretical literature has invoked the tendency to seek immediate gratification as a key mechanism underlying maladaptive behavior. Empirical studies largely bear this out, as delay discounting tasks have value in predicting risk-taking behavior in clinical samples (Bickel & Johnson, 2003; Reynolds, 2006). Given the potential of delay discounting, or impulsive decision-making, as a significant target for intervention, it is important to continue examination of the role of delay discounting in perpetration of aggression. Toward this aim, future studies may consider the use of alternative measures of delay discounting. The Delay of Gratification Inventory (DGI; Hoerger, Quirk, & Weed, 2011) is one promising alternative to traditional measures such as the MCQ, as it assesses delay of gratification across five domains of reward (food, physical pleasure, social interactions, money, and achievement). The DGI correlates with other measures of self-control, and is associated with risky behavior. This suggests the DGI has better construct validity than the MCQ, and that it also maintains predictive utility. Pertinent to the current study, delay of gratification in the domain of physical pleasure was a better predictor of aggression than delay of gratification in the domain of money (Hoerger et al., 2011)

Behavioral measure of proactive aggression. A major strength of the current study was the use of a laboratory aggression paradigm, as it allowed for experimental manipulation of reactive and proactive conditions and inclusion of a baseline measure of aggression (i.e., unprovoked aggression) to control for a general tendency toward laboratory-based aggression. Although previous studies have sought to measure proactive aggression using laboratory paradigms, the majority of these studies have conflated proactive aggression with unprovoked aggression. The design of the current study allowed for comparison of behavior during unprovoked trials with behavior during incentivized trials in the proactive condition. We found that average shock intensity and duration significantly increased following the introduction of a monetary incentive tied to aggressive behavior (See Table 4). This finding suggests that our manipulation of proactive aggression differed substantively from our manipulation of unprovoked aggression and further highlights the need for valid behavioral measurements of proactive aggression. Importantly, the increase in aggression from the unprovoked condition to the proactive condition occurred during the first 12 proactive trials in which participants did not receive shocks. This suggests the current manipulation isolated proactive aggression from both unprovoked aggression and reactive aggression, respectively..

4.3 Clinical Implications

The extant literature's focus on identifying distinguishable mechanisms has led to the development of distinct treatments for reactive and proactive aggression (Crick & Dodge, 1996; McAuliffe et al., 2007; Lobbestael et al., 2016). However, the reality is that many individuals perpetrate both reactive and proactive aggression. The current findings could have implications for the development of practical interventions that reduce both reactive and proactive aggression.

A potential cognitive component of treatment for both reactive and proactive aggression could involve modifying positive outcome expectancies by enhancing focus on short-term and long-term negative consequences of aggression. Individuals who plan a proactively aggressive act likely consider consequences of their behavior. However, the research suggests that their evaluation of consequences is positively skewed (Lobbestael et al., 2016), such that they focus more on the reward to be obtained through aggression and less on the immediate impact of causing harm to another person. In contrast, individuals who perpetrate aggression in reaction to provocation likely consider immediate consequences of their behavior (e.g., mood improvement, Chester, Merwin, & DeWall, 2015). However, they are likely to show similarly skewed evaluation of consequences, since their attention is likely focused on positive short-term consequences at the expense of considering negative long-term consequences of aggression. In both cases, modifying expectancies could reduce the presumed connection between behavior and reinforcement that drives behavioral approach (i.e., engagement in aggressive behavior).

The construct of reward sensitivity also includes positive affect in response to rewards. Research posits that heightened positive affect increases subjective value of rewards, thereby increasing likelihood of behavioral approach toward rewards (Carver & White, 1994). Consistent with this view, research on targets for substance abuse intervention suggests that increasing reward value of non-substance related reinforcement decreases the reward value of substance use (Dennhardt, Yurasek, & Murphy, 2105). This process may also be a key mechanism of change in brief motivational interventions (BMIs), which have been found to be effective in reducing a variety of risk-taking behaviors (Larimer & Cronce, 2007; Yakovenko, Quigley, Hemmelgarn, Hodgins, & Ronksley, 2015). It is possible that an intervention designed to increase the reward value of consequences of not engaging in aggressive behavior (i.e., positive relationships, maintaining employment) could reduce the reward value of engaging in aggressive behavior.

4.4 Limitations and Future Directions

Several limitations of the present study merit attention. Although this study takes an important step toward identifying a common risk factor for proactive and reactive aggression, further research is needed to determine the cascade of mechanisms that lead from reward sensitivity to these phenotypically different behaviors. For example, one putative mechanism driving the positive association between trait levels of behavioral approach and reactive aggression is increased tendency to experience anger (Smits & Kuppens, 2005; Beaver, Lawrence, Passamonti, & Calder, 2008; Gable & Poole, 2014). Berkowitz's (1983) cognitive neoassociation theory identifies the experience of negative affect, including anger, as a crucial mediator of the association between aversive stimuli and aggressive responses. Experimental studies could measure trait levels of reward sensitivity, state anger following a mood manipulation, and subsequent perpetration of aggression under reactive and proactive conditions, respectively. This design would allow for comparison of the mediating role of anger in the association between reward sensitivity and perpetration of aggression in reactive vs. proactive conditions.

Second, research supporting distraction-based interventions for reducing reactive aggression has implicated biased attention toward provocation as a key process facilitating reactive aggression (e.g., Ward et al., 2008; Wang et al., 2011; Subramani, Parrott, Latzman, & Washburn, 2018). Similarly, research on mechanisms underlying proactive aggression implicate biased attention toward the rewarding aspects of the behavior (i.e., positive outcome expectancies) at the expense of processing less salient, negative consequences of the behavior (Dodge et al., 1997; Merk et. al, 2005). Future research could utilize a distraction task to indirectly manipulate biased attention toward emotional cues, allowing for comparison of this attentional mechanism in perpetration of proactive vs. reactive aggression.

Pertinent theory on cognitive-affective mechanisms underlying maladaptive behavior suggests that elicitation of intense emotional states in response to emotional cues, including both provocation (i.e., reactive aggression) and reward (i.e., proactive aggression), promotes behavioral approach toward immediately-rewarding, but ultimately maladaptive, behavior (Mischel, 1974; Metcalfe & Mischel, 1999). As such, introduction of a distraction task that reduces the salience of these emotional cues during a laboratory aggression paradigm would be expected to reduce both reactive and proactive aggression.

Second, the current study's composite of reward sensitivity was limited to self-report measures. Although we attempted to assess reward multi-modally, we only used one behavioral indicator of reward sensitivity that has shown limitations in construct validity. Future research should continue utilizing multi-modal approaches to measuring the broad construct of reward sensitivity. Extant literature has provided a wealth of potential measures, including neurophysiological indicators of the BAS (e.g., Coan & Allen, 2004; Harmon-Jones, 2003b; Beauchaine, & Gatzke-Kopp, 2012), behavioral tasks (e.g., Chelonis, Gravelin, & Paule, 2011; Pizzagalli, Jahn, & O'Shea, 2005), and self-report measures (Rewarding Events Inventory, Hughes et al., 2017; Reward Responsiveness scale, Van den Berg, Franken, & Muris, 2010).

Third, the between-subjects design of the current study did not allow for examination of the correlation between proactive and reactive aggression often demonstrated on self-report measures. Researchers have often addressed the correlation by calculating residualized scores of each subscale. Using residualized scores instead of raw scores to examine correlates of proactive and reactive aggression might affect substantive interpretations of findings. This is especially problematic when examining potential common correlates. It could be argued that using a between-subjects manipulation of motivational condition in the current study was akin to artificially isolating behaviors that are thought to co-occur. To address this concern, future laboratory studies could manipulate motivational condition within subjects. One possibility is measuring proactive and reactive aggression with different "opponents" on separate days. This design would allow for the controlled manipulation of proactive and reactive aggression that was a major strength of the current study. This design could also provide insight into the co-occurrence of engagement in proactive and reactive aggression.

Finally, it is important to situate the current findings within a broader ecological context. Indeed, reward sensitivity does not operate in a vacuum as real-life situations likely include multiple cues signaling both reward and punishment. Thus, an important future direction is to consider other biobehavioral factors, like sensitivity to cues of punishment and non-reward (i.e., the Behavioral Inhibition System (BIS); Gray, 1981) that may moderate or qualify the association between reward sensitivity and aggression. Another promising meta-theory in which to situate future studies is the I^3 Model of aggression (Finkel, 2007; Finkel, 2014). This theory accounts for the relative intra-individual and environmental influences that impel (e.g., reward sensitivity), inhibit (e.g., behavioral inhibition), and instigate (e.g., provocation, monetary reward) aggression.

4.5 Conclusions

This study is the first to examine the role of reward sensitivity in perpetration of reactive and proactive aggression on a laboratory paradigm. Findings suggest that the biobehavioral construct of reward sensitivity, conceptualized within Reinforcement Sensitivity Theory, facilitates both reactive and proactive aggression. The present study also provides initial support for a valid behavioral measurement of proactive aggression. The present findings support future research on shared risk factors that could be targeted to reduce both reactive and proactive aggression.

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APPENDICES

Appendix A: BIS/BAS Scales

BIS/BAS

Below is a list of statements. Please read each statement *carefully* and rate how strongly you agree or disagree with it by circling your answer. There are no right or wrong answers, or trick questions.

1. If I think something unpleasant is going to happen I usually get pretty "worked up."	Strongly Agree	Slightly Agree	Slightly Disagree	Strongly Disagree
2. I worry about making mistakes.	Strongly Agree	Slightly Agree	Slightly Disagree	Strongly Disagree
3. Criticism or scolding hurts me quite a bit.	Strongly Agree	Slightly Agree	Slightly Disagree	Strongly Disagree
4. I feel pretty worried or upset when someone is angry at me.	Strongly Agree	Slightly Agree	Slightly Disagree	Strongly Disagree
5. Even if something bad is about to happen to me, I rarely experience fear or nervousness.	Strongly Agree	Slightly Agree	Slightly Disagree	Strongly Disagree
6. I feel worried when I think I have done poorly at something.	Strongly Agree	Slightly Agree	Slightly Disagree	Strongly Disagree
7. I have very few fears compared to my friends.	Strongly Agree	Slightly Agree	Slightly Disagree	Strongly Disagree
8. When I get something I want, I feel excited and energized.	Strongly Agree	Slightly Agree	Slightly Disagree	Strongly Disagree
9. When I'm doing well at something, I love to keep at it.	Strongly Agree	Slightly Agree	Slightly Disagree	Strongly Disagree
10. When good things happen to me, it affects me strongly.	Strongly Agree	Slightly Agree	Slightly Disagree	Strongly Disagree
11. It would excite me to win a contest.	Strongly Agree	Slightly Agree	Slightly Disagree	Strongly Disagree
12. When I see an opportunity for something I like, I get excited right away.	Strongly Agree	Slightly Agree	Slightly Disagree	Strongly Disagree
13. When I want something, I usually go all-out to get it.	Strongly Agree	Slightly Agree	Slightly Disagree	Strongly Disagree
14. I go out of my way to get things I want.	Strongly Agree	Slightly Agree	Slightly Disagree	Strongly Disagree
15. If I see a chance to get something I want, I move on it right away.	Strongly Agree	Slightly Agree	Slightly Disagree	Strongly Disagree
16. When I go after something, I use a "no holds barred" approach.	Strongly Agree	Slightly Agree	Slightly Disagree	Strongly Disagree
17. I will often do things for no other reason than that they might be fun.	Strongly Agree	Slightly Agree	Slightly Disagree	Strongly Disagree
18. I crave excitement and new sensations.	Strongly Agree	Slightly Agree	Slightly Disagree	Strongly Disagree
19. I'm always willing to try something new if I think it will be fun.	Strongly Agree	Slightly Agree	Slightly Disagree	Strongly Disagree

20. I often act on the spur of the moment.	Strongly Agree	Slightly Agree	Slightly Disagree	Strongly Disagree

Appendix B: Sensitivity to Punishment/Sensitivity to Reward Questionnaire

Please answer the following questions by checking either yes or no.

	Yes	No
1. Do you often refrain from doing something because you are afraid of it being illegal?	○	○
2. Does the good prospect of obtaining money motivate you strongly to do some things?	○	○
3. Do you prefer not to ask for something when you are not sure you will obtain it?	○	○
4. Are you frequently encouraged to act by the possibility of being valued in your work, in your studies, with your friends or with your family?	○	○
5. Are you often afraid of new or unexpected situations?	○	○
6. Do you often meet people that you find physically attractive?	○	○
7. Is it difficult for you to telephone someone you do not know?	○	○
8. Do you like to take some drugs because of the pleasure you get from them?	○	○
9. Do you often renounce your rights when you know you can avoid a quarrel with a person or an organization?	○	○
10. Do you often do things to be praised?	○	○
11. As a child, were you troubled by punishments at home or in school?	○	○
12. Do you like being the center of attention at a party or a social meeting?	○	○
13. In tasks that you are not prepared for, do you attach great importance to the possibility of failure?	○	○
14. Do you spend a lot of your time on obtaining a good image?	○	○
15. Are you easily discouraged in difficult situations?	○	○

16. Do you need people to show their affection for you all the time?	○	○
17. Are you a shy person?	○	○
18. When you are in a group, do you try to make your opinions the most intelligent or the funniest?	○	○
19. Whenever possible, do you avoid demonstrating your skills for fear of being embarrassed?	○	○
20. Do you often take the opportunity to pick up people you find attractive?	○	○
21. When you are with a group, do you have difficulties selecting a good topic to talk about?	○	○
22. As a child, did you do a lot of things to get people's approval?	○	○
23. Is it often difficult for you to fall asleep when you think about things you have done or must do?	○	○
24. Does the possibility of social advancement, move you to action, even if this involves not playing fair?	○	○
25. Do you think a lot before complaining in a restaurant if your meal is not well prepared?	○	○
26. Do you generally give preferences to those activities that imply an immediate gain?	○	○
27. Would you be bothered if you had to return to a store when you noticed you were given the wrong change?	○	○
28. Do you often have trouble resisting the temptation of doing forbidden things?	○	○
29. Whenever you can, do you avoid going to unknown places?	○	○
30. Do you like to compete and do everything you can to win?	○	○
31. Are you often worried by things that you said or did?	○	○
32. Is it easy for you to associate tastes and smells to very pleasant events?	○	○
33. Would it be difficult for you to ask your boss for a raise (salary increase)?	○	○
34. Are there a large number of objects or sensations that remind you of pleasant events?	○	○
35. Do you generally try to avoid speaking in public?	○	○
36. When you start to play with a slot machine, is it often difficult for you to stop?	○	○
37. Do you, on a regular basis, think that you could do more things if it was not for your insecurity or fear?	○	○
38. Do you sometimes do things for quick gains?	○	○
39. Comparing yourself to people you know, are you afraid of many things?	○	○
40. Does your attention easily stray from your work in the presence of an attractive stranger?	○	○

41. Do you often find yourself worrying about things to the extent that performance in intellectual abilities is impaired?	◯	◯
42. Are you interested in money to the point of being able to do risky jobs?	◯	◯
43. Do you often refrain from doing something you like in order not to be rejected or disapproved of by others?	◯	◯
44. Do you like to put competitive ingredients in all of your activities?	◯	◯
45. Generally, do you pay more attention to threats than to pleasant events?	◯	◯
46. Would you like to be a socially powerful person?	◯	◯
47. Do you often refrain from doing something because of your fear of being embarrassed?	◯	◯
48. Do you like displaying your physical abilities even though this may involve danger?	◯	◯

Appendix C: Monetary Choice Questionnaire

For each of the next 27 choices, please indicate which reward you would prefer: the smaller reward today, or the larger reward in the specified number of days.

1. Would you prefer $54 today, or $55 in 117 days?

    [ ] smaller reward today

    [ ] larger reward in the specified number of days

2. Would you prefer $55 today, or $75 in 61 days?

    [ ] smaller reward today

    [ ] larger reward in the specified number of days

3. Would you prefer $19 today, or $25 in 53 days?

    [ ] smaller reward today

    [ ] larger reward in the specified number of days

4. Would you prefer $31 today, or $85 in 7 days?

    [ ] smaller reward today

    [ ] larger reward in the specified number of days

5. Would you prefer $14 today, or $25 in 19 days?

    [ ] smaller reward today

    [ ] larger reward in the specified number of days

6. Would you prefer $47 today, or $50 in 160 days?

    [ ] smaller reward today

    [ ] larger reward in the specified number of days

7. Would you prefer $15 today, or $35 in 13 days?

    [ ] smaller reward today

    [ ] larger reward in the specified number of days

8. Would you prefer $25 today, or $60 in 14 days?

[ ] smaller reward today

[ ] larger reward in the specified number of days

9. Would you prefer $78 today, or $80 in 162 days?

[ ] smaller reward today

[ ] larger reward in the specified number of days

10. Would you prefer $40 today, or $55 in 62 days?

[ ] smaller reward today

[ ] larger reward in the specified number of days

11. Would you prefer $11 today, or $30 in 7 days?

[ ] smaller reward today

[ ] larger reward in the specified number of days

12. Would you prefer $67 today, or $75 in 119 days?

[ ] smaller reward today

[ ] larger reward in the specified number of days

13. Would you prefer $34 today, or $35 in 186 days?

[ ] smaller reward today

[ ] larger reward in the specified number of days

14. Would you prefer $27 today, or $50 in 21 days?

[ ] smaller reward today

[ ] larger reward in the specified number of days

15. Would you prefer $69 today, or $85 in 91 days?

[ ] smaller reward today

[ ] larger reward in the specified number of days

16. Would you prefer $49 today, or $60 in 89 days?

[ ] smaller reward today

[ ] larger reward in the specified number of days

17. Would you prefer $80 today, or $85 in 157 days?

[ ] smaller reward today

[ ] larger reward in the specified number of days

18. Would you prefer $24 today, or $35 in 29 days?

[ ] smaller reward today

[ ] larger reward in the specified number of days

19. Would you prefer $33 today, or $80 in 14 days?

[ ] smaller reward today

[ ] larger reward in the specified number of days

20. Would you prefer $28 today, or $30 in 179 days?

[ ] smaller reward today

[ ] larger reward in the specified number of days

21. Would you prefer $34 today, or $50 in 30 days?

[ ] smaller reward today

[ ] larger reward in the specified number of days

22. Would you prefer $25 today, or $30 in 80 days?

[ ] smaller reward today

[ ] larger reward in the specified number of days

23. Would you prefer $41 today, or $75 in 20 days?

[ ] smaller reward today

[ ] larger reward in the specified number of days

24. Would you prefer $54 today, or $60 in 111 days?

[ ] smaller reward today

[ ] larger reward in the specified number of days

25. Would you prefer $54 today, or $80 in 30 days?

[ ] smaller reward today

[ ] larger reward in the specified number of days

26. Would you prefer $22 today, or $25 in 136 days?

[ ] smaller reward today

[ ] larger reward in the specified number of days

27. Would you prefer $20 today, or $55 in 7 days?

[ ] smaller reward today

[ ] larger reward in the specified number of days

Appendix D: Tables and Figures

Table 1 Participant demographics and descriptives

	Proactive (n = 93)		Reactive (n = 91)			
	Mean	*SD*	Mean	*SD*	*t*	*p*
Age	19.38	2.02	19.24	1.70	.50	.62
Years of education	14.14	1.48	13.87	2.19	.99	.32
BAS	3.38	.35	3.22	.35	3.23*	.001
Sensitivity to Reward	1.52	.16	1.45	.16	2.60*	.01
Unprovoked Aggression	-.08	1.58	.09	2.13	-.62	.54

Note: ** $p < .001$, * $p < .05$. BAS is the per item mean on the BAS total scale. Scale ranges from 0-3 with higher scores indicating higher levels of behavioral activation system.

Sensitivity to Reward is the per item mean on the Sensitivity to Reward total scale. Scale ranges from 0-3 with higher scores indicating higher levels of behavioral activation system. Unprovoked aggression is the sum of standardized average intensity and duration of shocks administered during the unprovoked trials.

	Proactive	Reactive
Administered shocks	79.6%	80.2%
Did not administer shocks	20.4%	19.8%

Table 2 Distribution of participants who did vs. did not administer shocks across proactive and reactive conditions

Table 3 Participant demographics and descriptives in individuals who administered vs. did not administer shocks

	Administered Shocks (n = 147)		Did not Administer Shocks (n = 37)			
	Mean	*SD*	Mean	*SD*	*t*	*p*
Age	19.22	1.73	19.65	2.31	-1.24	.22
Years of education	14.01	1.95	13.97	1.52	.12	.91
BAS	3.31	.35	3.25	.40	.93	.36
Sensitivity to Reward	1.50	.17	1.41	.14	3.15*	.002

Note: ** $p < .001$, * $p < .05$. BAS is the per item mean on the BAS total scale. Scale ranges from 0-3 with higher scores indicating higher levels of behavioral activation system.

Sensitivity to Reward is the per item mean on the Sensitivity to Reward total scale. Scale ranges from 0-3 with higher scores indicating higher levels of behavioral activation system. Unprovoked aggression is the sum of standardized average intensity and duration of shocks administered during the unprovoked trials.

Table 4 Shock intensity and duration for each type of trial

	Unprovoked		First 12 Incentivized		Last 12 Incentivized	
	Mean	*SD*	Mean	*SD*	Mean	*SD*
Proactive						
Average Shock Intensity	1.01[a]	.17	1.57[b]	.268	1.63[b]	.22
Average Shock Duration	286.10[a]	600.10	577.57[b]	1345.58	619.54[b]	1118.91
Reactive						
Average Shock Intensity	1.10[a]	.19	2.92[b]	.25	2.99[b]	.26
Average Shock Duration	377.17[a]	933.43	523.15[b]	997.58	631.73[b]	982.10

Note: Within each row, different superscripts indicate a significant difference at $p < .05$.

Table 5 Correlations among key study variables

Variable	Unp Agg	Agg	SR	BAS	BASD	BASRR	BASFS	MCQ	RewCom
Unp Agg	-	.82**	.18	.09	.10	.05	.06	-.012	.17
Agg	.74**	-	.26*	.12	.10	.07	.08	-.03	.23*
SR	.29**	.37**	-	.36**	.23*	.22*	.37**	.02	.82**
BAS	.16	.19	.31**	-	.87**	.69**	.67**	.09	.83**
BASD	.02	.08	.17	.80**	-	.45**	.38**	.05	.67**
BASRR	.19	.18	.20	.76**	.54**	-	.17	.06	.55**
BAS FS	.18	.19	.34**	.67**	.19	.27*	-	.10	.64**
MCQ	.11	.14	.10	.09	.01	.15	.07	-	.07
RewCom	.28**	.35**	.82**	.80**	59**	.58**	.62**	.12	-

Note: *N*= 91 for reactive condition (below the diagonal). N = 93 for proactive condition (above the diagonal). Unp Agg

Table 6 Regression model for effects of the reward composite variable and condition on aggression

Predictor variable	**b**	***β***	**p**	**R^2**	**p**
Step 1				.58	<.001
Unprovoked Aggression	.75	.77**	<.001		
Gender	.20	.056	.26		
Step 2				.61**	<.001
Reward Composite	.22	-.12*	.015		
Condition	.54	.15*	.003		
Step 3				.61**	<.001
Reward Composite	.27	.15*	.034		
Condition	.53	.15*	.003		
Reward Composite x Condition	-.092		.61		

Note: ** $p < .001$, * $p < .05$.

Table 7 Regression model for effects of the reward composite variable and condition on aggression without controlling for unprovoked aggression

Predictor variable	**b**	***β***	**p**	**R^2**	**p**
Step 1				.005	.34
Gender	-.26	-.07	.34		
Step 2				.102	<.001
Reward Composite	.52	.28**	<.001		
Condition	.82	.23*	.002		
Step 3				.104	<.001
Reward Composite	.44	.24*	.02		
Condition	.82	.23*	.002		
Reward Composite x Condition	.17		.54		

Table 8 Regression model for effects of the MCQ discounting variable and condition on aggression

Predictor variable	**b**	***β***	**p**	**R^2**	**p**
Step 1				.59	<.001
Unprovoked Aggression	.75	.78**	<.001		
Gender	.13	.035	.50		
Step 2				.60**	<.001
MCQ “k”	.008	.004	.93		
Condition	.34	.09	.08		
Step 3				.60**	<.001
MCQ “k”	-.048	-.025	.74		
Condition	.34	.09	.08		
MCQ “k” x Condition	.101		.60		

Table 9 Regression model for effects of BAS Reward Responsiveness and condition on aggression

Predictor variable	**b**	***β***	**p**	**R^2**	**p**
Step 1				.59**	<.001
Unprovoked Aggression	.76	.77**	<.001		
Gender	.18	.05	.31		
Step 2				.60**	<.001
BAS RR	.03	.02	.72		
Condition	.39	.11*	.03		
Step 3				.60**	<.001
BAS RR	.07	.04*	.58		
Condition	.39	.11*	.03		
BAS RR x Condition	-.08		.67		

Table 10 Regression model for effects of Sensitivity to Reward and condition on aggression

Predictor variable	**b**	***β***	**p**	**R^2**	**p**
Step 1				.58	<.001
Unprovoked Aggression	.75	.77**	<.001		
Gender	.20	.056	.26		
Step 2				.62**	<.001
Sensitivity to Reward	.28	.15*	.002		
Condition	.53	.14*	.003		
Step 3				.62**	<.001
Sensitivity to Reward	.35	.19*	.007		
Condition	.52	.14*	.003		
Sensitivity to Reward x Condition	-.13		.46		