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Autonomic Conditioning to Monetary and Social Stimuli and Aggression in Children

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Abstract

Poor conditioning to punishment, such as loud tones or electric shock, has been proposed as an important factor involved in the etiology of aggressive and psychopathic behavior. However, it is not known whether the association holds when monetary or social stimulus is used as the unconditioned stimulus, and if aggressive individuals also have impaired conditioning to rewards. In this study, skin conductance responses in a conditioning task involving both monetary/social reward and punishment as unconditioned stimuli were assessed in 340 male and female 8-to 9-year-old children from the community. Children reported their reactive and proactive aggression using the Reactive and Proactive Aggression Questionnaire (RPQ; Raine et al., 2006). Results showed that monetary/social reward and punishment were effective in eliciting physiological classical conditioning in children, and that reduced reward conditioning was associated with high levels of proactive aggression in particular. Findings highlight the importance of distinguishing between reactive and proactive aggression when examining antisocial behavior in children, and suggest that reward-oriented treatment programs may not be effective for children with more proactive, instrumental aggressive behavior.

Keywords

Pavlovian conditioning; reward; punishment; electrodermal; aggression

Introduction

Aggression constitutes a problem of significant clinical and social concern, and increasing evidence suggests that neurobiological mechanisms, such as poor conditioning, are important in explaining individual differences in aggressive and antisocial behavior.

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Impaired autonomic conditioning to punishment has been a key concept in theories of aggression and crime. It has been conceptualized that conscience is a set of classically conditioned emotional responses and impaired conditioning may result in a lack of conscience that predisposes individuals to aggressive and antisocial behavior (Eysenck, 1977). In a typical conditioning (Pavlovian) paradigm, a neutral, non-aversive tone (conditioned stimulus, CS) is presented to the participant, followed a few seconds later by a negative outcome such as a loud tone or an electric shock (unconditioned stimulus, UCS). Skin conductance response, reflecting small changes in the electrical activity of the skin and a measure of sympathetic nervous system activity, is typically recorded at the palmer surface of the hands or fingers where the concentration of eccrine sweat glands is highest. In the conditioning paradigm, increased skin conductance responses are expected after a number of CS-UCS pairings, suggesting successful emotion learning. Failure to form the CS-UCS association, as measured by an absence of increased responsivity to the reinforced CS (CS+) followed by the UCS, compared to a control stimulus not followed by an aversive event (CS -), may indicate a lack of anxiety or anticipatory fear, which in turn may give rise to aggressive acts in some individuals (Hare & Quinn, 1971).

Consistent with this hypothesis, previous work strongly implicates alterations in physiological punishment conditioning in aggression and criminality (Fairchild, van Goozen, Stollery, & Goodyer, 2008), and this association may have a genetic basis (Wang et al., 2015). For example, using longitudinal data collected from a Mauritian sample we found that reduced skin conductance fear conditioning to aversive tones from ages 3 to 8 years is associated with more aggressive behavior at age 8 years (Gao, Raine, Venables, Dawson, & Mednick, 2010b), and that impaired conditioning as early as age 3 years predisposes individuals to criminal offending at age 23 years (Gao, Raine, Venables, Dawson, & Mednick, 2010a). Additionally, increased conditioned responses to aversive tones at age 15 years, distinguished adolescents who desisted from crime by age 29 from those that did not (Raine, Venables, & Williams, 1996), suggesting that enhanced conditioning has a protective role of against antisociality.

However, most conditioning studies have employed physical stimuli (e.g., electric shock or aversive tones) as the UCS, and it is unknown whether antisocial individuals show conditioning deficits to more socially meaningful and ecologically valid stimuli, such as losing money or unhappy faces. Studies have shown that antisocial adolescents and adults do not show responsivity deficits to the loss of money (Castellanos-Ryan, Rubia, & Conrod, 2011; Hartung, Milich, Lynam, & Martin, 2002), but whether this is also the case for children, for whom the loss of relatively small amounts of money may be more important, is less clear. Another gap in the literature concerns lack of research on reward (appetitive) conditioning, to physical or non-physical stimuli, in relation to aggression in humans. Although prior theories have focused on conditioning to punishments rather than to rewards, several studies have shown reduced responsivity to rewards in antisocial and psychopathic individuals (Blair, Peschardt, Budhani, Mitchell, & Pine, 2006; Mitchell, Richell, Leonard, & Blair, 2006; Rubia et al., 2009; although see Kimonis, Frick, Fazekas, & Loney, 2006). Blair (2004) proposed that antisocial individuals show amygdala dysfunction, which leads to a failure to encode the emotional components of reward and punishment and are thus unable to acquire conditioned associations (Blair, 2004). Based on this theory and the proposition

that poor skin conductance conditionability is a proxy for amygdala dysfunction (Bechara et al., 1995; Büchel, Morris, Dolan, & Friston, 1998; LaBar, Gatenby, Gore, LeDoux, & Phelps, 1998), aggressive individuals are expected to show reduced skin conductance conditioning responses to both rewards and punishments.

Another caveat is that aggressive children and youths are a heterogeneous group. Two prominent forms of aggression are reactive and proactive aggression (Dodge, Lochman, Harnish, Bates, & Pettit, 1997; Hubbard, McAuliffe, Morrow, & Romano, 2010). Reactive aggression has been characterized as impulsive, hostile, affective, and an uncontrolled angry response to frustration or provocation, while proactive aggression has been characterized as predatory, controlled, and instrumental in that it is used to obtain rewards beyond harming the victim (Crick & Dodge, 1996; Vitiello & Stoff, 1997). Both types of aggression have been associated with antisocial behavior, including delinquency and substance abuse (see a review by Babcock, Tharp, Sharp, Heppner, & Stanford, 2014), although it has been suggested that a general propensity towards impulse control problems contributes to reactive aggression whereas a separate propensity involving deficient empathy and stimulation-seeking tendencies appears to contribute independently to proactive aggression (Patrick, 2008).

Although evidence has suggested that these two forms of aggression differ in their phenomenology and neurobiological features (Lopez-Duran, Olson, Hajal, Felt, & Vazquez, 2009; Raine et al., 1998; van Goozen, Fairchild, Snoek, & Harold, 2007; Vitiello & Stoff, 1997), only a few studies have examined their psychophysiological correlates. In one study of school-aged children, those scoring high on reactive aggression (but not proactive aggression) showed increased heart rate reactivity during a provocation when compared to those high on both reactive and proactive aggression (Pitts, 1997). In another study of second graders, reactive aggression was positively associated with skin conductance reactivity to a frustration challenge, although no heart rate effect was found (Hubbard et al., 2002). In a pilot study of 36 fourth- and fifth- graders, Hubbard et al. (2010) found that increased skin conductance and heart rate were associated with high reactive aggression when provoked, whereas reduced skin conductance and heart rate were associated with high proactive aggression. Specifically, one recent study showed that reduced skin conductance conditioning was associated with persistently high proactive but not reactive aggression (Gao, Tuvblad, Schell, Baker, & Raine, 2015). These findings support the proposition that reactive and proactive aggression may be characterized by autonomic hyperarousal and hypoarousal, respectively (Scarpa & Raine, 1997, 2000).

We took advantage of the fact that monetary incentives represent a common UCS that can be either positive (rewards/gains) or negative (punishments/losses), and adapted the paradigm from Delgado, Labouliere, and Phelps (2006) to include both reward and punishment conditioning sessions. This allows for within-subject comparisons of learning by positive and negative UCS, respectively. Losing money has been found to be a powerful incentive as an UCS that can have similar effects on punishment conditioning as a physical UCS (i.e., electric shock) in 20-year-olds (Delgado et al., 2006). Losing or gaining money has also been found to affect similar brain circuitry as the physical UCS (e.g., electric shock or juice) in classical conditioning paradigms (Delgado, Jou, & Phelps, 2011). It was therefore

expected that gaining or losing money would be effective in eliciting conditioning responses in children.

In the current study, we aimed to examine whether reactive and proactive aggression are differentially associated with conditioning deficits to punishments or rewards using non-physical UCS in a community sample of 8- to 9- year-old children. To enhance the ecological validity and the effect size of the paradigm, a combined monetary/social UCS was used in the conditioning paradigm, considering that in more naturalistic settings, such as home and school, children are often exposed to a combination of monetary and social rewards/punishments such as positive facial expression or praises. Prior studies have indicated that conditioning deficits to aversive tones, reflecting fearlessness temperament that impairs the ability to learn from punishment, may be a risk factor for proactive aggression in particular (Gao, Tuvblad, et al., 2015). In addition, psychopathic traits, a cluster of personality traits that are more strongly associated with proactive aggression than with reactive aggression (Fite, Raine, Stouthamer-Loeber, Loeber, & Pardini, 2009), have been consistently associated with deficient amygdala activation in responses to emotional stimuli (Blair, 2007; Jones, Laurens, Herba, Barker, & Viding, 2009). Taken together, it was predicted that skin conductance conditioning deficits to both punishments and rewards, reflecting impaired amygdala function in general, would be associated with high proactive but not reactive aggression. The potential effects of sex, cognitive awareness of the CS/UCS relationship, and the responsivity to rewards and punishments were also examined.

Materials and Methods

Participants

Data for this study come from the Healthy Childhood Study, a longitudinal study examining the development of conduct problems in middle childhood. The sample consisted of 8- and 9-year old boys and girls (Mean age = 9.06, $SD = 0.60$) living in Brooklyn, New York. Within the study area, flyers soliciting enrollment were placed in recreation centers, libraries, churches, and other community centers. Targeted mailings were also sent to parents of 8- to 9- year-old children living in the geographic catchment area. Children with a diagnosed psychiatric disorder, intellectual disabilities, or a pervasive developmental disorder were excluded. The initial sample consisted of 340 subjects, 164 of whom were male (48.2%), with ethnic breakdown as follows: 11% Hispanic, 21% Caucasian, 52% Black, 2% Asian, and 14% mixed/ other. Compared to the ethnic distribution in the Kings County or New York population, our sample consisted of more African Americans and people with more than one race. Caregiver participants were primarily biological mothers of the children (86.4%). Median family income was \$43,200, which is slightly lower than the median income in Kings County (average median = \$45,215) of the state of New York between 2008 and 2012. More details about the sample can be found elsewhere (Gao, Borlam, & Zhang, 2015).

Procedures and Measures

Participants and their main caregivers were invited to the university for a laboratory assessment. During a 2-hr visit, psychophysiological recording, clinical interviews,

neurocognitive testing, and social risk factor assessments were conducted. Caregivers were also interviewed about their child's behavior, as well as their own behavior and relationship to their child. Compensation (including incentive and transportation reimbursement) was provided to the participating families at the end of the assessment. Written parental consent and verbal child assent were required for each child's participation. All of the study procedures were approved by the City University of New York Institutional Review Board. Skin conductance and cardiovascular measures were recorded during a psychophysiological testing session, which lasted approximately 40 minutes and included several tasks. After the psychophysiological testing session, participants were administered an IQ test by trained research assistants.

Reactive and Proactive Aggression Questionnaire (RPQ; (Raine et al., 2006))—

The RPQ includes 11 items assessing reactive aggression (e.g., “Yelled at others when they have annoyed you”) and 12 items assessing proactive aggression (e.g., “Had fights with others to show who was on top”). For each item, children rated the frequency of occurrence on a scale of 0 (*never*), 1 (*sometimes*), or 2 (*often*). Scores for each subscale were calculated by summing the scores across items, with higher scores indicating higher levels of reactive aggression or proactive aggression. Previous studies have documented that the two subtypes of aggression are positively correlated, with the correlation coefficient ranging from .67 to .83 (Poulin & Boivin, 2000; Raine et al., 2006). Consistent with prior literature, reactive aggression was significantly associated with proactive aggression in our sample ($r = .55$, $p < .001$). The internal reliability was .82 and .81 for reactive and proactive aggression scale, respectively.

Conditioning Paradigm—Before the conditioning paradigm, a number judgment task was administered in which one single-digit number was presented on the screen for one second, and the participants were asked to decide whether the current number was smaller or bigger than a previous one. For each correct answer, a \$0.10 reward was granted. This task lasted 120 s, and the average amount of money gained was \$7.75. Participants were told that the money was theirs, and at the end of the number judgment task, a small safety box containing the money was placed next to the participant as the “piggy bank”.

The conditioning session was adapted from Phelps, Delgado, Nearing, and LeDoux (2004) and Delgado et al. (2006). Before the task began, children were instructed to pay close attention to the screen throughout the task for presentation of different colored shapes. They were told that there was a possibility of seeing a −\$2.00 sign which signaled that the experimenter would take out 2 dollars from their “piggy bank”. If they saw a +\$2.00 sign the experimenter would put 2 dollars into their “piggy bank”. All colored shapes served as conditioned stimuli (CS) and were presented for 6 s, followed by an inter-trial interval ranging from 12 to 20 s (mean = 16 s). After the offset of the CS, one of the two types of UCS was presented: One was loss of money, depicted by the symbol −\$2.00 written in black font along with a sad face on top for 1,250 ms; another type of UCS was gain of money, depicted by the symbol of +\$2.00 written in black font together with a happy face on top for 1,250 ms. When the −\$2.00 sign showed up on the screen, the experimenter who sat next to the participant took out 2 dollars from the “piggy bank”, and at the same time said “sorry,

you lost two dollars” in a sad voice (i.e., punishment). When the +\$2.00 sign showed up on the screen, the experimenter put 2 dollars into the bank and said “congratulations, you’ve got two dollars” in a pleasant voice (i.e., reward). A blue square was always paired with the punishment (CS+p), while an orange circle was always paired with the reward (CS+r). A third shape, a green triangle was never paired with the UCS (CS–). There were 8 presentations of the CS–, CS+p, and CS+r, respectively (see Figure 1). The order of presentation was randomized and the same stimulus-outcome associations were used for all participants. This task lasted about 10 m.

At the end of the conditioning task, participants were asked whether they were aware of the type of shape that was paired with the punishment or reward, and how certain they were about their answer. Participants who selected the correct shape and indicated that they were “completely certain” or “fairly certain” of their choice were considered aware of the CS-UCS relationship. Participants also rated how they felt about the punishment, on a 7-point scale from 1 (not at all unpleasant) to 7 (extremely unpleasant), and about the reward, from 1 (not at all pleasant) to 7 (extremely pleasant). At the end of the 2-hr lab visit, all participants were debriefed and each child was paid \$20 in compensation.

Skin Conductance Recording and Data Reduction

Psychophysiological measures were acquired using BIOPAC hardware and software (BIOPAC Inc., Goleta, CA). Skin conductance data were recorded using a GSR100C amplifier with 6 mm diameter silver/silver chloride electrodes (TSD203) attached to the whorl of the distal phalanges of the first and second fingers of the non-dominant hand. Participants were instructed to keep their fingers as still as possible. Quantification of skin conductance response amplitude was achieved using the peak-to-peak function in AcqKnowledge 4.2 (BIOPAC system, Inc.). A positive amplitude exceeding 0.05 μ S within a latency window of 1–4 s following the onset of CS presentations was considered to indicate an elicited response. Additionally, the slope in skin conductance level was required to exceed the baseline slope (at stimulus onset) by a minimum of 0.05 μ S/s. Skin conductance response amplitude was defined as the peak change in skin conductance occurring within 7 s of response initiation. If no response was detected, then the magnitude for that particular trial assumed a value of zero (Gao, Tuvblad, et al., 2015; Isen et al., 2010). A square root transformation was performed on the skin conductance responses before inferential statistical analyses were conducted to help attain normality (Dawson, Schell, & Filion, 2007). Acquired responses were then averaged per participant, per type of trial. Mean values of unconditioned responses (UCRs) amplitudes to reward and punishment were also computed and square root transformed.

Statistical Analyses

All analyses were conducted using SPSS 22 (SPSS Inc., Chicago, IL, USA). First, to test for the presence of conditioning, a repeated-measures analysis of variance (ANOVA) with trial blocks (1, 2, 3, and 4) and stimulus type (CS+p, CS+r, and CS–) as the within-subject factors and sex as the between-subjects factor followed by post hoc tests was conducted. The task was divided into four blocks, each comprising two presentations of the CS+ and two presentations of the CS–, to examine the time course of learning. In addition, to further

assess the efficacy of monetary/social UCS during reward conditioning, a two-tailed correlation between the levels of reward conditioning (the difference between CS+r and CS– trials) and the levels of punishment conditioning (the difference between CS+p and CS– trials) was conducted. We also examined whether awareness of the CS/UCS relationship might have any effect on aggression or conditioning. Independent *t*-tests were conducted to examine potential sex differences in all variables. Effect sizes were reported using Cohen's *d* (Cohen, 1988), and dependence among means were adjusted for repeated measures (Morris & DeShon, 2002). Finally, hierarchical linear regressions were undertaken to examine the effects of conditioning responses on aggression. Specifically, we aimed to determine whether conditioning responses were significantly associated with reactive or proactive aggression after the nonfocal aggression measure was controlled for. In these analyses, the outcome variable was children's reactive or proactive aggression. In step 1, the nonfocal aggression measure was entered to control for its effect. In step 2, reward and punishment conditioning measures were entered using the stepwise method.

Results

Descriptive Statistics

Data were unavailable for 14 participants due to technical or experimenter error or inability to complete the testing session. In addition, outliers ($\pm 3SD$ s from the mean) were examined prior to analyses. Thirty-one outlying values were found for aggression or conditioning measures, and were removed from relevant analyses. Boys and girls did not differ on proactive aggression ($t = 1.25, p = .21$), reward conditioning ($t = 0.86, p = .39$), punishment conditioning ($t = 1.80, p = .24$), UCR to reward ($t = 1.44, p = .15$), UCR to punishment ($t = 1.70, p = .10$), intensity rating of reward ($t = -0.67, p = .50$), intensity rating of punishment ($t = 0.33, p = .75$), or ethnicity [$\chi^2(4) = 5.45, p = .48$]. However, compared to girls, boys had higher reactive aggression scores (boys $M = 2.43, SD = 1.02$; girls $M = 2.19, SD = 1.03$; $t = 2.14, p = .03, d = 0.23$), were more aware of the CS-UCS (punishment) relationship [$\chi^2(1) = 4.39, p = .036$] and the CS-UCS (reward) relationship [$\chi^2(1) = 8.30, p = .005$]. Although estimated IQ score was negatively correlated with proactive aggression ($r = -.19, p = .001$), it was not associated with conditioning responses. Therefore IQ score was not included in the following analyses.

Effect of Monetary/Social UCS

A repeated-measure ANOVA with trial block and stimulus type as the within-subject factors and sex as the between-subjects factor revealed significant main effects due to stimulus type [$F(2, 305) = 28.69, p < 0.001$], trial block [$F(3, 304) = 4.079, p = 0.007$], and sex [$F(1, 306) = 11.06, p = .001$]. Post hoc *t*-tests indicated that both reward and punishment were successful in inducing conditioning, as skin conductance responses were higher for both CS+p ($t = 2.25, p = .025, M = 0.46, SD = 0.35, d = 0.10$) and CS+r ($t = 3.16, p = .002, M = 0.49, SD = 0.36, d = 0.19$) than those for CS– trials ($M = 0.42, SD = 0.31$), respectively. Skin conductance responses to the trial block 1 were larger than those to blocks 3 and 4 ($p < .015$), and responses to block 2 were also higher than to block 4 ($p = .015$). There was also a significant sex $\times$ stimulus type interaction effect, $F(2, 305) = 4.08, p = .018$. Boys showed larger responses to the CS+p ($M = 0.23, SD = 0.20$) than to the CS+r trials ($M = 0.19, SD =$

0.16, $p = .002$, $d = 0.24$), whereas girls failed to demonstrate this difference between reward ($M = 0.14$, $SD = 0.16$) and punishment ($M = 0.15$, $SD = 0.17$) in the role of an effective UCS ($p = .585$, $d = -0.08$). No other significant two-way or three-way interaction effects were found.

The levels of reward conditioning (CS+r minus CS-) and the levels of punishment conditioning (CS+p minus CS-) were significantly correlated, ($r = .50$, $p < .001$). Neither conditioning responses nor aggression measures were significantly associated with UCRs to reward, UCRs to punishment, or intensity ratings, with the exception that individuals with high reactive aggression rated punishment as more negative ($r = .13$, $p = .02$). In general, participants rated reward ($M = 5.79$, $SD = 1.60$) as more intensive than punishment ($M = 3.19$, $SD = 1.80$, $t = 21.67$, $p < .001$, $d = 1.19$), and participants' UCRs to reward ($M = 0.51$, $SD = .32$) were higher than those to punishment ($M = 0.40$, $SD = .33$, $t = 6.36$, $p < .001$, $d = 0.37$),

Finally, we examined whether awareness of the CS/UCS relationship has any effect on aggression or skin conductance conditioning. Compared to those who were unaware of the CS+r/UCS relationship, participants who were aware of this relationship scored higher on reactive aggression ($t = 2.26$, $p = .025$), and rated reward as more positive ($t = 2.65$, $p = .008$). The two groups did not differ on other measures ($p > .14$). Compared to those who were unaware of the CS+p/UCS relationship, participants who were aware of this association scored lower on proactive aggression ($t = -2.93$, $p = .004$), but not other measures ($p > .14$). Specifically, reward conditioning was not significantly different between participants who were or were not aware of the CS+r/UCS relationship ($t = 0.95$, $p = .34$). Similarly, punishment conditioning was not related to awareness of the CS+p/UCS relationship ($t = 0.72$, $p = .47$). The correlations between main study variables are listed in Table 1.

Conditioning and Aggression

Hierarchical regression analyses were conducted to predict the aggression scores from conditioning responses, and results are listed in Table 2. Given that boys had higher scores than girls on reactive aggression, sex was also entered in the first step to predict reactive aggression. After proactive aggression and sex were controlled for, neither type of conditioning responses was significantly associated with reactive aggression. Therefore, reactive aggression was not entered into the model. In contrast, after reactive aggression was controlled for, reward but not punishment conditioning was significantly associated with proactive aggression (Figure 2), $\beta = -0.11$, $F = 4.56$, $p = .03$, $R^2 = .01$.

Discussion

In this study we found that non-physical and more socially valid stimuli such as the monetary/social stimuli can be effective UCS during a reward and punishment conditioning paradigm in 8-to 9-year-old children. More importantly, high proactive aggression was associated with reduced skin conductance responses to cues predicting rewards. This is the first study examining the relationship between subtypes of aggression and both reward and punishment conditioning in response to non-physical UCS in children. Findings suggest that

impaired associative learning processes in the context of monetary/social reward prediction may in particular underlie the proactive/instrumental type of aggression.

Partly consistent with our hypothesis, conditioning deficits to monetary/social reward were found to be associated with proactive but not reactive aggression. This significant relationship was found in the hierarchical regression, but not in the zero-correlation correlations, suggesting the operation of cooperative suppressor effects (Cohen, Cohen, West, & Aiken, 2013). Specifically, the correlation between reactive and proactive aggression ($r = .55$, see Table 1) may suppress the divergent correlations between these two variables and the conditioning responses. It was only when the effect of reactive aggression was controlled that the association between proactive aggression and conditioning deficits emerged. Proactive aggression was not associated with the UCRs to reward or children's cognitive awareness of the CS+ r /UCS contingency. Therefore the reward conditioning deficits observed were not the result of their insensitivity to rewards or cognitive learning impairments, but instead reflected a selective deficit in emotional learning. Our finding provides further evidence that the pathways to proactive and reactive aggression are distinct. Reduced reward conditioning in children with high proactive aggression may reflect their neural hyposensitivity to reward that drives maladaptive reward-seeking and predatory/instrumental aggressive behavior via attempts to "normalize" reward-related neural reactivity (Beck et al., 2009). Alternatively, this reward learning deficiency may result in compromised learning of appropriate behavior. In contrast, autonomic hyperarousal and negative emotionality are believed to be associated with impulsive and hostile types of aggression (Scarpa & Raine, 1997, 2000). These different patterns are also in line with twin research demonstrating stronger genetic etiologies underlying proactive aggression and its development (Baker, Raine, Liu, & Jacobson, 2008; Tuvblad, Raine, Zheng, & Baker, 2009). Together with cumulating evidence distinguishing proactive and reactive aggression along emotional, attentional, neural, and autonomic indices (Scarpa, Haden, & Tanaka, 2010), our findings further highlight the importance of distinguishing between types of aggression when examining antisocial behavior in children.

We found that participants' skin conductance responses to this combined monetary/social UCS were larger than those to the stimulus that is non-predictive, indicating that overall the \$2 reward or punishment (together with the social stimuli) was effective in eliciting conditioned responses. Prior literature has demonstrated that money is a powerful incentive when presented in the appropriate context, and that individuals may learn its reinforcing properties through association (e.g., money, social rewards) in day-to-day behavior (Delgado et al., 2006). The current study extends our understanding of money and social rewards as reinforcers for human behavior by demonstrating that combined monetary/social stimuli can be used as a UCS during conditioning paradigms in children as young as eight years of age.

Furthermore, we compared reward and punishment affective learning using the same metric (i.e., losing or gaining \$2) in one paradigm. At the cognitive level participants were more aware of the CS-UCS contingency to reward than to punishment (52% vs. 42%), and they rated the positive outcome as more intensive than the negative outcome. In addition, their skin conductance responses to reward (UCRs) were larger than those to punishment, suggesting that in general children are more sensitive to reward than punishment of the same

amount. The finding of higher intensity rating for reward than for punishment seems in contrast to the loss aversion intuition as predicted by the prospect theory (Kahneman & Tversky, 1984), which suggests that a loss of \$2 should be more aversive than a gain of \$2 is attractive. This might be partly due to the discrepancy between our reward and punishment conditions. In the punishment trials, although money was taken out of the participants' piggy bank when cued, this money was their earnings from the prior task, but not their own money. So strictly speaking, participants did not pay the experimenter directly and the punishment never resulted in a negative total value, whereas in the reward trials participants did gain more money. Alternatively, it is important to acknowledge that the body of literature on loss aversion has mainly focused on adult populations and under risky decision-making scenarios in which various probabilities are associated with outcomes. In fact, limited evidence suggests that children seem more inconsistent and impulsive than adults regarding their decision-making strategies (Beitz, Salthouse, & Davis, 2014). Therefore the framework and assumptions of the prospect theory (Kahneman & Tversky, 1984) may not directly apply to the 8- to 9-year-olds in a paradigm in which no active decision-making is involved. Nevertheless, the higher positive rating for reward than for punishment suggests that psychologically and physiologically children place higher value on "earning" than "losing" the same amount money (in combination with social stimuli). However, this difference was not apparent in the skin conductance conditioned responses, that is, their abilities to differentiate cues predicting negative or positive outcomes from a non-predictive stimulus were not different. Furthermore, intensity ratings were not significantly associated with participants' UCRs or conditioned responses. The discrepancy between subjective ratings and implicit conditioned responses to a potential negative or positive outcome is not unexpected. For example, Delgado et al. (2006) found that when different types of UCS (shock and loss of money) were intermixed, skin conductance responses to the stimulus predicting shock was higher than for the stimulus predicting loss of money, although participants' subjective ratings of intensity were not significantly different.

Although prior studies showed that proactive aggression was associated with lower conditioning to physical punishment, we did not find this link using monetary/social punishment as the UCS. Considerable evidence has linked proactive aggression with psychopathy (Babcock et al., 2014), a personality disorder that is characterized by the callous, manipulative use of interpersonal violence (Hare, 2003). Although many studies have demonstrated lower punishment conditioning in psychopathic individuals, the majority of research has used physical UCS such as electric shock and aversive tones. Only one study examined the relationship between psychopathy and conditioning to non-physical UCS (Schmauk, 1970). It was found that although psychopathic adults showed lower anticipatory arousal to physical (i.e., electric shock) and social punishment (i.e., experimenter saying "wrong") than normal controls, they did not show conditioning deficits when the punishment was tangible, i.e., loss of money (Schmauk, 1970). The researcher argued that psychopathic individuals are able to form the associations between neutral stimuli and punishments if "the punishment is appropriate to their value system, that is, if the punishment is genuinely experienced as noxious or distressing" (p. 334). In our study, the combination of loss of money (-\$2) and social punishment (a sad face and experimenter saying "sorry you lost two dollars") seemed to act as the type of stimuli that is capable of generating physiological

responses in children with high proactive aggression, who became as aroused as those low on proactive aggression in response to potential monetary/social punishment. This finding also corroborates previous reports of intact punishment conditioning in psychopathic offenders once motivated attention is drawn to the CS+ (Baskin-Sommers, Curtin, & Newman, 2011; Newman, Curtin, Bertsch, & Baskin-Sommers, 2010).

One limitation of the study is that a combined monetary/social UCS was used in the paradigm. Although this was originally designed to enhance the ecological validity and the effect size of the paradigm, one issue may be that it is unclear whether the observed findings are due to direct removal/return of the \$2 or to indirect forms of conditioning (e.g., information, vicarious learning), or a blend of both (Field, 2006). For example, it can be argued that the smiling face itself may have less rewarding effects for proactively aggressive individuals. Therefore, it cannot be completely ruled out that the reduced reward conditioning is due to this combined UCS. Furthermore, it is unclear how learning through the potential monetary/social reward or punishment is related to physical UCS (e.g., shock, loud tone) and other types of non-physical UCS for children (e.g., compliments, touching/hug, privilege or honors). Second, our sample was composed of community-recruited children, among whom the base rate of high-scorers on proactive or reactive aggression is generally low. Future studies should test if these findings are generalizable to more severely aggressive samples. In addition, the sample was not well represented in terms of ethnic and socioeconomic diversity (i.e., there were more African-American participants and lower median income families in our sample). This places a limitation of the generalizability of the current findings to other samples.

In summary, with prior studies focusing on the effects of physical UCS, this is the first study to examine the associations between subtypes of aggression and reward and punishment conditioning using non-physical UCS. We found that in a community sample of 8- to 9-year-old children, monetary/social UCS can successfully elicit skin conductance conditioning responses. More importantly, high proactive but not reactive aggression was associated with reduced conditioning to monetary/social rewards. Although tentative, our findings suggest that the reward-oriented treatment programs may not be very effective for children with more proactive, instrumental aggressive behavior. Further study of the underlying brain functioning and the effects of other socially meaningful UCS in eliciting conditioning is needed given the potential treatment applications for children with aggressive behavior.

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Figure 1. Conditioning procedure. CS+p trials predicted monetary/social punishment, CS+r trials predicted monetary/social reward, and CS- trials were non-predictive.

Figure 2. Scatter plot representations of the partial correlation (controlled for reactive aggression thus both variables expressed as residuals) between proactive aggression and reward conditioning.

Table 1

Descriptive Statistics and Correlations between Main Study Variables

	Reactive Aggression	Proactive Aggression	Reward Conditioning	Punishment Conditioning	UCRs to Reward	UCRs to Punishment	Intensity of Reward	Intensity of Punishment
Proactive Aggression	.55***	1						
Reward Conditioning	.05	-.08	1					
Punishment Conditioning	-.01	-.04	.50***	1				
UCRs to Reward	.01	-.05	.06	.10 ^a	1			
UCRs to Punishment	.05	.05	-.02	.09	.58***	1		
Intensity of Reward	.14*	.07	.06	.06	.08	.07	1	
Intensity of Punishment	.18**	.20***	-.01	.01	-.01	.03	.17**	1
Mean	2.31	0.83	0.05	0.04	0.51	0.40	5.79	3.19
S.D.	1.03	0.98	0.32	0.28	0.32	0.33	1.60	1.80
Min	0	0	-1.23	-1.12	0	0	1	1
Max	18	11	1.03	1.02	1.88	1.83	7	7
Skewness	0.55	2.16	-0.29	-0.08	0.36	0.68	0.74	-1.27

Note.

* $p < .05$,

**

* $p < .01$,

* $p < .001$,^a $p < .10$.

Table 2
Hierarchical Regression Analyses Predicting Reactive and Proactive Aggression

	Reactive Aggression				Proactive Aggression			
	β	SE	R ²	Step 1	β	SE	R ²	Step 2
<i>Step 1</i>			0.32***				0.31***	
Proactive Aggression	0.55***	0.05		Reactive Aggression	0.56***	0.05		
Sex	-0.18 ^a	0.10		-				
<i>Step 2</i>			-	<i>Step 2</i>			0.01*	
Proactive Aggression	-	-		Reactive Aggression	0.56***	0.05		
Sex	-	-		-				
Reward Conditioning	-	-		Reward Conditioning	-0.11*	0.15		
Punishment Conditioning	-	-		Punishment Conditioning	-	-		

Note.

* $p < .05$,

** $p < .01$,

*** $p < .001$,

^a $p < .10$.