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Risk taking differences on a behavioral task as a function of potential reward/loss magnitude and individual differences in impulsivity and sensation seeking

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ABSTRACT

Although previous studies have shown that the Balloon Analogue Risk Task (BART; [Lejuez, C.W., Read, J.P., Kahler, C.W., Richards, J.B., Ramsey, S.E., Stuart, G.L., et al. (2002). Evaluation of a Behavioral Measure of Risk Taking: The Balloon Analogue Risk Test (BART). J Exp Psychol, Appl, 8, 75–84.; Lejuez, C., Aklin, W., Jones, H., Richards, J., Strong, D., Kahler, C.W., et al. (2003a). The Balloon Analogue Risk Task (BART) Differentiates Smokers and Nonsmokers. Exp Clin Psychopharmacol, 11, 26–33.; Lejuez, C., Aklin, W., Zvolensky, M., & Pedulla, C. (2003b). Evaluation of the Balloon Analogue Risk Task (BART) as a Predictor of Adolescent Real-world Risk-taking Behaviors. J Adolesc, 26, 475–479.]) can be used to index real-world risk-taking behavior, questions remain regarding how performance on the task may vary as a function of reward/loss value and how this relationship may differ as a function of relevant personality traits. The present study examined BART score at 1, 5, and 25 cents per pump and how this relationship differed at low and high levels of impulsivity and sensation seeking. Results indicated that riskiness on the BART decreased as reward/loss magnitude increased. Further, this decrease was most prominent in those low in Impulsivity/Sensation Seeking, whereas those high in Impulsivity/Sensation Seeking were largely insensitive to variation in reward/loss magnitude. Findings are discussed in terms of sensitivity to reward and loss, and how these processes can be studied further using the BART including extensions to cognitive modeling and the measurement of neurobehavioral functioning.

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Although risk-taking behaviors have been defined in a variety of ways (Byrnes, 1998; Jessor, 1998; Lopes, 1987; Zuckerman, 1994a,b), most definitions focus on the opportunity to gain some form of reward with a corresponding potential for loss, danger, and/or harm (Leigh, 1999). Based on such definitions, public health research traditionally has focused on behaviors including substance use, criminal activity, and unsafe sexual practices (Bronfenbrenner et al., 1996; Centers for Disease Control and Prevention [CDC], 2002; Nation et al., 2003; Weissberg et al., 2003). Despite important advances, questions remain as to the best strategies for prevention and treatment of risk taking (Nation et al., 2003). As such, it is important to elucidate the basic behavioral processes underlying the development and maintenance of risk-taking behaviors. One approach for addressing these goals is the development of reliable and valid tasks that can be used to study risk taking behavior in the laboratory.

Towards this end, there are several useful risk taking assessment tasks, such as the Iowa Gambling Task (IGT; Bechara et al., 2001). However, the IGT focuses on poor decision making by providing a choice between: a) a "risky" option that involves the opportunity for gain but also the potential for even greater penalty resulting in a long-term net loss; or b) a safe option where a smaller gain is available, but with the potential for an even smaller penalty resulting in a long-term net gain. As such, the "risky" option also is the disadvantageous option and therefore should be avoided. Although understanding the poor decision making process that often underlies risk behavior is of great importance, the task does not address the consideration of risk taking along a continuum in which some level of risk is adaptive, but more excessive levels produce deleterious consequences.

Taking a slightly different approach, we have developed the Balloon Analogue Risk Task (BART; Lejuez et al., 2002), which is a computerized task that creates a laboratory-based, ecologically valid risk-taking scenario. In this task, the participant accumulates money in a temporary bank by pressing a button that inflates a simulated balloon on the computer screen. There are a set number of balloons and each balloon has an explosion point, with a corresponding loss of all money accrued in

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the temporary bank. After each successful pump (i.e., one that does not result in an explosion), the participant has the option of pressing a "collect" button that will transfer the money accrued in the temporary bank to a permanent bank. Thus, the BART provides a sequential assessment of risk taking (Wallsten et al., 2005), where with every pump the participant must balance the potential gain of accruing more money against the potential risk of losing all money accrued for that balloon. Therefore, instead of learning to identify and making the decision to avoid the "risky" option as with tasks such as the IGT, the participant must balance gain and potential loss of already acquired gains in deciding to make each pump.

Performance on the BART has been shown to correlate with self-reported addictive, health, and safety risk behaviors in younger adults and adolescents; performance on the task accounts for variance in these behaviors beyond that accounted for by demographics and self-report measures of risk-related constructs (Lejuez et al., 2002, 2003a,b, 2007). In addition to identifying individuals most likely to take real-world risks, tasks such as the BART can be useful for understanding the multiple determinants of risk-taking behavior. One such determinant involves magnitude of rewards and losses by focusing on the magnitude of reward (i.e., cents available per pump within the task). Manipulating magnitude allows the task to be used to examine whether a participant is focused on the potential gain, potential loss of accrued earnings, or the ratio of the two. Consider the comparison of two balloons: a balloon where each pump is worth 1 cent versus a balloon where each pump is worth 25 cents. This difference results in 24 more cents for any individual pump on the latter balloon, but also the potential loss of 24 more accrued cents, with this difference doubling with each subsequent pump. For example, by the tenth pump there is a potential loss of 10 accrued cents on the 1 cent per pump balloon compared to the potential loss of $2.50 on the 25 cents per pump balloon.

In determining how individuals respond to reward/loss magnitude, it is useful to consider aspects of prospect theory that suggest that losses may influence behavior more than gains (e.g., Tversky and Kahneman, 1981). Following the logic of this theoretical framework, it would be hypothesized that most participants would pump less on balloons with greater magnitude because they would be more driven by potential losses, compared to gains or even the ratio of the two. In considering this hypothesis, however, it is important to factor in how individual differences may influence response to increasing reward/loss magnitude. Two individual difference variables that may moderate the response to reward/loss magnitude are impulsivity (Eysenck et al., 1985) and sensation seeking (Zuckerman et al., 1978). In a study using a different behavioral task (Iowa Gambling Task), Bechara et al. (1999, 2002) provide preliminary evidence that impulsive and risky decision makers are indeed less sensitive to negative consequences, as evidenced by attenuated physiological responses when making high risk decisions on a gambling task. Further, self-report data suggest that high sensation seekers tend to appraise risk as lower than do low sensation seekers (Horvath and Zuckerman, 1993). As such, it is reasonable to propose that individuals low in these traits would be more focused on loss, whereas among individuals high on these traits, attention and sensitivity to loss should be attenuated.

Taken together, the present study investigated differences in risk taking on the BART as a function of reward/loss magnitude at 1, 5 and 25 cents per pump. Despite the fact that the ratio of gains to potential losses was the same across each magnitude, we hypothesized that behavior would be driven by losses such that pumps on the BART would decrease as a function of increased cents per pump. Further, we hypothesized that a composite of impulsivity and sensation seeking would moderate this relationship, such that the decrease would be most clearly evident among those low in impulsivity and sensation seeking. Although the research literature outlined above has identified those high in impulsivity and sensation seeking to be less sensitive to loss, few studies specifically have examined sensitivity to gain for these individuals. As such, we had no a priori hypothesis as to whether pumps for this group would remain constant or increase at higher magnitudes.

1. Method

1.1. Participants

Participants were forty gender balanced undergraduate college students (ages 18–21; $M=19.8$; $SD=1.3$) recruited from elective Psychology courses at Allegheny College in Meadville, PA. Eighty-eight percent were Caucasian. To obtain a range of scores, advertisements were not targeted to over-recruit risky, impulsive, or sensation seeking participants, but the advertisement did mention that participation would include completion of a computer game and their performance on that game would influence the amount of study compensation. Each participant signed a consent form prior to beginning the experiment. Details regarding compensation for participation are provided in the procedure section below.

1.2. Measures

1.2.1. Balloon Analogue Risk Task (BART; Lejuez et al., 2002)

To assess risk taking, we administered the Balloon Analogue Risk Task (BART), which has been used to describe currently occurring risk behaviors in young adults and adolescents (Lejuez et al., 2002, 2003a, b, 2007). Specifically, the task is presented on a computer screen which includes a small simulated balloon accompanied by a balloon pump, a reset button labeled "Collect $," a permanent money earned display labeled "Total Earned," a second display listing the money earned on the last balloon and labeled "Last Balloon," and a third display presenting the current balloon's reward/loss magnitude labeled "$ per pump." Each click on the pump inflated the balloon one degree (about .125" in all directions). With each pump, an amount of money (see below) was accrued in a temporary reserve (the amount of money in this reserve is never indicated to the participant). When a balloon was pumped past its individual explosion point, a "pop" sound effect was generated from the computer. Modeling real-world situations in which excessive risk often results in diminishing returns and increasing health and safety threats, each successive pump on any particular balloon trial (a) increased the amount to be lost due to an explosion and (b) decreased the relative gain of any additional pump. The explosion points were determined before each session in a semi-random fashion. Specifically, the computer drew a random distribution of 30 explosion points and continued to draw additional distributions until one included an average explosion point of 64 for the 10 balloons at each magnitude and therefore across all 30 balloons. This was done to ensure equal distributions across magnitude.

When a balloon exploded, all money in the temporary bank was lost and the next un-inflated balloon appeared on the screen. At any point during each balloon trial, the participant could stop pumping the balloon and click the "Collect $" button. Clicking this button would transfer all money from the temporary bank to the permanent bank, during which the new total earned would be incrementally updated cent by cent while a slot machine payoff sound effect played. After each balloon explosion or money collection, the participant's exposure to that balloon ended, and a new balloon appeared until a total of 30 balloons (i.e., trials) had been completed.

In the current study, reward/loss magnitude was varied across the following values: 1 cent, 5 cents, and 25 cents. Each participant encountered ten balloons of each per pump payout value. The 30 total balloons were presented in a randomly computer-generated order to each participant. Because of the high potential payout for the 30 balloons, the participants were not paid for each balloon. Instead the participants were informed that they would be paid the average amount earned across each reward value. For example, if a participant exploded five balloons and earned $3.25, $20.00, $15.75, $8.50, and 21.50 on the remaining balloons at the 25 cent magnitude, the payment would be $6.90 for the 25 cent balloon.

1.2.2. Impulsivity and sensation seeking

We utilized both the Impulsivity Subscale of the Eysenck Impulsiveness Scale (Eysenck et al., 1985) and the Zuckerman Sensation Seeking Scale (Zuckerman et al., 1978). To measure impulsivity we administered the 19-item impulsivity subscale of the Eysenck Impulsiveness scale. Each item consists of an impulsivity-related statement, with endorsement scored as a 1 and non-endorsement scored as a 0; possible total score ranged from (0–19). Eysenck et al. (1985) found that the alpha coefficient was .84 for impulsiveness which is consistent across both males and females. The Sensation Seeking Scale is 40-item questionnaire that presents participants with forced choice between two opposite statements to determine seeking of novel and varied experiences. Items on which the sensation seeking statement was endorsed were scored as 1 and endorsement of the opposite choice was scored as a 0, resulting in a possible score range of 0–40. This instrument has excellent psychometric properties (Zuckerman, 1979, 1994a,b). Internal consistency has been shown to range from .83 to .86 for the total score (Zuckerman et al., 1978, 1979). The test–retest reliability at 3 weeks was .94. In addition, evidence of construct and concurrent validity is provided by Zuckerman (1979, 1983, 1984), Zuckerman et al. (1978). The mean value for sensation seeking was 22.95 (SD = 6.68) and the mean value for impulsivity was 10.03 (SD = 5.12). These are very consistent with similar studies in our laboratory investigating risk taking behavior among college student volunteers with an ample range of substance use and other risk behaviors (e.g., Lejuez et al., 2002; sensation seeking M = 24.7; SD = 7.0; impulsivity M = 10.1; SD = 4.6). Additionally, in the current data set, the impulsivity and sensation seeking values fell between scores for smokers and non-smokers in a second relevant study (Lejuez et al., 2003a,b; impulsivity: non-smokers M = 8.4 and smokers M = 11.8; sensation seeking: non-smokers M = 20.8 and smokers M = 26.3).

To create a measure of impulsivity and sensation seeking (i.e., impulsivity/sensation seeking), the impulsivity and sensation seeking scores were combined into a single a score (cf. Zuckerman and Kuhlman, 2000). It should be noted that although comparable in many ways, the composite score is not identical to the original ImpSS measure (Zuckerman and Kuhlman, 2000). Although the correlation between the two scales was moderate (r = .51), a wealth of empirical support suggests that impulsivity and sensation seeking may be considered emergent properties of one underlying approach/avoidance system oriented toward engagement in hedonic behavior (Cloninger, 1987; Depue and Collins, 1999; Gray, 1987; Zuckerman, 1991; Zuckerman and Kuhlman, 2000). In support of the complementary nature of these constructs, empirical evidence identifies impulsivity and sensation seeking as working together in concert to constitute a vulnerability to various risk behaviors (Kopstein et al., 2001; Krueger et al., 2002; Sher et al., 2000; Tarter et al., 2003) and both evidence high correlations with real-world risk behaviors, specifically substance use and misuse (Lejuez et al., 2005; Stephenson et al., 2003) and problem gambling (Zuckerman and McDaniel, 2003).

To calculate Impulsivity/Sensation Seeking, we summed each individual's average score per item for the two scales. Given that the two scales utilized the same scoring options for each item (0 or 1), but had a different number of items (impulsivity subscale contained 19 items and sensation seeking contained 40 items), average score per item were used as opposed to total score to ensure that both scales contributed equally to the resulting composite score. After obtaining a median split on the resulting composite score, we created a high and low group for impulsive sensation seeking (n = 20 in both groups). Within this composite, mean score for impulsivity was 6.4 (SD = 3.9) for the Low Impulsivity/Sensation Seeking group and 13.7 (SD = 3.2) for the High Impulsivity/Sensation Seeking group, while mean score for sensation seeking was 18.3 (SD = 4.9) for the Low Impulsivity/Sensation Seeking group and 27.6 (SD = 4.8) for the High Impulsivity/Sensation Seeking group. Of clinical relevance, the impulsivity and sensation seeking scores of the High Impulsivity/Sensation Seeking group are comparable to that reported above for college student smokers (Lejuez et al., 2003a,b).

2. Procedure

Before starting the BART, the task was thoroughly explained using a visual of the task accompanied by the following directions.

> Throughout the task, you will be presented with 30 balloons, one at a time. For each balloon you can click on the button labeled "Click this Button to Pump Up the Balloon" to increase the size of the balloon. You will accumulate 1 cent, 5 cents, or 25 cents in a temporary bank for each pump depending on what type of balloon comes up. You will not be shown the amount you have accumulated in your temporary bank. At any point, you can stop pumping up the balloon and click on the button labeled "Collect $." Clicking this button will start you on the next balloon and will transfer the accumulated money from your temporary bank to your permanent bank labeled "Total Earned." The amount you earned on the previous balloon is shown in the box labeled "Last Balloon." It is your choice to determine how much to pump up the balloon, but be aware that at some point the balloon will explode. The explosion point varies across balloons, ranging from the first pump to enough pumps to make the balloon fill the entire computer screen. If the balloon explodes before you click on "Collect $," then you move on to the next balloon and all money in your temporary bank is lost. Exploded balloons do not affect the money accumulated in your permanent bank.

Participants were further informed of the payment structure as outlined above. Further, although not mentioned in the instructions, a box on the screen was labeled "$ per pump" and informed participants as to whether a balloon was 1, 5, or 25 cents per pump.

We analyzed the adjusted number of pumps across balloons (i.e., BART score) as the primary dependent measure. This adjusted value, defined as the average number of pumps on balloons that did not explode, is preferable to the unadjusted average because the number of pumps is necessarily constrained on balloons that exploded,

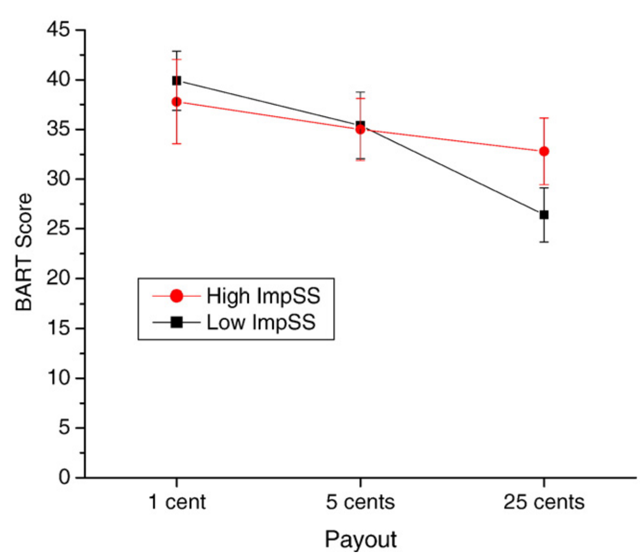

Fig. 1. Riskiness as indexed by BART score as a function of reward/loss magnitude (cents per pump) across groups of low and high Impulsivity/Sensation Seeking. Standard errors of the mean are indicated by vertical bars.

thereby limiting between-participant variability in the unadjusted averages (cf. Lejuez et al., 2002). However, it should be noted that other variables such as number of explosions, maximum number of pumps on a balloon, and unadjusted average number of pumps produced similar findings as those reported below.

3. Results

The demographic variables of age, gender, and family income were not related to any key study variable and therefore were not included in the analyses presented below. As shown in Fig. 1, we examined the effects of reward/loss magnitude as a function of Impulsivity/Sensation Seeking group on the adjusted average number of pumps. Specifically, we conducted a repeated measures ANOVA with magnitude as the within subjects factor and Impulsivity/Sensation Seeking as the between subjects factor. Regarding the primary aim of change in BART score as a function of magnitude, a main effect was evident [$F(2, 37) = 13.44$, $p < .001$; $\eta^2 = .42$]. Follow-up t-tests (setting the p value to .0167 to correct for multiple analyses) suggested that the difference between 1 cent and 5 cents approached but did not achieve statistical significance ($p = .08$), whereas the differences between 5 cents and 25 cents [$t(39) = 4.4$, $p < .001$], as well as 1 cent and 25 cents [$t(39) = 4.0$, $p < .001$] achieved significance, with fewer pumps occurring at 25 cents in each case. No main effect of Impulsivity/Sensation Seeking group was found ($p > .05$).

Qualifying this main effect, a two-way interaction between magnitude × Impulsivity/Sensation Seeking was significant [$F(2, 37) = 4.26$, $p = .022$; $\eta^2 = .19$]. Largely due to the modest sample size, the difference between Impulsivity/Sensation Seeking groups was not significant at any magnitude. However, examining each group separately revealed a difference in the presence of a linear relationship. Specifically, a significant decreasing linear effect was evidenced for low Impulsivity/Sensation Seeking [$F(1, 19) = 33.68$, $p < .001$; $\eta^2 = .64$]. Probing this overall finding (again setting the p value to .0167 to correct for multiple tests), the difference between 1 cent and 5 cents was not significant ($p = .06$), but the difference between 1 cent and 25 cents [$t(19) = 5.8$, $p < .001$], as well as 5 cents and 25 cents [$t(19) = 5.5$, $p < .001$] were significant, with fewer pumps occurring at 25 cents in each case. In contrast, a linear relationship was not evident for the High Impulsivity/Sensation Seeking participants [$F(1, 19) = 1.66$, $p = .213$; $\eta^2 = .08$].

Although Lejuez et al. (2002, 2007) indicate that adjusted average pumps should be used as the main dependent variable for the BART, we also considered examining maximum number of pumps, number of explosions, and earnings. Results were largely identical for maximum number of pumps. Again, a main effect of magnitude was evident [$F(2, 37) = 11.36$, $p < .001$; $\eta^2 = .38$]. Follow-up t-tests (setting the p value to .0167 to correct for multiple analyses) suggested that the difference was significant at all three comparison points (1 cent and 5 cents: $p = .012$; 5 cents and 25 cents: $p = .005$; 1 cent and 25 cents: $p < .001$), with fewer pumps occurring at the higher magnitude in all cases. No main effect of Impulsivity/Sensation Seeking group was found ($p > .05$).

Qualifying this main effect, a two-way interaction between magnitude × Impulsivity/Sensation Seeking was significant [$F(2, 37) = 3.79$, $p = .032$; $\eta^2 = .17$]. Again, largely due to the modest sample size, the difference between Impulsivity/Sensation Seeking group was not significant at any magnitude. However, examining each group separately revealed a difference in the presence of a significant linear relationship. Specifically, a significant decreasing linear effect was evidenced for low Impulsivity/Sensation Seeking [$F(1, 19) = 36.22$, $p < .001$; $\eta^2 = .66$]. Probing this overall finding (again setting the p value to .0167 to correct for multiple tests), the difference between 1 cent and 5 cents was not significant ($p = .03$), but the difference between 1 cent and 25 cents [$t(19) = 4.53$, $p < .001$], as well as 5 cents and 25 cents [$t(19) = 6.01$, $p < .001$] were significant, with fewer pumps occurring at 25 cents in each case. In contrast, a linear relationship was not evident for the High Impulsivity/Sensation Seeking participants [$F(1, 19) = 2.24$, $p = .15$; $\eta^2 = .106$]. The overall main effect for magnitude was evident for explosions ($p < .001$), with number of explosions decreasing at each magnitude. However, the interaction with Impulsivity/Sensation Seeking was not significant, although sample size should be considered as $\eta^2 = .053$. We did not examine money earned as the difference in magnitude prevents meaningful interpretations.

The construct and combined score of Impulsivity/Sensation Seeking was chosen over either individual constructs of impulsivity and sensation seeking for theoretical and empirical reasons outlined in the present paper, but we also analyzed these measures separately in their interaction with magnitude. Beginning with adjusted average number of pumps, the interaction approached significance for impulsivity ($p = .051$) and was nonsignificant for sensation seeking ($p = .23$). Although both evidenced a nontrivial effect size ($\eta^2 = .15$ and .08 respectively), the combination of Impulsivity/Sensation Seeking was a more useful variable than either alone given its significant interaction with magnitude and more robust effect size ($\eta^2 = .19$). Continuing with maximum number of pumps, the interaction approached significance for impulsivity ($p = .057$) and was nonsignificant for sensation seeking ($p = .25$). Although both evidenced a nontrivial effect size ($\eta^2 = .14$ and .07 respectively), the combination of Impulsivity/Sensation Seeking was a more useful variable than either alone given its significant interaction with magnitude and more robust effect size ($\eta^2 = .17$). In line with the findings using Impulsivity/Sensation Seeking together, the interaction for number of explosions was nonsignificant for both impulsivity and sensation seeking separately.

4. Discussion

In the present study we examined the relationship between a) general “riskiness” on the BART and reward/loss magnitude, and b) the personality trait of Impulsivity/Sensation Seeking and reward/loss magnitude as variables that may influence risk-taking behavior. Our findings indicated that overall, the participants were less risky at greater levels of reward/loss magnitude. This finding is consistent with current theories suggesting that decision-making is driven by potential losses, rather than gains or the ratio of the two (Tversky and Kahneman, 1981). Our findings also indicated that Impulsivity/Sensation Seeking moderated the effect of reward magnitude on BART score, with those low in Impulsivity/Sensation Seeking being even more risk averse at higher magnitudes, and largely no change for those high in Impulsivity/Sensation Seeking. These results suggest that compared to those low in Impulsivity/Sensation Seeking, individuals high in Impulsivity/Sensation Seeking are either less sensitive to potential loss, or alternatively, have a relatively balanced sensitivity to both losses and gains. The design of the current study does not allow us to differentiate between these two competing hypotheses, and future investigations will benefit from attempting to disentangle the precise process underlying the stability of responding among this subset of participants.

These findings should be considered in light of key limitations of the current design. The primary limitations concern the modest sample size and our use of a sample consisting of primarily Caucasian college students. The use of this sample limits generalizability to more diverse and perhaps more clinically impaired groups; however, it is also worth noting that college students are a group for which risk taking activities are highly accessible and potentially problematic. Because of the newfound freedom of adulthood and campus life, risky behavior such as gambling, unsafe sexual practices, and drug abuse are salient concerns (Patrick et al., 1997). As such, the current sample serves as both a strength and a limitation. As a second limitation, the current study utilized an analogue measure of risk-taking (which is admittedly easier to manipulate), but did not collect information on “real-world” risk-taking. It would be of both theoretical interest and clinical relevance to examine whether the current results "hold" when considering actual risk-taking behavior, such as gambling, or examine the relationship of the risk-taking slope across reward/loss magnitude to other real-world risk behaviors. A third limitation involves measurement, including shortcomings in how we created groups in the current study. Beyond issues related to combining impulsivity and sensation seeking into a single measure, a constraint of the Impulsivity/Sensation Seeking measure is that it serves as an incomplete measure of risk-seeking and risk-"averseness". That is, although the Impulsivity/Sensation Seeking scale focuses on action without planning and inattention to potential harm (Zuckerman and Kuhlman, 2000), it does not take other dimensions of risk approach or avoidance into account (e.g., other aspects of impulsivity such as delay discounting and behavioral inhibition) and in this respect, might be considered an incomplete measurement device for identifying risk-seeking versus risk-averse individuals. Clearly, more sophisticated measurement and sampling strategies are necessary in order to validate the relationships identified in the current study, and multiple studies have argued for measurement techniques that can compensate for the multi-dimensional nature of measurement of risk-proneness (Leigh, 1999). Such strategies would need to fully encompass all aspects involved in identifying an individual as risk-seeking or risk-averse in order to expand the applicability of the results.

Despite the limitations, the current study provides an initial step in understanding the relationship between personality, reward/loss magnitude, and risk-taking behavior. These results set the stage for additional behavioral research extending this work to more diverse sample including more impaired samples such as individuals presenting with substance use disorders. Moreover, this work would benefit from the development of cognitive models (e.g., Busemeyer and Stout, 2002; Wallsten et al., 2005) and neurobehavioral assessment to determine the extent to which increased reward/loss magnitude is represented in differential neurobehavioral functioning across key brain regions (e.g., subcortical including nucleus accumbens and prefrontal including orbital frontal cortex; Galvan et al., 2006), which may help address issues raised above regarding the difficulty of separating out the independent contribution of reward and loss. Such extensions would add explanation to the current descriptive results and increase the precision with which these more basic findings can be applied to understanding and intervening with real world risk behavior.

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