

The Balloon Analogue Risk Task (BART) Differentiates Smokers and Nonsmokers

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In trying to better understand why individuals begin and continue to smoke despite the obvious health consequences, researchers have become interested in identifying relevant personality variables, such as risk taking. In this study, the authors compared the ability of 2 behavioral measures of risk taking, the Bechara Gambling Task (BGT) and the Balloon Analogue Risk Task (BART), to differentiate smokers and nonsmokers. Self-report measures of impulsivity and sensation seeking were taken for comparison with the 2 behavioral risk-taking tasks. Results indicate that behavior on the BART, and not the BGT, was related to smoking status. Further, when considered in a logistic regression analysis, only the Sensation Seeking total score and the BART score contributed uniquely to the differentiation of smokers and nonsmokers.

Cigarette smoking remains the leading preventable cause of death and disability in the United States (Centers for Disease Control and Prevention [CDC], 1998). Almost one third of all deaths from cancer in the United States each year (about 173,000) are directly caused by tobacco use (American Cancer Society, 1999). Despite the fact that most individuals are aware of the dangers of cigarette smoking, both adults and adolescents continue to smoke at a high rate (CDC, 1999a; Johnston, O'Malley, & Bachman, 1994).

Researchers have become interested in identifying relevant personality variables that may either contribute to or co-occur with risky behaviors such as smoking, thus possibly facilitating early identification and intervention (Gilbert, Crauthers, Mooney, McClernon, & Jensen, 1999). One such personality construct is risk taking. *Risk taking* may be defined as the engagement in a behavior that involves the potential for gain balanced by the potential of negative consequences resulting from that behavior (cf. Jessor,

1998), and, thus, risk taking appears to map onto smoking and other deleterious health behaviors quite well. Data support this theoretical association, as individuals who smoke also are more likely to engage in other risk-taking behaviors compared with nonsmokers. For example, daily smokers are more likely to be involved in traffic accidents than nonsmokers (DiFranza, Winters, Goldberg, Cirillo, & Bilioris, 1986), less likely to wear their seat belts than nonsmokers (Eiser, Sutton, & Wober, 1979), tend to choose riskier occupations than nonsmokers (Hersch & Viscusi, 1998), may engage in more high-risk sexual behaviors than nonsmokers (Valois, 1999), and are more likely to use other substances, including alcohol and marijuana, than nonsmokers (Coogan, 1998). Taken together, it appears that a better understanding of risk taking might shed light on why individuals smoke despite the clear negative consequences.

Although seemingly related, risk-taking tendencies appear to be differentiable from other facets of disinhibition/undercontrol, such as impulsivity or novelty/sensation seeking (Eysenck & Eysenck, 1977), and have distinct paths in conveying risk of engaging in substance use behaviors (Wills, Sandy, & Yaeger, 2002). These differences have implications for measurement approaches. Whereas other facets of disinhibition/undercontrol may be tapped using well-established self-report measures, there are several challenges to the development of a self-report assessment of risk-taking propensity. First, the veracity of self-report may be limited by any perceived negative consequences of reporting risky behavior. In addition, some respondents may lack the insight or ability to provide an accurate report of their own behavior (e.g., Ladouceur et al., 2000). Further, as these instruments often rely on questions that directly query about the behavior under question, such measures are considerably less useful in a prevention context when attempting to predict the emergence of new risk behaviors (Andrew

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& Cronin, 1997; Greene, Krcmar, Walters, Rubin, & Hale, 2000). Perhaps the greatest limitation of self-report measures is that they cannot readily be used to examine moment-to-moment effects of particular manipulations thought to affect risk taking (e.g., stress; administration of psychoactive drugs, such as alcohol or stimulants).

Given the shortcomings of relying solely on self-report measures to assess risk taking and the utility of more recent laboratory procedures tapping related constructs, such as delay discounting, in differentiating smokers and nonsmokers (Bickel, Odum, & Madden, 1999; Mitchell, 1999), behavioral measures provide a promising complementary assessment strategy. The most commonly used behavioral measure is the Bechara Gambling Task (BGT; Bechara, Damasio, Damasio, & Anderson, 1994). The BGT originally was developed to assess decision-making processes resulting from neuropsychological impairment (e.g., Bechara et al., 1994; Rogers et al., 1999). More recent research has focused on differentiating typologies of individuals who engage in substance abuse. These studies have provided evidence suggesting that drug-abusing individuals may be more risky than non-drug-abusing individuals on the BGT (Bechara et al., 2001; Petry, 2001; Petry, Bickel, & Arnett, 1998).

In the BGT, the participant is provided with four decks of cards on a computer screen. Using a mouse, the participant clicks on any of the four decks. After each selection, the computer provides feedback indicating the amount of money the participant has won and lost on that card as well as a grand total. Following this feedback, the participant can select another card. For cards from two of the decks (A and B), the winnings are high but the losses are even higher. In contrast, for cards from the other two decks (C and D), the winnings are somewhat low but the losses are even lower. Thus, according to Bechara et al. (2001), Decks A and B are disadvantageous, whereas Decks C and D are advantageous. When used to determine the likelihood of individuals' engagement in real-world risk behaviors, such as problematic substance use, it is expected that risk-prone individuals will select more cards from the disadvantageous decks than the advantageous decks.

Taking a somewhat different approach, we have developed the Balloon Analogue Risk Task (BART; Lejuez et al., 2002). In this task, participants accumulate money in a temporary bank by pressing a button that inflates a simulated balloon. Each balloon has an explosion point, which if reached, results in the loss of all money in the temporary bank. After each pump that does not result in an explosion, participants have the option of pressing a collect button that will transfer their money to a permanent bank. There is a set number of balloons, and regardless of whether the balloon explodes or money is collected, the participant moves on to the next balloon. Therefore, in deciding whether to make each pump, the participant must balance the potential gain of accruing more money against the potential risk of losing all money accrued for that balloon. Thus, unlike the BGT, in which each trial involves a choice between a risky and a nonrisky alternative (i.e., card selection), the BART involves a variable number of choices in a context of increas-

ing risk (i.e., the amount of money accrued and the probability of losing that money increase with each pump of the balloon). An initial study has shown riskiness on the BART to be associated with the occurrence of real-world risk behaviors, including smoking, even beyond that provided by self-report measures of risk-related constructs, including impulsivity and sensation seeking (Lejuez et al., 2002). However, the performance of the task has not been compared directly with other behavioral laboratory measures of risk taking, such as the BGT.

The purpose of the current study was to compare smokers and nonsmokers on two behavioral risk-taking tasks and self-report measures of impulsivity and sensation seeking. Following up on the hypothesized link between risk-taking propensity and smoking, we expected that smokers would evidence increased risk taking on the BART and the BGT. Further, although we also expected smokers to evidence higher levels of impulsivity and sensation seeking than nonsmokers, we hypothesized that risk-taking differences on the behavioral tasks would account for variance in smoking status in addition to that accounted for by the self-report measures.

Method

Participants

Sixty undergraduate students ranging between 18 and 30 years of age ($M = 20.1$, $SD = 2.8$) were recruited using both the University of Maryland introductory psychology participant pool and advertisements posted throughout campus. Half of the advertisements specifically requested current daily smokers to increase the number of smokers in the sample. Within the smoker ($n = 26$) and nonsmoker ($n = 34$) groups, the sample was stratified by gender to ensure an equal number of male and female participants in each group. Sixty-eight percent were Caucasian, 13 % were Asian American, and 12 % were African American (the remaining 7% marked "other" on the demographics form). All of the participants were native English speakers and had no prior knowledge of the experimental procedures. Each participant signed a consent form prior to the beginning of the experiment.

Materials

Demographics

In addition to assessing age, gender, and parental income, we also administered the original version of the vocabulary section of the Shipley Institute of Living Scale (Shipley, 1940; Shipley & Burlingame, 1941). This section consists of 40 multiple-choice words for which the respondent must choose the best synonym. Scores on this measure are significantly correlated with the Wechsler Adult Intelligence Scale—Revised (WAIS-R; Wechsler, 1981), a standardized test of IQ. For example, Zachary, Crumpton, and Spiegel (1985) found a correlation of .87 with the full-scale WAIS-R, and Weiss and Schell (1991) found a correlation of .86. Test-retest reliability for this measure over a 2-week period has been established ($r = .77$; Ruiz & Krauss, 1967).

Smoking Status

To acquire information regarding current smoking status and other smoking-related variables (e.g., number of previous quit

attempts, daily number of cigarettes consumed, age of smoking onset), a smoking history questionnaire was administered. Individuals who smoked at least one cigarette per day over the past 6 months were classified as daily smokers, and individuals with no history of daily smoking were classified as nonsmokers. Individuals who were currently not smoking but had a previous history of daily smoking were not included in the study.

Self-Report Predictors of Smoking Status

To measure a propensity to engage in impulsive behavior, participants completed the Impulsivity subscale of the Eysenck Impulsiveness Scale—V (Eysenck, Pearson, Easting, & Allsopp, 1985). The 19-item subscale (scores range from 0 to 19, with higher scores indicating higher levels of impulsivity) has good internal consistency with an alpha coefficient equaling .84 (Eysenck et al., 1985). To assess the seeking of varied, novel, complex, and intense situations and experiences, and the willingness to take physical, social, and financial risks for the sake of such experiences (Zuckerman, 1994), we had participants complete the Sensation Seeking Scale (Zuckerman, Eysenck, & Eysenck, 1978). The 40-item measure (scores range from 0 to 40, with higher scores indicating higher levels of sensation seeking) has good internal consistency with alpha coefficients above .80 for both males and females (Zuckerman, 1994; Zuckerman et al., 1978).

Behavioral Predictors of Smoking Status

In addition to the self-report measures above, we also used the following behavioral measures:

BART. At the start of the BART, the computer screen displayed four items: a small balloon accompanied by a balloon pump, a reset button labeled *Collect \$\$\$*, a *Total Earned* display, and a second display labeled *Last Balloon* that listed the money earned on the last balloon.

Each click on the pump inflated the balloon 1° (about .125 in. [about .32 cm] in all directions). With each pump, money (\$.05 per pump) was accumulated in a temporary bank, the holdings of which were never indicated to the participant. When a balloon was pumped past its individual explosion point, a “pop” sound effect was generated by the computer. When a balloon exploded, all money in the temporary bank was lost, and the next uninflated balloon appeared on the screen. At any point during each balloon trial, a participant could stop pumping the balloon and click the “Collect \$\$\$” button. Clicking this button transferred all money from the temporary bank to the permanent bank, at which time the new total earned would be incrementally updated while a slot machine payoff sound played to confirm payment.

A new balloon appeared after each balloon explosion or money collection until a total of 30 balloons (i.e., trials) were completed. The probability that a balloon would explode was fixed at 1/128 for the first pump. If the balloon did not explode after the first pump, the probability that the balloon would explode was 1/127 on the second pump, 1/126 on the third pump, and so on, until the 128th pump at which point the probability of an explosion was 1/1 (i.e., 100%). According to this algorithm, the average explosion point was 64 pumps. Modeling real-world situations in which excessive risk often produces diminishing returns and increasing threats to one’s health and safety, 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. For example, after the first pump, the next pump risked only the \$.05 accrued in the temporary bank and increased the possible earnings on that balloon by 100%; yet after the 30th pump, the next

pump risked \$3 accrued in the temporary bank and increased possible earnings on that balloon trial only by 1.6%. Detailed instructions provided to the participant were based on those provided by Lejuez et al. (2002, pp. 78–79), yet it is important to note that participants were given no precise information about the probability of explosion. Specifically, they were told the following: “It is your choice to determine how much to pump up the balloon, but be aware that at some point the balloon will explode.” Further, they were informed that “the explosion point varies across balloons, ranging from the first pump to enough pumps to make the balloon fill the entire computer screen.” In a previous study, participants were paid the exact amount of their earnings. However, because it was not feasible to pay participants their exact earnings on the other behavioral task (i.e., the BGT), such a strategy was not used here. Further details regarding payment for participation is provided in the *Procedure* section.

Although there are several potential dependent measures, we analyzed the adjusted number of pumps across balloons (i.e., BART score). 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, 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.

BGT. At the start of this task, participants were provided with four decks of cards on a computer screen. As described by Bechara et al. (2001), the decks were labeled A, B, C, and D at the top end of each deck. Each deck was programmed to have 60 cards, and participants continued until 100 cards were selected. Participants were not told how many cards were in each deck. The backs of the cards were all identical, and all cards provided different hypothetical payoffs and losses. Using a mouse, participants clicked on a card from any of the four decks. Once a card was selected, the computer emulated a sound similar to that of a slot machine, at which point the card turned black, the amount won was indicated, and the total earnings were updated on a status bar on the top of the screen. If a loss was not programmed for that card, the participants moved on to selecting the next card. However, if a loss was programmed, the computer then emulated a sound similar to that of a buzzer, at which point the card turned red, the amount lost was indicated, and the total earnings were updated on a status bar on the top of the screen. Following this feedback, the participants moved on to selecting the next card.

Cards from Decks A and B paid an average of \$100, and cards from Decks C and D paid an average of \$50. As outlined above, on some cards participants both won money and lost money. Specifically, Deck A included losses on 50% of the first 10 cards from that deck, with a 10% increase in frequency for each subsequent set of 10 cards from that deck (e.g., 6 losses from Cards 11–20 selected from Deck A). Losses on Deck A were moderate in amount, ranging between –\$150 and –\$350. Deck B included losses on 10% of all the cards chosen from that deck. Although infrequent, losses were large beginning at –\$1,250 and incremented by –\$250 with each subsequent loss (e.g., the second loss was –\$1,500, and so forth). For both of these decks, losses outweighed gains and, therefore, these decks were considered disadvantageous (Bechara et al., 2001). The frequency of losses was the same for Deck C as described for Deck A, but the amount of the losses was considerably smaller, ranging between –\$25 and –\$75. The frequency of losses was the same for Deck D as described for Deck B, but the amount of the losses was consider-

ably smaller, starting at $-\$275$ and incremented by $-\$25$ with each subsequent loss (e.g., the second loss was $-\$300$, and so forth). For both Decks C and D, the gains outweighed losses and, therefore, these decks were considered advantageous (Bechara et al., 2001). Thus, although considering only the gains for the decks would lead one to prefer Decks A and B, Decks C and D were in the participant's long-term best interest when the associated losses are taken into account. The dependent measure (i.e., BGT score) was percentage of cards selected from Decks A and B (i.e., the disadvantageous decks), with lower scores indicating less risky behavior and higher scores indicating more risky behavior.

Apparatus

Sessions were conducted in a 12 ft $\times$ 8 ft (approximately 3.66 $\times$ 2.44 m) experimental room at the University of Maryland. Participants sat at a desk with a Dell Pentium computer, a 17-in. (43.18-cm) color monitor, a keyboard, and a mouse.

Procedure

After completing the questionnaires, participants were exposed to three separate administrations of the BART and the BGT. For half of the participants in the smoker and nonsmoker groups, the order consisted of BART, BGT, BART, BGT, BART, and BGT. For the remaining half of the participants, the order was reversed.

Regarding payment, participants were told their hypothetical earnings on each administration of each task would be averaged to create a total BART score and a total BGT score. Next, they were informed that their total scores would be compared with total scores from others who had completed the tasks in previous experiments, and that for each task a total score in the bottom third earned \$5, a total score in the middle third earned \$10, and a total score in the top third earned \$15. Combining the payouts for the two tasks, earnings could range from \$10 to \$30. Finally, they were informed that payment would be made in cash immediately after the conclusion of the session. Because scores on both tasks were reflected in hypothetical dollar amounts, we attempted to avoid confusion by stressing that the dollar amounts earned on the tasks were hypothetical and would result in an actual payment in accordance with the schedule described above. Because there was no actual database of scores for comparison, all participants completing the study were told that they scored in the middle third on

both tasks and were then paid \$20 (\$10 for the BART and \$10 for the BGT) at the end of each session. We used this monetary reward system because it appeared to be a feasible strategy to increase the likelihood that participants would put forth consistent and representative effort on both tasks.

Results

The first column of data in Table 1 provides means and standard deviations for the self-report measures and each administration of the BART and the BGT. As shown in the top panel of Figure 1, smokers scored higher than nonsmokers on the Eysenck Impulsivity subscale, $F(1, 58) = 4.9$, $p < .05$, and the Sensation Seeking Scale, $F(1, 58) = 13.0$, $p < .01$. As shown in the middle panel of Figure 1, examination of BART data indicated a main effect of smoking status, $F(1, 58) = 9.3$, $p < .01$, with smokers scoring higher than nonsmokers across all administrations of the BART. In addition, a main effect of repeated task administration over time was significant, $F(2, 57) = 9.8$, $p < .01$, indicating that individuals became increasingly risky with each additional exposure to the BART. An interaction between smoking status and repeated task administration over time was not found ($p = .34$). Although the BART was conducted using 30 balloons, it should be noted that almost identical results were found using only the first 10 balloons of each administration, with smokers producing higher BART scores than nonsmokers in each case ($p < .01$ across each of the three administrations). Examining earnings as opposed to BART scores also produced similar results. Specifically, a comparison of earnings across each administration of the BART for smokers (\$37.30, \$40.74, and \$41.29, respectively) and nonsmokers (\$33.24, \$36.51, and \$38.72, respectively) evidenced a main effect of smoking status, $F(1, 58) = 5.4$, $p < .05$, and repeated task administration over time, $F(2, 57) = 18.9$, $p < .01$, but no interaction ($p = .52$).

As shown in the bottom panel of Figure 1, examination of BGT data indicated no main effect of smoking status ($p = .33$) and a negative effect of repeated task administration

Table 1
Means, Standard Deviations, and Intercorrelations Among Each of the Independent and Dependent Variables

Variable	M	SD	1	2	3	4	5	6	7	8	9	10
1. Smoke (y/n)			—	.28*	.43**	.36**	.39**	.27*	-.06	.20	.12	.00
2. E-Imp	9.6	4.8		—	.58**	-.06	.01	.06	.11	.01	.02	-.10
3. SSS	23.2	6.4			—	.06	.13	.16	-.12	-.21	-.04	.13
4. BART 1	37.6	11.9				—	.79**	.62**	-.11	.12	-.01	.32**
5. BART 2	39.8	11.8					—	.82**	-.08	.07	-.09	.23
6. BART 3	42.1	11.8						—	-.04	.00	-.08	.24
7. BGT 1	45.5	13.4							—	.58**	.57**	-.32**
8. BGT 2	33.9	22.1								—	.61**	-.24
9. BGT 3	27.9	20.9									—	-.34**
10. Gender												—

Note. Smoke (y/n) = nonsmoker (scored as 0) or daily smoker (> 1 cigarette/day; scored as 1); E-Imp = Impulsivity subscale scores on the Eysenck Impulsiveness Scale; SSS = total score on the Sensation Seeking Scale; BART 1, 2, and 3 = adjusted average number of pumps on the Balloon Analogue Risk Task (BART) across the respective administrations; Bechara Gambling Task (BGT) 1, 2, and 3 = percentage of choices of the disadvantageous deck across the respective administrations. For gender, male is scored as 1, and female is scored as 0.

* $p < .05$. ** $p < .01$.

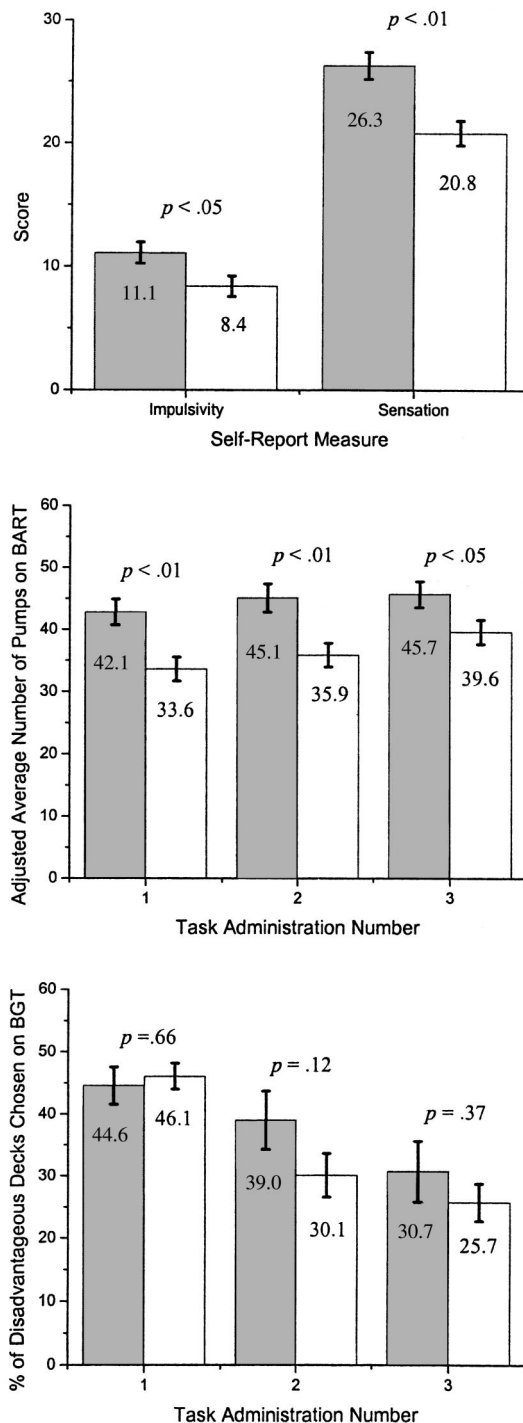


Figure 1. Differences between smokers and nonsmokers on self-report measures, including the Eysenck Impulsivity subscale of the Eysenck Impulsiveness Scale (Impulsivity) and the Sensation Seeking Scale (Sensation), as well as behavioral tasks including the Balloon Analogue Risk Task (BART) and the Bechara Gambling Task (BGT). Smokers are indicated by shaded columns and nonsmokers by open columns. Means and significance values comparing smokers and nonsmokers are provided, along with vertical bars indicating standard error of the mean.

over time, $F(2, 57) = 27.8$, $p < .01$, indicating that individuals became less risky with additional exposures to the BGT. Although it approached significance, an interaction between smoking status and BGT score was not found ($p = .07$). Examining earnings as opposed to BGT scores produced similar results. Specifically, a comparison of earnings for smokers ($-\$795$, $\$996$, and $\$1,602$, respectively) and nonsmokers ($-\$438$, $\$244$, and $\$1,099$, respectively) evidenced no main effect of smoking status ($p = .46$), but a main effect of repeated task administration over time, $F(2, 57) = 29.0$, $p < .01$. Similar to BGT scores, the interaction of smoking status and repeated task administration over time approached, but did not achieve, significance ($p = .09$).

Intercorrelations among smoking status, the self-report measures, the behavioral tasks, and gender are shown in Table 1. Age, parental income, and IQ were not correlated with any of the above measures and, therefore, are not included in the table. The Eysenck Impulsivity subscale score, Sensation Seeking Scale total score, and BART scores on each administration were correlated with smoking status, such that smokers had higher scores on these measures than nonsmokers. Scores on each BGT administration and gender were not related to smoking status. The Sensation Seeking Scale total score and Eysenck Impulsivity subscale score were not significantly related to scores on the behavioral measures. Similar relationships, at a slightly lower magnitude, were found when the scores on these measures were correlated with number of cigarettes smoked.

To examine the unique contributions of each of the variables in differentiating smokers and nonsmokers, we conducted a forward logistic regression using a probability value of .05 to enter the model. In doing so, we chose to use the first administration of the BART (i.e., BART1) and the BGT (i.e., BGT1) because the most likely use of these tasks would involve a single administration and also because the findings using this first administration were similar to those that would have been found if the other administrations were used instead. Given the difference in the range of scores across these measures, we converted all scales to standardized z scores for ease of interpretation.

In the final logistic model, only the BART1 score and the Sensation Seeking Scale total score were included, $\chi^2(2, N = 60) = 23.1$; $p < .01$. Specifically, the higher BART1 score ($B = 1.12$, $SE = 0.37$, odds ratio [OR] = 3.06, $p < .01$) and the Sensation Seeking Scale total score ($B = 1.30$, $SE = 0.41$, OR = 3.66, $p < .01$) were associated with greater odds of being a smoker.

In addition to smoking status, we also collected data on *polydrug use* (e.g., Babor et al., 1992; Grant, Contoreggi, & London, 2000; Lejuez et al., 2002), defined as number of drug classes tried over the past 12 months across the following categories: (a) marijuana, (b) stimulants, (c) cocaine, (d) hallucinogens, (e) opiates, (f) sedatives, and (g) other, including designer drugs such as MDMA. Smokers in the sample were found to have tried a higher number of drug classes than nonsmokers ($M = 2.4$ and $SD = 1.9$ for smokers; $M = 0.7$ and $SD = 0.9$ for nonsmokers). Further, the Eysenck Impulsivity subscale

score ($r = .26, p < .05$), the Sensation Seeking Scale total score ($r = .37, p < .01$), and the BART1 score ($r = .27, p < .05$) were correlated with number of drug classes tried; a relationship between number of drug classes tried and age, gender, parental income, IQ, or any of the BGT administrations was not found. To determine whether the relationship between scores on the BART and smoking status was influenced by polydrug use, we used number of drug classes tried as a covariate and reconducted the analyses presented above and found the significant results reported above were unchanged.

Discussion

In the present study, we compared smokers and nonsmokers on two behavioral measures of risk taking. Data indicated that only the BART was related to smoking status. Further, when self-report measures of impulsivity and sensation seeking were considered with the behavioral measures in a regression analysis, only the Sensation Seeking Scale total score and the BART1 score accounted for unique variance in smoking status. In line with the hypothesis that risk taking is related to smoking, the current results suggest that the BART provides a potentially useful behavioral measure of these risk-taking tendencies that differentiate smokers and nonsmokers.

The current results are consistent with those found in a previous study (Lejuez et al., 2002) showing that the BART is useful for assessing a propensity to take risks across a variety of risk-taking behaviors. Although Lejuez et al. also showed a moderate relationship between the BART score and scores on the Eysenck Impulsivity subscale and the Sensation Seeking Scale, such a relationship was not found in the present study. Although future research is necessary, the lack of a relationship in the current study supports the suggestion that risk taking, as measured by the BART, represents a distinct form of behavioral inhibition/undercontrol and, therefore, taps unique aspects of why individuals choose to smoke.

On a methodological note, the relationship of the BART with smoking status remained stable across administrations, despite the fact that a small increase in risk taking on the task was noted across these administrations. As noted above, behavior on the BGT was not significantly associated with the other related self-report measures or with smoking status regardless of which administration was considered. Although it is difficult to speculate why the BGT did not differentiate smokers and nonsmokers, one possibility might lie in the fact that the BGT operates from an approach that all aspects of risk taking are disadvantageous. Using smoking as an example, however, the uncertainty and delay of future negative consequences coupled with other factors, such as peer pressure and mood management, may make smoking appear to be a choice that provides some gain despite the potential negatives. Thus, big wins followed consistently and immediately with bigger losses may not be the most appropriate analogue for this type of behavior. In addition to a lack of relationship with smoking status, a reversal of earnings from negative to positive

reflected a large degree of change in participant behavior on the BGT across administrations. It is interesting that, in contrast to the BART, participants became less risky over time on the BGT, which may be due to the fact that participants became aware by the second administration that earnings were maximized on the BGT with almost exclusive avoidance of Decks A and B. Such a speculation is supported by the significant decrease in disadvantageous decks chosen at each additional BGT administration, suggesting that learning affected performance.

Although the difference in BART performance among smokers and nonsmokers suggests that the BART is tapping risk taking, this interpretation should be made with some caution. Indeed, although smokers evidenced a higher average number of pumps on the BART than nonsmokers, the average number of pumps for both groups was less than the number that would provide optimal earnings. Specifically, although the average explosion point across balloons (which is also the optimal number of pumps to maximize earnings) was 64, smokers averaged only 44.3 pumps and nonsmokers averaged 36.4. Thus, one possible implication of this finding is that smokers may not necessarily be more risky than nonsmokers but instead may be performing at a more optimal level. This finding should be further investigated in future replications, yet at least two aspects of the current data do not support such a conclusion. First, it is important to consider that IQ was not related to smoking status or performance on the task. Second, smokers performed differently than nonsmokers from the very first administration of the task through the last administration and even performed differently from nonsmokers in the first 10 balloons of the first administration of the task. This suggests that the findings are not due to more rapid learning of the contingencies by smokers. That is, smokers took greater risks even before they had enough information to discern optimal response patterns.

Another issue of interpretation that calls for caution involves the assumption that the differences found on the measures comparing smokers and nonsmokers are due to smoking status and not some associated third variable. For example, because the smokers in the current sample engaged in more drug use than the nonsmokers, the supposed differences in risk taking may be due as much to differences in drug use as in smoking status. However, such an argument is weakened by the fact that the BART score was only moderately correlated with polydrug use both in the current study and in a previous study (Lejuez et al., 2002) and that the use of number of drug classes tried as a covariate did not alter the reported relationships. Nevertheless, the co-occurrence of smoking with polydrug use, as well as with other risk-taking propensities, should be taken into account when considering smoking itself as a risk-taking behavior.

Beyond the implications for better understanding risk taking as it relates to smoking behavior, the current study suggests the possibility for a number of laboratory experiments with human participants aimed at determining the behavioral and neurophysiological processes underlying risk taking. For example, the effects of stress induced

by manipulation of environmental variables or the effects of a variety of different drugs could be measured in the laboratory with the BART. Because relatively simple behavioral tasks, such as the BART, can be performed by both children and adults, the task also might have value in combination with self-report measures in the prediction of future engagement in risk-taking behaviors in adolescents. Finally, it would be interesting to extend the relationship of the BART with other related constructs such as delay discounting, which also has been shown to differentiate substance users from nonsubstance users (Bickel et al., 1999; Mitchell, 1999). Thus, although further studies are necessary to replicate and extend the current findings, well-characterized behavioral tasks such as the BART provide promising tools for studying basic behavioral and physiological mechanisms in the context of developing comprehensive multimethod assessments of risk-taking tendencies and the resulting engagement in risk-taking behaviors such as smoking.

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