Journal of Behavioral Decision Making, *J. Behav. Dec. Making*, **28**: 504–514 (2015)
Published online 10 March 2015 in Wiley Online Library (wileyonlinelibrary.com) **DOI:** 10.1002/bdm.1866

Risk-Taking Tendencies in Prisoners and Nonprisoners: Does Gender Matter?

SZYMON WICHARY[1]*, THORSTEN PACHUR[2] and MENGDUO LI[1]
[1]*University of Social Sciences and Humanities, Warsaw, Poland*
[2]*Max Planck Institute for Human Development, Berlin, Germany*

ABSTRACT

Several investigations have found that prisoners are more likely than nonprisoners to engage in risky behavior, which may contribute to their propensity to commit criminal offenses. However, this research has been limited by an almost exclusive focus on male samples. Given the established link between risk taking and gender, it is thus unclear how findings on the risk-taking propensities of prisoners also hold in women. The present study uses both a self-report questionnaire (Domain-Specific Risk Taking scale, DOSPERT) and a behavioral task (Balloon Analogue Risk Task, BART) to investigate risk-taking tendencies in a Chinese prisoner group and a nonprisoner control group with balanced gender proportions. Across both genders, prisoners both indicated a higher risk-taking tendency on the DOSPERT and showed more risk-taking behavior on the BART than did nonprisoners. Importantly, the differences were considerably more pronounced in women than in men. Relative to nonprisoners, gender differences in risk taking were substantially smaller, or even reversed, in prisoners. Computational modeling of respondents' behavior in the BART revealed that the prisoners had higher reward sensitivity and lower response consistency than the nonprisoners; these differences were again more pronounced among women. Our results suggest that previous studies based primarily on male prisoners may have underestimated differences in risk taking between prisoners and nonprisoners, and that female prisoners may represent an even more extreme subpopulation than male prisoners. Copyright © 2015 John Wiley & Sons, Ltd.

KEY WORDS risk taking; prisoners; gender; computational modeling; BART; DOSPERT

Crime represents a major issue worldwide. In the US alone, the annual cost of criminal acts has been estimated to exceed \$1 trillion (Anderson, 1999). Who are the people committing these illegal acts? Do they differ from noncriminals in their tendency to take risks, as several theories of crime suggest (e.g., Becker, 1968; Gottfredson & Hirschi, 1990; Lombroso, 1911/2005)? Importantly, given that risk-taking behavior often differs between men and women (e.g., Byrnes, Miller and Schafer, 1999), do the same patterns hold across genders? To address these questions, we report a study comparing risk taking in prisoners and nonprisoners, using a sample with balanced gender proportions. We assess risk taking using both a self-report instrument and a behavioral task. The possible psychological mechanisms underlying the behavioral measure of risk taking are further decomposed using computational modeling.

Previous studies have found that prisoners are more likely to engage in substance abuse, unsafe sex, and gambling than are nonprisoners (Fazel, Bains, & Doll, 2006; Frost & Tchertkov, 2002; Hanoch & Gummerum, 2011; Lahn, 2005). They also have higher levels of sensation seeking (Wilson & Daly, 2006) and impulsivity (Hanoch, Gummerum, & Rolison, 2012), characteristics that are related to risk taking. In addition, prisoners score higher on instruments specifically developed to measure the tendency to take risks. A popular self-report tool is the Domain-Specific Risk Taking scale (DOSPERT; Blais & Weber, 2006; Weber, Blais, & Betz, 2002), which measures risk taking in ethical, financial, health and safety, recreational, and social domains. Using the DOSPERT, Hanoch and Gummerum (2011) have found that prisoners have a higher tendency than nonprisoners to take health and safety risks.

Beyond self-report measures such as the DOSPERT, prisoners have also been shown to have a higher risk-taking propensity in behavioral tasks, such as choices between monetary lotteries (Block & Gerety, 1995; Pachur, Hanoch, & Gummerum, 2010). Using cumulative prospect theory (Tversky & Kahneman, 1992) as a computational model to decompose the cognitive and motivational factors underlying differences in choice behavior between prisoners and nonprisoners, Pachur et al. (2010) found that prisoners were less sensitive to differences in outcomes and to differences in the probability of gains and showed higher loss aversion.

Although a popular method to measure risk-taking propensity, tasks asking for a choice between monetary lotteries have been criticized for their static nature and failure to involve the dynamic and affective dimensions (e.g., tension and hope) that often accompany naturalistic risky behaviors (Schonberg, Fox, & Poldrack, 2011). A behavioral task that does approximate the dynamic nature of risk taking is the Balloon Analogue Risk Task (BART; Lejuez et al., 2002). In this task, the decision maker is presented with a balloon on a computer screen and asked to pump it up by clicking a button. With each click, the balloon inflates to some extent, and money is added to the participant's temporary winnings. However, the balloon may also explode, in which case all the money accrued in the trial is lost. The probability of the balloon exploding increases the more often it is pumped, and the decision maker has to learn that probability in order to perform well. Behavior in the BART (i.e., how many pumps

*Correspondence to: Dr. Szymon Wichary, Interdisciplinary Center for Applied Cognitive Studies, University of Social Sciences, and Humanities, Ul. Chodakowska 19/31, 03-815 Warsaw, Poland. E-mail: swichary@swps.edu.pl

are made at each trial) has been shown to predict real-life risk taking, such as unsafe driving, unprotected sex, substance abuse, and gambling (Lejuez et al., 2002). Importantly for the present context, behavior on the BART has also been found to correlate with the self-reported number of occasions of stealing (Wallsten, Pleskac, & Lejuez, 2005). However, we are not aware of studies that have used the task to study differences between prisoners and nonprisoners.

One major limitation of previous studies on risk taking in prisoners is that, with few exceptions, they have focused exclusively on males—perhaps because it is predominantly men who commit crimes and therefore constitute the large majority of the prison population. Nevertheless, women represent a substantial proportion of the prison population (e.g., around 13% in the U.S.; Sabol, Minton, & Harrison, 2007), increasing by almost 650% from 1980 to 2010 (Guerino, Harrison, & Sabol, 2011). It is currently unclear to what extent the pattern of differences in risk taking observed between male prisoners and nonprisoners holds across genders.

Why might gender matter? In nonprisoner populations, women are generally more risk-averse than men (Byrnes et al., 1999). These differences are often explained by reference to gender differences in testosterone levels, which have been implicated in various forms of risk taking (Archer, 2004; Coates & Herbert, 2009; Eisenegger, Haushofer, & Fehr, 2011; Sapienza, Zingales, & Maestripieri, 2009). Interestingly, testosterone levels may also mediate risk-taking differences in the context of crime. For instance, the second to fourth digit ratio, a marker of exposure to testosterone, is lower in male offenders than nonoffenders, indicating higher testosterone levels in offenders (Hanoch et al., 2012). Moreover, testosterone has been linked to crime and prison violence in both men and women (Dabbs, Carr, Frady, & Riad, 1995; Dabbs & Hargrove, 1997; Dabbs, Ruback, Frady, Hopper, & Sgoutas, 1988). Given the potentially common influence of testosterone on differences in risk taking both between men and women and between prisoners and nonprisoners, it seems important to consider the two factors simultaneously. For instance, given women's lower testosterone levels, differences between prisoners and nonprisoners may be smaller in women than in men. Alternatively, given that women tend to be less risk taking than men and that criminal behavior may occur only with extremely high levels of risk-taking propensity, the differences could be more pronounced in females; it is thus possible that female prisoners represent a more extreme subpopulation than male prisoners. Because the literature on risk taking among prisoners has previously focused on males, the aim of this study was to examine risk taking in prisoners, as compared with a control group of nonprisoners, with a special emphasis on the potentially moderating role of gender.

The present study

We analyzed risk attitudes and behavior of male and female prisoners in a Chinese prison, asking whether prisoners differ from nonprisoners and whether there are any gender differences. To this end, we applied two popular methods, the DOSPERT scale (Blais & Weber, 2006) and the BART (Lejuez et al., 2002). Moreover, we used computational modeling to decompose the psychological mechanisms underlying risky behavior (for a discussion, see Glöckner & Pachur, 2012; Scheibehenne & Pachur, 2014), as reflected in individual differences in the BART. Specifically, we fitted the Bayesian Sequential Risk-taking model (BSR; Pleskac, 2008; Wallsten et al., 2005) to each individual participant's responses in this task.[1] The BSR assumes that behavior in the BART is primarily a function of three cognitive processes: learning about the probability of an explosion, evaluation of the rewards obtained during the trials, and response selection. A detailed formal description of the model can be found in Appendix B. In a nutshell, the BSR has four free parameters that can be estimated from the data: a_1 and b_1, from which a parameter indicating the initial belief about the probability of an explosion ($\hat{q}_1$), as well as a parameter indicating the learning rate (δ) are derived; a reward sensitivity parameter γ^+; and a response sensitivity parameter β indicating how closely the predicted probability of choosing a particular response follows the subjective valuation of the response option. Table 1 gives an overview of the components of the BSR.

METHOD

Participants

The prisoner group consisted of 40 adults being held in a medium security prison in China: 20 male inmates, ranging in age from 29 to 56 years ($M = 44.6$ years, $SD = 8.29$), and 20 female inmates, ranging from 37 to 58 years of age ($M = 47.05$ years, $SD = 6.13$), who volunteered to participate in the study. Their sentences ranged from 2 to 12 years. Of the participants, 7.5% were sentenced for a crime against persons (including assault, injury, and human trafficking), 42.5% for a crime against property (theft, corruption, and defacement), 32.5% for fraud, robbery, or drugs, and 17.5% for other offenses. The comparison sample of nonprisoners consisted of 40 adults from the general Chinese population who had never been prosecuted and who were (approximately) matched in terms of gender and age: 20 male participants between the age of 29 and 53 years ($M = 41.65$ years, $SD = 6.46$) and 20 female participants between the age of 35 and 51 years ($M = 42.25$ years, $SD = 4.48$), who volunteered to participate in the study. Although we were unable obtain data on the participants' educational levels, previous research has indicated that education does not critically influence risk-taking behavior (Pachur et al., 2010).

Materials

We administered the DOSPERT scale, translated into Chinese, and the BART to assess risk-taking propensities.

[1]In addition, we fitted a version of the expectancy valence model (e.g., Busemeyer & Stout, 2002), as adapted to the BART by Rolison et al. (2012), to our data. The results are reported in Appendix A.

DOI: 10.1002/bdm

Table 1. Description of the parameters of the BSR model, their estimated means, and lower and upper bounds of 95% confidence intervals (in brackets), separately for men and women and for prisoners and nonprisoners

Parameter	Description	Nonprisoners		Prisoners	
		Men	Women	Men	Women
$\hat{q}_1$	Index of initial belief that the balloon will not explode. Larger values of $\hat{q}_1$ lead to a higher number of targeted pumps and thus more pumps being made on average.	.988 (.982, .993)	.988 (.982, .994)	.990 (.984, .995)	.992 (.986, .998)
log(δ)	Measure of uncertainty participants have in their initial belief about the likelihood of the balloon exploding. Larger values indicate more uncertainty and thus more sensitivity to pump experiences (i.e., whether the balloon explodes or not).	−13.03 (−15.22, −10.85)	−13.08 (−15.4, −10.76)	−14.35 (−16.54, −12.16)	−14.68 (−16.99, −12.36)
γ^+	Measure of reward sensitivity. Higher values lead to a higher number of targeted pumps and thus more pumps being made on average.	.71 (.46, .95)	.33 (.07, .59)	.78 (.53, 1.02)	1.01 (.75, 1.27)
β	Measure of how consistently participants follow their targeted evaluation. Lower values of β indicate that the decision to pump is sensitive to other information beside their pump target and is thus more variable.	.24 (.06, .42)	.47 (.28, .67)	.14 (−.04, .32)	.10 (−.09, .29)
BIC	Model fit	171.58 (144.48, 198.89)	178.59 (149.73, 207.44)	187.12 (159.91, 214.32)	170.54 (141.68, 199.39)

[a]Note BIC, Bayesian Information Criterion. The Bayesian Sequential Risk-taking (BSR) analyses are based on the 68 of the 80 respondents for whom the BSR model performed better than the baseline model.

DOSPERT scale

The DOSPERT scale is a 30-item questionnaire designed to assess risk taking in six life domains: ethical (E), financial/investment (F/I), financial/gambling (F/G), health and safety (HS), recreational (R), and social (S). It covers three aspects of people's attitudes to risks: self-reported risk-taking propensity, risk perception, and expected benefits (Blais & Weber, 2006; Weber et al., 2002). Participants in this study only completed the risk-taking propensity part of the instrument, indicating their (hypothetical) tendency to engage in various risk activities. The scales included items such as "Revealing a friend's secret to someone else" (ethical), "Betting a day's income at the horse races" (financial/gambling), "Investing 5% of your annual income in a very speculative stock" (financial/investment), "Engaging in unprotected sex" (health and safety), "Piloting a small plane" (recreational), and "Disagreeing with an authority figure on a major issue" (social). All assessments were made on a 7-point Likert scale, ranging from 1 (*extremely unlikely*) to 7 (*extremely likely*). The risk-taking score for each domain was obtained by summing up the scores on the individual items belonging to that domain. Higher scores indicate a greater risk-taking propensity. The reliabilities of the DOSPERT and its subscales are reported in Appendix C.

Balloon Analogue Risk Task

The BART (Lejuez et al., 2002) is a computerized task consisting of 30 trials. In each trial, the participant presses the "Space" button to inflate the image of a balloon displayed on the computer screen. Next to the balloon, the amount of money earned in the current trial is displayed, as well as the total amount of money earned so far. At any point during a trial, the participant can stop inflating the balloon and click the "Enter" button to transfer the sum accumulated from the current trial to his or her permanent account. If a balloon explodes, a "pop" is visualized on the screen, the money in the temporary account for that trial is lost, and the next trial begins. At the beginning of each of the 30 trials, the probability that the balloon will explode is 1/128 and increases with each pump. Risk-taking behavior on the BART is indexed by the average (per trial) number of pumps.

Procedure

The study protocol was approved by both the ethics committee of the University of Social Sciences and Humanities in Warsaw and the Chinese prison authorities. Prisoners were informed that participation was voluntary and that there would be no negative consequences for participating or nonparticipating. Participants were first asked to provide demographic information, including age and gender. The nonprisoners were also asked for their profession and employment status; the prisoners were asked to state their profession and employment status prior to imprisonment, the type of offense for which they were incarcerated, and the length of sentence. Groups of male and female prisoners who agreed to participate were separately led into a big room, where they were provided with instructions

DOI: 10.1002/bdm

Table 2. Means and lower and upper bounds of 95% confidence intervals (in brackets) of risk-taking scores in the Domain-Specific Risk-Taking (DOSPERT) scale, separately for the six risk domains

	Nonprisoners		Prisoners	
Risk domain	Men	Women	Men	Women
Ethical	16.50 (13.71, 19.29)	15.45 (12.66, 18.24)	24.40 (21.61, 27.19)	25.05 (22.26, 27.84)
Financial/investment	14.00 (11.90, 16.09)	13.70 (11.60, 15.79)	13.05 (10.95, 15.15)	11.45 (9.35, 13.55)
Financial/gambling	8.10 (5.75, 10.45)	5.95 (3.60, 8.30)	11.95 (9.60, 14.30)	12.15 (9.80, 14.50)
Health and safety	23.85 (20.84, 26.86)	19.35 (16.34, 22.36)	24.55 (21.54, 27.56)	26.35 (23.34, 29.36)
Recreational	19.10 (16.44, 21.76)	15.85 (13.19, 18.51)	24.40 (21.74, 27.06)	21.50 (18.84, 24,16)
Social	28.50 (26.13, 30.87)	27.95 (25.58, 30.32)	27.20 (24.83, 29.57)	26.70 (24.33, 29.07)

on the DOSPERT. After completing the questionnaires, they worked on the BART individually in a designated room. All participants were rewarded according to their final score on the BART, receiving .01 point for each pump of unexploded balloons. For the prisoners, the incentive scheme was a reduction of one day, two days, or three days per year from their sentence for obtaining fewer than 5 points, 5–10 points, or more than 10 points, respectively. Such reductions in sentence based on work and achievement are common practice in Chinese prisons, and the sentences of the prisoners in our sample were indeed reduced. The nonprisoners received one, two, or three boxes of chocolate for obtaining fewer than 5 points, 5–10 points, or more than 10 points, respectively. After completion of the task, participants were rewarded and thanked for their participation. The experimenter was present in the room at all times.

RESULTS

DOSPERT scores

In order to compare the tendency of prisoners and nonprisoners to take risks, while taking gender differences into account, we first analyzed participants' responses on the DOSPERT scale, using analyses of variance (ANOVAs) with prison status and gender as between-participants factors and the measures of risk-taking propensity as the dependent variables. The analyses were conducted separately for each risk domain of the DOSPERT. Table 2 presents the average risk-taking tendencies in the six domains, separately for prisoners and nonprisoners, and for men and women. Prisoners indicated a higher tendency to take ethical risks, $F(1,76) = 38.9$, $p < .001$, partial $\eta^2 = .34$; financial/gambling risks, $F(1,76) = 18.2$, $p < .001$, partial $\eta^2 = .19$; recreational risks, $F(1,76) = 16.8$, $p < .001$, partial $\eta^2 = .18$; and health and safety risks, $F(1,76) = 6.5$, $p = .013$, partial $\eta^2 = .08$. They did not differ from nonprisoners in their propensity to take financial/investment or social risks ($F < 1$). Men reported higher risk-taking tendencies than women for recreational risks, $F(1,76) = 5.3$, $p = .024$, partial $\eta^2 = .07$. The other domains did not show a main effect of gender ($F < 1$).

Importantly, for the domain of health and safety risks, there was an interaction between prison status and gender, $F(1,76) = 4.3$, $p = .041$, partial $\eta^2 = .05$, with women prisoners and nonprisoners differing in their propensity to take risks, ($p = .002$, partial $\eta^2 = .22$), but no difference between the two male groups. This interaction was not significant for the other domains. In nonprisoners, men had higher propensity to take risks in the health and safety domain than women ($p = .05$, partial $\eta^2 = .09$); in prisoners, men and women indicated similar tendencies to take these kinds of risks ($p = .37$, partial $\eta^2 = .02$).

The gender differences in prisoners' risk taking might be driven by factors confounded with gender, such as the severity of the crime or the type of crime committed. To examine this possibility, we compared female and male prisoners in terms of the length of the sentence (as an indicator of the severity of the crime) and the type of crime, but found no gender differences (see Appendix D for details). We also conducted a series of analyses of covariance for the prisoners, using the length of the sentence as a covariate. As reported in Appendix D, these analyses did not lead to different conclusions regarding gender differences in risk-taking tendencies as measured by the DOSPERT.

In sum, we found that prisoners reported greater risk-taking propensity on the DOSPERT than did nonprisoners, replicating findings by Hanoch and Gummerum (2011) obtained in British samples. Extending their results, however, we also found some indication of distinct patterns of differences between prisoners and nonprisoners in males and females—a result that could not be shown by previous analyses due to their focus on male samples.

Risk taking in the BART

We first report respondents' behavior in the BART and then decompose that behavior using computational modeling (for the correlations between the DOSPERT scores and measures of the risk taking in the BART, including the BSR parameters, see Appendix E).

Behavioral results

We assessed the differences between prisoners' and nonprisoners' behavior in the BART in terms of the average number of pumps per trial, with higher scores indicating a stronger risk-taking tendency.[2] The results, separately for

[2]We conducted analyses with the overall BART score, the number of pumps, and the adjusted number of pumps, and all three analyses gave very similar results. For simplicity, we report results for the most straightforward measure, that is, the number of pumps.

DOI: 10.1002/bdm

male and female prisoners and nonprisoners, are shown in Table 3. ANOVAs with prison status and gender as independent variables showed that the prisoners had higher scores than the nonprisoners, $F(1,76) = 14.49$, $p < .001$, partial $\eta^2 = .16$. In addition, there was a main effect of gender, with men scoring higher than women, $F(1,76) = 9.86$, $p = .002$, partial $\eta^2 = .11$. Importantly, there was also an interaction between prison status and gender, $F(1,76) = 5.62$, $p = .020$, partial $\eta^2 = .07$, and follow-up comparisons indicated that there was a difference between prisoners and nonprisoners for female respondents ($p < .001$, partial $\eta^2 = .28$), but not for male respondents ($p = .246$, partial $\eta^2 = .035$; Table 3). In nonprisoners, men made more pumps than women ($p < .001$, partial $\eta^2 = .35$), whereas in prisoners, women made more pumps than men ($p = .003$, partial $\eta^2 = .21$). These results indicate that, as for the domain of health and safety risks in the DOSPERT, the pattern of differences between prisoners and nonprisoners in risk-taking tendencies was affected by gender, with the differences being more pronounced among females than among males. As reported in Appendix D, controlling for sentence length (as an indicator or crime severity) in the prisoners group did not affect the conclusions.

Computational modeling

To decompose participants' behavior on the BART, we next fitted the BSR model (see Appendix B) to each individual participant using a maximum-likelihood approach. To avoid local minima in the fitting process, we first conducted a grid search (considering up to 80 000 value combinations of the entire parameter space, with all parameters partitioned similarly) and subsequently used the 20 best-performing parameter combinations arising from the grid search as starting values for the Simplex optimization algorithm (Nelder & Mead, 1965) as implemented in MATLAB (MathWorks, Natick, MA, USA). Additionally, we implemented a baseline model (for details, see Wallsten et al., 2005), which has the probability of pumping on each trial (which remains constant across trials) as a free parameter. As it does not make specific assumptions regarding cognitive processes, the baseline model allows us to test whether including the processes of learning, evaluation, and response selection in the BSR improves model fit.

We quantified the model fit of the BSR using the Bayesian Information Criterion (BIC; Schwarz, 1978). For 68 of the 80 participants (85%; 34 prisoners and 34 nonprisoners) the BSR showed a lower BIC (i.e., a better fit) than the baseline model. The mean best-fitting parameters of the BSR for these participants as well as the BIC are shown in Table 1, separately for prisoners and nonprisoners, and for men and women.

We conducted a series of ANOVAs with prison status and gender as between-participants factors and the BSR parameter estimates as dependent variables. Because all BSR parameter estimates had skewed distributions, they were log-transformed for use in the analyses. The variables were then back-transformed onto to the original scale for easier interpretability. The analyses showed that the prisoners had higher reward sensitivity (i.e., γ^+ parameter) than the nonprisoners, $F(1,64) = 8.62$, $p = .005$, partial $\eta^2 = .12$. This finding echoes results by Wallsten et al. (2005), who found that people who reported stealing on a higher number of occasions in the past year also had higher values on the BSR's reward sensitivity parameter. Furthermore, there was an interaction between prison status and gender, $F(1,64) = 5.75$, $p = .019$; partial $\eta^2 = .08$; the difference between prisoners and nonprisoners was pronounced in women ($p < .001$, partial $\eta^2 = .37$) and small and nonsignificant in men ($p = .72$, partial $\eta^2 = .004$). The difference between men and women in reward sensitivity was not significant for either nonprisoners ($p = .10$, partial $\eta^2 = .08$) or prisoners ($p = .08$, partial $\eta^2 = .09$).

Prisoners also had lower response consistency (i.e., β parameter) than nonprisoners, $F(1,64) = 13.70$, $p < .001$; partial $\eta^2 = .18$. This result is in line with the findings of Yechiam et al. (2008), who reported that respondents sentenced for assault and murder showed lower choice consistency than did controls in an experience-based task (specifically, the Iowa Gambling Task, modeled with the expectancy valence model). There was also an interaction of prison status and gender on this variable, $F(1,64) = 5.38$, $p = .024$; partial $\eta^2 = .08$, but no main effect of gender, $F(1,64) = .12$, $p = .729$; partial $\eta^2 = .002$. Here, too, the difference between prisoners and nonprisoners was pronounced in women ($p = .001$, partial $\eta^2 = .32$), but small and nonsignificant in men ($p = .66$, partial $\eta^2 = .005$). In nonprisoners, men and women did not differ in response consistency ($p = .15$, partial $\eta^2 = .06$); in prisoners, men had higher response consistency than women ($p = .02$, partial $\eta^2 = .16$). For the other two parameters, the initial belief that the balloon will not explode ($\hat{q}_1$) and the uncertainty in this belief (δ), there was neither a main effect of prison status or gender, nor an interaction between these factors. Controlling (in the prisoners group) for the length of the sentence did not alter the conclusions (see Appendix D for details).

In sum, using the BART, we found that prisoners were generally more willing to take risks than nonprisoners, and that this effect was mainly driven by the large difference

Table 3. Means and lower and upper bounds of 95% confidence intervals (in brackets) of the average number of balloon pumps per trial in the BART

Nonprisoners		Prisoners	
Men	Women	Men	Women
38.24 (34.19, 42.29)	22.91 (18.86, 26.96)	40.94 (36.89, 44.99)	48.07 (44.02, 52.12)

The optimal number of pumps was 64. BART, Balloon Analogue Risk Task

DOI: 10.1002/bdm

observed between female prisoners and nonprisoners. Using the BSR model to decompose performance on the BART, we found that the behavioral effect was due to prisoners' higher sensitivity to rewards and lower choice consistency. Again, these effects were mainly driven by large differences between female prisoners and nonprisoners.

DISCUSSION

Previous studies comparing risk taking in prisoners and nonprisoners have focused almost exclusively on men. This has made it difficult to assess whether the typical finding of increased risk propensity among prisoners holds irrespective of gender, which has also been found to impact risk taking. Using both a self-report instrument and a behavioral task, we found that prisoners had a higher tendency to take risks than nonprisoners, and that men had a higher tendency to take risks than women. Crucially, however, some differences between prisoners and nonprisoners were qualified by an interaction involving gender, such that the differences were more pronounced in women than in men. In fact, the female prisoners' risk-taking tendencies were rather similar to the male prisoners'.

Gender differences in risk taking have been examined in previous studies with nonprison samples, resulting in the general conclusion that women are more risk averse than men (Byrnes et al., 1999). In our sample, this pattern was replicated in the control group. Among prisoners, by contrast, women were as likely to take risks as men. To our knowledge, ours is the first study indicating that the established link between risk taking and gender may not hold in the prison population. This result is also consistent with findings that, while female prisoners commit fewer serious violent acts than male prisoners, they can engage in equally or even more risky activities; for instance, they become involved in a similar number of fights (Harer & Langan, 2001) and take more and harder drugs than comparable male prisoners (Langan & Pellisier, 2001).

What are possible reasons for the higher tendency of prisoners to take risks, relative to nonprisoners? And why is this pattern of results influenced by gender? There are at least two possible answers. First, risk-taking propensity may be driven by situational factors. Specifically, the prison environment may make inmates more willing to take risks, possibly through competition, a mechanism that has been shown to be linked to risk taking (at least in males; Wilson & Daly, 1985). If so, people released from prison should show a lower risk-taking propensity than those currently in prison. However, a study comparing male ex-prisoners and current prisoners (Rolison, Hanoch, & Gummerum, 2013a) found the opposite pattern (i.e., ex-prisoners showing higher risk taking than prisoners). Therefore, the prison environment seems an unlikely reason for the more pronounced risk taking of inmates. Note that the Rolison et al. findings also suggest that the difference between criminals and non-criminals in risk taking may be underestimated in studies with samples of currently imprisoned individuals.

Second, risk taking could be shaped by personality dispositions and their biological underpinnings. Several studies have established a link between personality and risk taking (Breivik, 1996; Levenson, 1990; Nicholson, Soane, Fenton-O'Creevy, & Willman, 2005; Zuckerman & Kuhlman, 2000). Moreover, male prisoners and nonprisoners seem to differ in personality characteristics, with prisoners being more impulsive than nonprisoners (Hanoch et al., 2012; Rolison, Hanoch, & Gummerum, 2013b).

A crucial neuromodulatory mechanism linking personality and risk-taking propensity may be testosterone. Testosterone has been connected to risk taking in both men and women (Coates & Herbert, 2009; Sapienza et al., 2009), and male prisoners show higher testosterone levels than nonprisoners (Hanoch et al., 2012). Moreover, in nonprison samples, testosterone has been found to be positively associated with the probability of engaging in criminal acts in males (Dabbs et al., 1995). Banks and Dabbs (1996) reported higher testosterone levels in both men and women from a delinquent and violent urban subculture than in age-matched college students, and Dabbs et al. (1988) obtained some indication that women imprisoned for unprovoked violent crimes may have higher testosterone levels than women from the general population.

How might testosterone influence risk taking? Testosterone is known to shift the balance between sensitivity to punishment and reward. For example, using the Iowa Gambling Task (Bechara, Damásio, Damásio, & Anderson, 1994), van Honk et al. (2004) showed (in women) that exogenously administered testosterone can increase reward sensitivity. According to results by Hermans et al. (2010), this effect seems to be due to increased activity in the dopaminergic neuromodulatory system, particularly in the nucleus accumbens, which is responsible for the expectation of reward. Psychologically, the effect of testosterone might be mediated by an attenuation of feelings of fear (Hermans et al., 2007). One possibility is thus that female prisoners differ from female nonprisoners in personality and its biological mechanisms, and that this difference is in fact larger than that observed in male samples.

What underlies the differences observed in reported risk-taking propensity between male and female prisoners and controls? Using the DOSPERT, Gummerum, Hanoch and Rolison (2014) showed that behavioral risk intensions in prisoners and ex-prisoners are predicted by the expected benefits and perceived risks, with expected benefits being the better predictor. Future studies could investigate whether gender differences in the risk-taking propensity of prisoners and nonprisoners are accompanied by differences in the expected benefits and perceived riskiness of various behaviors.

One potential peculiarity of our study is that the data were collected in an Asian population. Can one expect our results to generalize across cultures? There is increasing evidence for cultural differences in risk attitude. For instance, Weber and Hsee (1998), comparing US, Chinese, German, and Polish samples, found that Chinese participants were less risk averse than Americans, with the German and Polish participants falling in between (see also Hsee & Weber, 1999). The authors attributed these differences to differences in risk perception and proposed that the greater risk taking observed in Chinese respondents may be due to a stronger buffering of

DOI: 10.1002/bdm

negative outcomes by social support in collectivist cultures such as China. Although the overall level of risk taking in our study may thus be higher than would be expected for Western samples, the literature offers no indication that cultural differences might impact the interplay between risk taking, gender, and prisoner status. Note also that we replicated several patterns previously obtained for Western samples (Hanoch & Gummerum, 2011; Wallsten et al., 2005).

In our sample, the reliabilities of some subscales of the DOSPERT, particularly the social risks subscale, were rather low (Appendix C). This replicates results for the German adaptation of the DOSPERT (Johnson, Wilke, & Weber, 2004), which also found the social risks subscale to have the lowest reliability. In a study by Hu and Xie (2012), which validated the Chinese version of the DOSPERT in a college student sample, the social domain did not emerge as a separate factor. These results suggest that risk taking in the social risks domain may sometimes be rather difficult to assess reliably, and that it may actually not necessarily represent a distinct domain, at least among Chinese respondents. Despite the low reliability of some DOSPERT subscales in our study, note that our main conclusions regarding the interplay of prisoner status and gender are based on patterns that also emerged with the BART task.

Our results on the comparison of prisoners and nonprisoners must be qualified by possible differences in the education of these two groups and by differences in the incentive structure of the BART between the two groups. We did not obtain data on participants' educational levels, but previous research has shown that education does not critically impact risk taking (Pachur et al., 2010). Furthermore, we cannot rule out the possibility that the gender differences observed in risk taking in the prisoners group reflect different attitudes of incarcerated men and women to days left in jail. We also cannot rule out that the observed gender differences are due to the fact that the female prisoners in our sample represent an extreme subsample of Chinese female prisoners. This could be tested by comparing our sample with data for all prisoners in China, an analysis that we were unable to perform.

CONCLUSIONS

Risk taking is a ubiquitous activity jointly shaped by the expectation of reward and apprehension of negative consequences. For some individuals, excessive risk taking may contribute to a higher chance of committing a criminal offense, potentially leading to imprisonment. Our results suggest that the difference between prisoners and nonprisoners in risk taking is also found for women—in fact, the difference is even more pronounced in women than in men. Using computational modeling, we showed that the differences in risk behavior between prisoners and nonprisoners of both genders seem to be rooted in differences in reward sensitivity and response consistency. Our study thus contributes to a better understanding of the psychological processes driving individual differences in risk-taking propensity.

APPENDIX A: RESULTS OF THE EXPECTANCY VALENCE LEARNING MODEL AS ADAPTED TO THE BART

According to the expectancy valence learning model (EVL) —as applied to the BART by Rolison, Hanoch, and Wood (2012)—the valence v of a given balloon h in the BART is a function of the gains and losses accrued at the previous balloon (i.e., at trial $h - 1$):

$$v_h = w \cdot Win_{h-1} - l \cdot Loss_{h-1}, \quad \text{(A1)}$$

where w and l are the weights given to gains and losses, respectively, estimated from the data. It is further assumed that for each balloon, the decision maker has a target number of pumps, which is a function of the valence of the balloon and the target number of pumps at the previous balloon:

$$\textit{target number of pumps}_h = v_h + a \cdot \textit{target number of pumps}_{h-1}, \quad \text{(A2)}$$

where a is a learning rate parameter estimated from the data that governs the influence of the target number of pumps at the previous balloon. The target number of pumps at the first trial (i.e., $h = 1$) was set to equal rp, a free parameter that thus indicates the decision maker's initial level of risk taking. Finally, the probability of pumping balloon h at trial i is

$$r_{h,i} = \frac{1}{1 + e^{\beta(i - \textit{target number of pumps}_h)}}, \quad \text{(A3)}$$

where β is a response consistency parameter, with lower values indicating lower consistency (i.e., more noisy responding).

We applied the EVL model to our data, using a maximum-likelihood approach to fit the parameters and with the following parameter restrictions (see also Rolison et al., 2012): $-1 \le w \ge 1$, $-1 \le l \ge 1$, $0 \le a \le 2$, $0 \le rp \le 200$; $0 < \beta \le 10$. As it turned out, the EVL had a somewhat better model fit than the BSR, with a median BIC of 151.2 and 173.3 for the prisoner and the control groups, respectively (relative to median BICs of 157.8 and 176.5 for the BSR). For 72 of the 80 participants, the model fit was better than for the baseline model. Table A1 shows the mean best-fitting parameter values for the prisoners and nonprisoners, separately for male and female participants.

We conducted a series of ANOVAs with prison status and gender as predictors and the EVL parameters as dependent variables. Prisoners had higher values on the rp parameter than nonprisoners, $F(1,68) = 26,27$, $p < .0001$, partial $\eta^2 = .28$; they also had lower values on the β parameter, $F(1,68) = 13.85$, $p < .0001$, partial $\eta^2 = .17$. There were no differences between prisoners and nonprisoners on the other EVL parameters. Male and female participants did not differ with regard to the EVL parameters. Importantly, however, there was an interaction between prison status and gender on the rp parameter, $F(1,68) = 11.91$, $p = .001$, partial $\eta^2 = .15$, such that female prisoners had higher values than

DOI: 10.1002/bdm

Table A1. Description of the parameters of the EVL model, their estimated means, and lower and upper bounds of 95% confidence intervals (in brackets), separately for men and women and for prisoners and nonprisoners

Parameter	Description	Nonprisoners		Prisoners	
		Men	Women	Men	Women
w	Weight given to gains, that is, points won on balloons that did not explode.	−.243 (−.406, −.081)	−.476 (−.691, −.262)	−.355 (−.511, −.199)	−.365 (−.496, −.235)
l	Weight given to losses, that is, points lost on balloons that did explode.	.553 (.363, .743)	.772 (.615, .93)	.533 (.360, .707)	.645 (.474, .818)
a	Learning rate parameter. The higher the value, the more weight is given to the target number of pumps at the previous trial.	1.210 (1.081, 1.340)	1.347 (1.188, 1.507)	1.248 (1.154, 1.342)	1.273 (1.185, 1.361)
rp	Initial level of risk taking. The higher the value, the higher the initial target number of pumps assumed by the model.	60.58 (47.38, 73.77)	36.06 (23.59, 48.53)	71.11 (60.34, 81.89)	90.06 (77.22, 102.91)
β	Measure of how consistently participants follow their targeted evaluation.	.288 (.169, .408)	.384 (.242, .527)	.189 (.149, .229)	.133 (.111, .156)
BIC	Model fit	158.50 (145.55, 171.45)	170.53 (152.94, 188.12)	160.64 (150.63, 170.64)	141.64 (131.08, 152.20)

BIC, Bayesian Information Criterion. The expectancy valence learning (EVL) analyses are based on the 72 (of 80) respondents for whom the EVL model performed better than the baseline model.

female nonprisoners ($p < .0001$, partial $\eta^2 = .50$), whereas male prisoners and nonprisoners did not differ on this parameter ($p = .23$, partial $\eta^2 = .04$). Within the nonprisoners group, men had higher values on the *rp* parameter ($p = .012$, partial $\eta^2 = .18$), whereas in the prisoners group, it was women who had higher values on this parameter ($p = .033$, partial $\eta^2 = .12$). There were no interaction effects for the other EVL parameters.

Further analyses revealed that several of the EVL parameters were highly intercorrelated. For instance, the gain weight parameter was strongly correlated (across participants) with the learning rate parameter ($r = -.95$) and with the loss weight parameter ($r = -.79$), which was in turn strongly correlated with the learning rate parameter ($r = .77$). These parameter intercorrelations can severely complicate the estimation and interpretation of parameters (e.g., Scheibehenne & Pachur, 2014), and we therefore refrain from analyzing the relationship of the EVL parameters to the other risk-propensity measures in more detail.

APPENDIX B: FORMAL DESCRIPTION OF THE BAYESIAN SEQUENTIAL RISK-TAKING MODEL

The BSR assumes that people's behavior in a sequential risk-taking task such as the BART is primarily a function of three cognitive processes: learning, evaluation, and response selection. With regard to learning processes, the BSR assumes that the decision maker has an initial belief in the probability $\hat{q}_h$ that balloon h will not explode on any given pump. This belief is modeled with a beta distribution over $\hat{q}_h$, summarized by two parameters $a_h > 0$ and $b_h > 0$, which are estimated from the data. A quantification of the decision maker's belief in the chances of balloon h not exploding is derived from the mean of the beta distribution, defined as follows (Pleskac, 2008; Pleskac & Wershbale, 2014):

$$\hat{q} = \frac{a_h}{a_h + b_h}, \tag{B1}$$

The variance of the distribution, which can be interpreted as indicating the decision maker's uncertainty in the initial belief, is determined as

$$\delta_h = \frac{a_h b_h}{(a_h + b_h)^2 (a_h + b_h + 1)}, \tag{B2}$$

Larger values of δ_h translate into a greater adjustment after experiencing the trial outcome (i.e., whether the balloon explodes or not); the parameter can therefore also be viewed as a learning rate, with larger values indicating stronger learning. For readability, δ_h is sometimes log-transformed (e.g., Pleskac, 2008). The decision maker's initial belief that the balloon will explode as well as the initial uncertainty in the belief, $\hat{q}_1$ and δ_1, are estimated from the data by estimating a_1 and b_1.

The second key aspect of the BSR refers to the decision maker's reward sensitivity, that is, how the outcome experienced after each pump opportunity (i.e., whether the balloon explodes or not) impacts the evaluation of pumping at the subsequent pump opportunity. Specifically, the expected gain of pumping balloon h at opportunity i equals

$$v_{hi} = (\hat{q}_h)^i (ix)^{\gamma^+}, \tag{B3}$$

The variable $\hat{q}_h$ is the probability that balloon h will not explode after i pumps, and x is the reward for each successful pump. Higher values of γ^+ indicate greater sensitivity to differences in payoffs. Participants are assumed to have a target of c pumps, which maximizes the expected payoffs. This target number of pumps is defined as the maximum of Equation B3 (Wallsten et al., 2005), which is

$$G_h = \frac{-\gamma^+}{\ln(\hat{q}_h)}, \tag{B4}$$

Finally, the BSR models how reward evaluation and learning experience are translated into the probability r_i that the balloon is pumped another time:

$$r_i = \frac{1}{1 + e^{\beta d_{hi}}}, \tag{B5}$$

where β is a free parameter representing how consistently participants follow their target number of pumps (i.e., G_h). Lower values of β indicate that the decision maker's pump tendency is sensitive to other information besides his or her targeted reward pump (or is just noisy), and that the pumping behavior will thus be more variable. $d_h(i)$ is the distance at opportunity i from the targeted number of pumps, $d_h(i) = i - G_h$. To estimate the four free parameters of the BSR, we used the following parameter restrictions: $0 < \gamma^+ \leq 2$; $0 < \beta \leq 10$; $0 < a_{init} \leq 20\,000$; $0 < b_{init} \leq 500$.

We also tested an extended version of the choice rule (Pleskac, 2008), which additionally includes an exploration bias parameter (i.e., whether people have an enhanced tendency to pump more than the targeted number of pumps at early or late trials). Because the BIC (Schwarz, 1978), which trades off model fit against model flexibility, indicated that the addition of the parameter did not lead to an improved ability of the BSR to account for the data, we applied the original model of the BSR investigated by Wallsten et al. (2005).

APPENDIX C

Table C1. Reliability (Cronbach's alpha) of the DOSPERT scale and its subscales

$N = 80$	DOSPERT	E	F/I/G	F/I	F/G	H/S	R	S
Cronbach's alpha	.81	.60	.77	.63	.85	.54	.55	.30

Note. DOSPERT, Domain-Specific Risk Taking scale; E, ethical risks; F/I/G, financial/investment and financial/gambling risks together; F/I, financial/investment risks; F/G, financial/gambling risks; H/S, health and safety risks; R, recreational risks; S, social risks.

APPENDIX D: GENDER DIFFERENCES IN CRIMES FOR WHICH PRISONERS WERE INCARCERATED

There were no gender differences in the prison sample with regard to the severity of the crime, operationalized as the length of the prison sentence in years, $M_{men} = 5.84$ vs. $M_{women} = 5.55$, $t(37) = .33$, $p = .741$. Likewise, there were no gender differences in the type of crime committed. Specifically, male and female prisoners did not differ in terms of the frequencies of crimes against a person, crimes against property, fraud, robbery and drug related crimes, and other crimes, $\chi^2(df = 3,\ N = 40) = 2.37$, $p = .499$. The distribution of prisoners across different types of crime, separately for male and female prisoners, is reported in Table D1.

Table D1. Distribution across different types of crimes for which participants in the prison sample were incarcerated, separately for male and female participants. Given are percentages

	Crimes against person	Crimes against property	Fraud, robbery, drugs	Other
All	7.5	42.5	32.5	17.5
Men	10	40	25	25
Women	5	45	40	10

To examine whether risk taking in the prison sample was associated with the severity of the crime committed, we first correlated the length of the sentence with the DOSPERT scores, BART scores, and BSR parameters (among the prisoners). The only correlation to emerge was with risk taking in the ethical domain of the DOSPERT, $r = .49$, $p = .002$; risk taking in the other domains of the DOSPERT was unrelated to the length of the sentence (F/I: $r = .15$, $p = .36$, F/G: $r = .14$, $p = .39$, H/S: $r = .25$, $p = .12$, R: $r = .07$, $p = .67$, S: $r = .07$, $p = .68$). Length of the sentence was not correlated with either the number of pumps in BART ($r = .18$, $p = .28$) or the BSR model parameters (γ^+: $r = -.13$, $p = .45$; β: $r = .11$, $p = .54$, $\hat{q}_1$: $r = .16$, $p = .37$, log(δ): $r = -.13$, $p = .46$).

Second, we included length of the sentence as a covariate in an analysis of covariance, looking at gender differences in risk taking within the prisoner sample. The results suggested the same conclusions as without control for sentence length (as reported in the main text). Specifically, the analysis did not show an effect of gender on the DOSPERT subscales (E: $F(1,36) = .238$, $p = .629$, partial $\eta^2 = .007$; F/I: $F(1,36) = 1.50$, $p = .228$, partial $\eta^2 = .040$; F/G: $F(1,36) = .006$, $p = .939$, partial $\eta^2 = .001$; H/S: $F(1,36) = .887$, $p = .353$, partial $\eta^2 = .024$; S: $F(1,36) = .101$, $p = .752$, partial $\eta^2 = .003$), with the exception of a marginally significant effect for recreational risks, such that male prisoners indicated a higher tendency to take these risks than female prisoners, $F(1,36) = 4.074$, $p = .051$, partial $\eta^2 = .102$. As regards the BART, the analysis showed an association of gender with the number of pumps, with female prisoners making more pumps than male prisoners, $F(1,36) = 11.360$, $p = .002$, partial $\eta^2 = .238$. For the parameters of the BSR model, the analysis showed an effect of gender on the response consistency parameter β, such that

DOI: 10.1002/bdm

male prisoners had higher response consistency than female prisoners, $F(1,31) = 5.982$, $p = .020$, partial $\eta^2 = .162$. Moreover, there was a trend for male prisoners to have higher reward sensitivity (γ^+) than female prisoners, $F(1,31) = 3.627$, $p = .065$, partial $\eta^2 = .092$. The analysis did not show an association between gender and the other BSR parameters, $\hat{q}_I$: $F(1,31) = .828$, $p = .369$, partial $\eta^2 = .022$; log(δ): $F(1,31) = .059$, $p = .810$, partial $\eta^2 = .002$.

APPENDIX E

Table E1. Correlations of DOSPERT scores with risk taking in the BART and BSR model parameters

	Ethical	Financial/ Investment	Financial/ gambling	Health and safety	Recreational	Social
Pumps	.43**	−.07	.31**	.40**	.39**	.06
γ^+	.31*	−.02	.17	.30*	.24*	−.01
β	−.43**	−.06	−.38**	−.22	−.23	−.10
$\hat{q}_I$	.14	−.06	.14	−.05	.21	−.01
log(δ)	−.10	−.05	−.19	−.02	−.17	−.13

*$p < .05$,
**$p < .01$ (two-tailed). The BSR analyses are based on the 68 (of 80) respondents for whom the BSR model performed better than the baseline model.
DOSPERT, Domain-Specific Risk-Taking; BART, Balloon Analogue Risk Task; BSR, Bayesian Sequential Risk-taking.

ACKNOWLEDGEMENTS

This work was funded by grant no. 2012/04/M/HS6/00479 from the Polish National Science Center to Szymon Wichary, as well as by a grant from the German Research Foundation (DFG) (HE 2768/7-2) to Thorsten Pachur as part of the priority program on New Frameworks of Rationality (SPP 1516). Part of this work was submitted in fulfillment of the Master of Arts degree at the University of Social Sciences and Humanities in Warsaw by Mengduo Li. We thank Susannah Goss for editing the manuscript and two anonymous referees for their helpful comments on an earlier version of this paper.

REFERENCES

Anderson, D. A. (1999). The aggregate burden of crime. *Journal of Law and Economics*, *42*, 611–642.
Archer, J. (2004). Sex differences in aggression in real-world settings: A meta-analytic review. *Review of General Psychology*, *8*, 291–322.
Banks, T., & Dabbs, J. M. (1996). Salivary testosterone and cortisol in a delinquent and violent urban subculture. *The Journal of Social Psychology*, *136*, 49–56.
Bechara, A., Damásio, A. R., Damásio, H., & Anderson, S. W. (1994). Insensitivity to future consequences following damage to human prefrontal cortex. *Cognition*, *50*, 7–15.
Becker, G. S. (1968). Crime and punishment: An economic approach. *Journal of Political Economy*, *76*, 169–217.
Blais, A.-R., & Weber, E. U. (2006). A Domain-Specific Risk-Taking (DOSPERT) scale for adult populations. *Judgment and Decision Making*, *1*, 33–47.
Block, M. K., & Gerety, V. E. (1995). Some experimental evidence on differences between student and prisoner reactions to monetary penalties and risk. *Journal of Legal Studies*, *24*, 123–138.
Breivik, G. (1996). Personality, sensation seeking and risk taking among Everest climbers. *International Journal of Sport Psychology*, *27*, 308–320.
Busemeyer, J. R., & Stout, J. C. (2002). A contribution of cognitive decision models to clinical assessment: Decomposing performance on the Bechara gambling task. *Psychological Assessment*, *14*, 253–262.
Byrnes J. P., Miller, D. C., & Schafer, W. D. (1999). Gender differences in risk taking: A metaanalysis. *Psychological Bulletin*, *125*, 367–383.
Coates, J. M., & Herbert, J. (2009). Endogenous steroids and financial risk taking on a London trading floor. *Proceedings of the National Academy of Sciences*, *105*, 6167–6172.
Dabbs, J. M. Jr., Carr, T. S., Frady, R. L., & Riad, J. K. (1995). Testosterone, crime, and misbehavior among 692 male prison inmates. *Personality and Individual Differences*, *18*, 627–633.
Dabbs, J. M. Jr., & Hargrove, M. F. (1997). Age, testosterone, and behavior among female prison inmates. *Psychosomatic Medicine*, *59*, 477–480.
Dabbs, J. M. Jr., Ruback, R. B., Frady, R. L., Hopper, C. H., & Sgoutas, D. (1988). Saliva testosterone and criminal violence among women. *Personality and Individual Differences*, *9*, 269–275.
Eisenegger, C., Haushofer, J., & Fehr, E. (2011). The role of testosterone in social interaction. *Trends in Cognitive Sciences*, *15*, 263–271.
Fazel, S., Bains, P., & Doll, H. (2006). Substance abuse and dependence in prisoners: A systematic review. *Addiction*, *101*, 181–191.
Frost, L., & Tchertkov, V. (2002). Prisoner risk taking in the Russian Federation. *AIDS Education and Prevention*, *14*(Suppl. B), 7–23.
Glöckner, A., & Pachur, T. (2012). Cognitive models of risky choice: Parameter stability and predictive accuracy of prospect theory. *Cognition*, *123*, 21–32.
Gottfredson, M. R., & Hirschi, T. (1990). *A general theory of crime*. Palo Alto, CA: Stanford University Press.
Guerino, P., Harrison, P. M., & Sabol, W. (2011). *Prisoners in 2010*. Washington, DC: Bureau of Justice Statistics.
Gummerum, M., Hanoch, Y., & Rolison, J. J. (2014). Offenders' risk-taking attitude inside and outside the prison walls. *Risk Analysis*, *34*, 1870–1881.
Hanoch, Y., & Gummerum, M. (2011). A comparison of the risk-taking behaviors of prisoners and non-prisoners. *Journal of Behavioral Decision Making*, *24*, 431–442.
Hanoch, Y., Gummerum, M., & Rolison, J. (2012). Second-to-fourth digit ratio and impulsivity: A comparison between offenders and nonoffenders. *PloS One*, *7*, e47140.
Harer, M. P., & Langan, N. P. (2001). Gender differences in predictors of prison violence: Assessing the predictive validity of a risk classification system. *Crime and Delinquency*, *47*, 513–536.
Hermans, E. J., Bos, P. A., Ossewaarde, L., Ramsey, N., Fernandez, G., & van Honk, J. (2010). Effects of exogenous testosterone on the ventral striatal BOLD response during reward anticipation in healthy women. *NeuroImage*, *52*, 277–283.
Hermans, E. J., Putman, P., Baas, J. M., Gecks, N. M., Kenemans, J. L., & van Honk, J. (2007). Exogenous testosterone attenuates the integrated central stress response in healthy young women. *Psychoneuroendocrinology*, *32*, 1052–1061.
Hsee, C. K., & Weber, E. U. (1999). Cross-national differences in risk preference and lay predictions. *Journal of Behavioral Decision Making*, *12*, 165–179.
Hu, X., & Xie, X. (2012). Validation of the domain-specific risk-taking scale in Chinese college students. *Judgment and Decision Making*, *7*, 181–188.

DOI: 10.1002/bdm

Johnson, J. G., Wilke, A., & Weber, E. U. (2004). Beyond a trait view of risk taking: A domain-specific scale measuring risk perceptions, expected benefits and perceived-risk attitudes in German-speaking populations. *Polish Psychological Bulletin*, *35*, 153–163.

Lahn, J. (2005). Gambling among offenders: Results from an Australian survey. *International Journal of Offender Therapy and Comparative Criminology*, *49*, 343–355.

Langan, N. P., & Pellisier, B. M. M. (2001). Gender differences among prisoners in drug treatment. *Journal of Substance Abuse*, *13*, 291–301.

Lejuez, C. W., Read, J. P., Kahler, C. W., Richards, J. B., Ramsey, S. E., Stuart, G. L., Strong, D. R., & Brown, R. A. (2002). Evaluation of a behavioral measure of risk-taking: The Balloon Analogue Risk Task (BART). *Journal of Experimental Psychology: Applied*, *8*, 75–84.

Levenson, M. R. (1990). Risk taking and personality. *Journal of Personality and Social Psychology*, *58*, 1073–1080.

Lombroso, C. (2005). *Criminal man*. Durham, NC: Duke University Press. (Original work published 1911)

Nelder, J. A., & Mead, R. (1965). A simplex method for function minimization. *Computer Journal*, *7*, 308–313.

Nicholson, N., Soane, E., Fenton-O'Creevy, M., & Willman, P. (2005). Personality and domain specific risk taking. *Journal of Risk Research*, *8*, 157–176.

Pachur, T., Hanoch, Y., & Gummerum, M. (2010). Prospects behind bars: Analyzing decisions under risk in a prison population. *Psychonomic Bulletin and Review*, *17*, 630–636.

Pleskac, T. J. (2008). Decision making and learning while taking sequential risks. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *34*, 167–185.

Pleskac, T. J., & Wershbale, A. (2014). Making assessments while taking repeated risks: A pattern of multiple response pathways. *Journal of Experimental Psychology: General*, *143*, 142–162.

Rolison, J. J., Hanoch, Y., & Gummerum, M. (2013a). When opportunity matters: Comparing the risk-taking attitudes of prisoners and recently released ex-prisoners. *Risk Analysis*, *33*, 2013–2022.

Rolison, J. J., Hanoch, Y., & Gummerum, M. (2013b). Characteristics of offenders: The HEXACO model of personality as a framework for studying offenders' personality. *The Journal of Forensic Psychiatry and Psychology*, *24*, 71–82.

Rolison, J. J., Hanoch, Y., & Wood, S. (2012). Risky decision making in younger and older adults: The role of learning. *Psychology and Aging*, *27*, 129–140.

Sabol, W. J., Minton, T. D., & Harrison, P. M. (2007). *Prison and jail inmates at midyear 2006*. Washington, DC: Bureau of Justice Statistics.

Sapienza, P., Zingales, L., & Maestripieri, D. (2009). Gender differences in financial risk aversion and career choices are affected by testosterone. *Proceedings of the National Academy of Sciences of the USA*, *106*, 15268–15273.

Scheibehenne, B., & Pachur, T. (2014). Using Bayesian hierarchical parameter estimation to assess the generalizability of cognitive models of choice. *Psychonomic Bulletin and Review*. Advance online publication. DOI: 10.3758/s13423-014-0684-4

Schonberg, T., Fox, C. R., & Poldrack, R. (2011). Mind the gap: Bridging economic and naturalistic risk-taking with cognitive neuroscience. *Trends in Cognitive Sciences*, *15*, 11–19.

Schwarz, G. (1978). Estimating the dimension of a model. *Annals of Statistics*, *6*, 461–464.

Tversky, A., & Kahneman, D. (1992). Advances in prospect theory: Cumulative representation of uncertainty. *Journal of Risk and Uncertainty*, *5*, 297–323.

van Honk, J., Schutter, D. J. L. G., Hermans, E. J., Putman, P., Tuiten, A., & Koppeschaar, H. (2004). Testosterone shifts the balance between sensitivity for punishment and reward in healthy young women. *Psychoneuroendocrinology*, *29*, 937–943.

Wallsten, T. S., Pleskac, T. J., & Lejuez, C. W. (2005). Modeling behavior in a clinically diagnostic sequential risk-taking task. *Psychological Review*, *112*, 862–880.

Weber, E. U., Blais, A.-R., & Betz, N. (2002). A domain-specific risk-attitude scale: Measuring risk perceptions and risk behaviors. *Journal of Behavioral Decision Making*, *15*, 263–290.

Weber, E. U., & Hsee, C. (1998). Cross-cultural differences in risk perception, but cross-cultural similarities in attitudes towards perceived risk. *Management Science*, *44*, 1205–1217.

Wilson, M., & Daly, M. (1985). Competitiveness, risk taking, and violence: The young male syndrome. *Ethology and Sociobiology*, *6*, 59–73.

Wilson, M., & Daly, M. (2006). Are juvenile offenders extreme future discounters? *Psychological Science*, *17*, 989–994.

Yechiam, E., Kanz, J. E., Bechara, A., Stout, J. C., Busemeyer, J. R., Altmaier, E. M., & Paulsen, J. S. (2008). Neurocognitive deficits related to poor decision-making in people behind bars. *Psychonomic Bulletin and Review*, *15*, 44–51.

Zuckerman, M., & Kuhlman, D. M. (2000). Personality and risk taking: Common biosocial factors. *Journal of Personality*, *68*, 999–1029.

Authors' biographies:

Dr. Szymon Wichary is an assistant professor at the University of Social Sciences and Humanities, Warsaw, Poland. His research interests focus on cognition-emotion interactions and the role of emotions and individual differences in decision-making. In his research, he combines computerized cognitive tasks, neurophysiological methods, and formal modeling of decision-making.

Dr. Thorsten Pachur is senior researcher at the Center for Adaptive Rationality at the Max Planck Institute for Human Development in Berlin. He studies learning and memory processes in decision-making, strategy selection, and the psychology of a risky choice, using computational modeling and process analyses.

Mengduo Li is a Master student in Psychology at the University of Social Sciences and Humanities, Warsaw, Poland, and interested in decision-making under risk.

Authors' addresses:

Szymon Wichary, University of Social Sciences and Humanities, Warsaw, Poland.

Thorsten Pachur, Max Planck Institute for Human Development, Berlin, Germany.

Mengduo Li, University of Social Sciences and Humanities, Warsaw, Poland.

DOI: 10.1002/bdm