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Multidimensional Latent Structure of Risk-Related Phenotypes in Healthy Young Adults

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Abstract

Risk-taking behavior can result in a range of maladaptive behaviors such as illicit substance use, unsafe driving, and high-risk sexual behavior. Perception of risk and preference for engaging in risky behaviors have been measured using both self-report measures and a range of behavioral tasks designed for the purpose, and these may predict future risk-taking behavior. However, the interrelationships between these measures and the latent constructs underlying them are poorly understood. In the present study, we examined data from over 1,000 men and women who completed measures of risk-related behaviors, including self-reports of perception of risk, propensity to engage in risky behaviors, and incentivized performance on tasks that involve risk. We conducted principal component analyses (PCAs) to understand the underlying latent structure of these measures. A PCA with the full sample revealed 5 distinct components, corresponding to measures of (a) health/ethical risks, (b) discounting of uncertain rewards, (c) risk of personal finances, (d) preferences in recreational hobbies and social interactions that involve risk, and (e) behavior involving risks in interpersonal interactions. Although we found sex differences on several of the measures, the sex-adjusted PCA components were similar to those of the unadjusted full sample PCA. These findings add to a growing literature revealing different components of the broad category of risk perception and risk-taking behaviors. A better understanding of the multidimensionality of risk preference will help lay the foundation for more refined measures, develop better predictors of future risk-taking behavior, and ultimately to study the genetic or other biological basis of risk-taking.

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Keywords

risk; Balloon Analogue Risk Task; principal components analysis

Many of life's decisions involve the opportunity to gain a reward that may be uncertain or may be combined with the possibility of a loss or harm (Leigh, 1999). Such decisions are commonly referred to as "risk-taking behaviors," typically involving voluntary engagement in activities that are probabilistically linked to monetary, social or interpersonal outcomes (Bechara, 2003). An important question is whether the propensity to engage in behavior involving risk is a unitary and broad-based construct which applies across a range of behaviors, or whether it is multifactorial and specific to certain types of decisions. Recent evidence strongly suggests that it is multifactorial, and may include self-perceptions and objective behavioral tendencies, stable trait-like characteristics or momentary tendencies (Frey, Pedroni, Mata, Rieskamp, & Hertwig, 2017). Whereas early personality studies identified individuals on a single dimension as risk-taking or risk averse (Bromiley & Curley, 1992; Eysenck & Eysenck, 1977), later researchers noted that specific domains of risk-taking behaviors, including financial, ethical and social, are not necessarily related to one another (Blais & Weber, 2001; Horvath & Zuckerman, 1993; Zuckerman & Kuhlman, 2000).

There is also question about whether self-report measures of preference for risky behaviors are related to performance on behavioral tasks designed to assess risk-taking. For example, the Balloon Analogue Risk Task (BART; Lejuez et al., 2002) is a widely used task to assess risk-taking behavior, in which subjects make responses for gain at increasing risk of loss. Performance on this task is related to real-life risky behaviors such as smoking and seat belt use, but whether it is related to other standardized self-report measures of risk-taking remains to be determined. One comprehensive recent study (Frey et al., 2017) examined the factor structure among 39 different risk-taking measures in a sample of 1500 healthy adults, including measures of perception of risk, levels of habitual risk behaviors, as well as behavioral tasks such as the BART. They found that correlations between propensity to engage in risky behaviors and performance on behavioral measures were weak, but nevertheless they identified a general factor of risk preference emerged from stated preferences that corresponded to real-world risky activity such as smoking. Studies such as this will help define the relationships between perceptions of risk and likelihood of engaging in behaviors involving risk, and whether these tendencies are uniform across different forms of risk (e.g., monetary or health-related) and measures of risk-taking (self-report or task-related).

We recently completed a study assessing a broad range of measures of impulsive behaviors and personality (MacKillop et al., 2016). The study included several indices of risk-related behaviors, including perceptions of risk, self-reported likelihood of engaging in behaviors involving risk and behavioral tasks involving risk. Our study included some of the same measures used by Frey et al. (2017), but not enough to fully replicate the Frey analysis. Moreover, we intentionally avoided defining risk using measures of health behaviors such as smoking, heavy alcohol use, or unprotected sex, because those behaviors may reflect adverse

outcomes that result from risk propensity as a trait. The participants were young adults with intentionally limited involvement with drugs of abuse, minimizing the influence of prior drug use on the behaviors (Nasrallah, Yang, & Bernstein, 2009). Thus, we were able to examine the latent structure of several narrowly defined risk-related measures, including indices of perception of risk, willingness to engage in risky behaviors of various kinds, and behavioral performance on objective, computer-based tasks. The measures included in our analysis were (a) The Survey of Consumer Finances Investment Risk Question (SCF IRQ; Aizcorbe, Kennickell, & Moore, 2003), which is a single question asking how much the individual is willing to risk financially; (b) The Domain-Specific Risk-Taking Scale (DOSPERT; Blais & Weber, 2006), which is a multidimensional questionnaire that assesses both the likelihood to engage in risky behaviors and the perception of risk for 6 commonly encountered risk-taking domains; (c) The Probabilistic Choice Questionnaire (PCQ; Madden & Bickel, 2010) which is a questionnaire assessing delay discounting with choices between certain smaller amounts of money and larger uncertain amounts of money; (d) The Probability Discounting Task (PDT; Richards, Zhang, Mitchell, & de Wit, 1999), which also measures delay discounting but is a behavioral task measuring actual choice between certain and uncertain rewards; and (e) the BART (Lejuez et al., 2002) which is a behavioral task involving repeated choices between monetary gains and increasing risk of losses. These measures partially overlapped with the more comprehensive array of measures studied by Frey et al. (2017).

We conducted principal components analyses (PCAs) to identify the component structure of the measures, and to determine how risk perception, likelihood of engaging in behaviors involving risk and performance on tasks involving risk differ across individuals and domains. Contrary to Frey et al. we used an exploratory approach (PCA) rather than a confirmatory analysis because we had a limited array of measures and no specific a priori prediction about the nature of the structure (cf. MacKillop et al., 2016). In addition, we used PCA to examine the latent structure of all variance, not just shared variance, because we expected that risk-related behaviors would be multifaceted in nature. We also examined sex differences and the robustness of the latent structure of risk-related behaviors in our data set.

Understanding the components that comprise the larger constructs of risk perception, willingness to engage in behaviors involving risk and the laboratory measures designed to measure risk is important for several reasons. First, more refined measures will help to characterize the developmental trajectory of risk-taking, related to such factors as age, hormones, and environmental factors. Second, knowing which aspects of risk best predict drug-taking will help to develop interventions to prevent drug misuse and other harmful behaviors. Third, refining the components of risk measures will set the stage for future studies on the genetic or other biological basis of risk-taking.

Method

Participants

Healthy men and women aged 18–31 were recruited at two sites (Athens, GA and Chicago, IL) through online and printed advertisements. A total *N* of 1252 were initially enrolled and the final sample that met eligibility criteria and provided complete data was 1058. Online

screening identified individuals who were fluent in English, had completed high school education, had taken no psychiatric medications in the last year, and reported no current psychiatric treatment. Participants completed the Alcohol Use Disorder Identification Test (AUDIT; Babor, Higgins-Biddle, Saunders, & Monteiro, 2001) and Drug Use Disorder Identification Test (DUDIT; Berman, Bergman, Palmstierna, & Schlyter, 2005), and were only included if they scored 11 or below to avoid any influence of recent substance use. During the in-person visit we verified alcohol sobriety via breathalyzer (Alco-sensor III or IV; Intoximeters, St. Louis, MO) and lack of recent drug use via urine drug screen (ToxCup, Branan Medical Co. Irvine, CA and iCup, Alere North America, LLC, Orlando, FL). Participants were men and women in their early 20's mostly of European-ancestry with about 2 years of college education ($N = 1058$, Table 1). The study was approved by the Institutional Review Boards (IRB11–0549, The genetic basis of behavior) of the University of Chicago and the University of Georgia, and all participants provided informed consent.

Procedures

Participants attended a single 4-hr experimental session to complete study tasks. They were instructed to abstain from alcohol and drugs other than their usual amounts of caffeine and nicotine for 24 hr before the visit. Individuals with positive drug tests were excluded. The measures reported here were part of a larger battery of tasks described elsewhere (MacKillop et al., 2016). The tasks were presented in one of 24 predetermined task orders using a counterbalanced method, with two 5-min breaks. The present analysis consists of both self-report and behavioral indices of risk-taking (listed below). Participants were either paid $40 or received research participation credits, and on one of the tasks (Kirby, Petry, & Bickel, 1999) had a one in six chance of receiving a monetary payoff (up to $10) to incentivize performance. After completing the study, participants were debriefed and compensated for their time.

Self-Report Measures

Survey of Consumer Finances Investment Risk Question (SCF IRQ)—The SCF IRQ (Aizcorbe et al., 2003) measures financial risk-taking behavior. The single multiple-choice question asks, "Which of the statements below comes closest to the amount of financial risk that you are willing to take when you save or make investments?" Possible responses included (a) Substantial financial risks expecting to earn substantial returns, (b) Above-average financial risks expecting to earn above-average returns, (c) Average financial risks expecting to earn average returns, (d) No financial risks. This question is included in a survey sponsored by the Federal Reserve Board in cooperation with the U.S. Department of the Treasury (Grable & Lytton, 1999).

Domain-Specific Risk-Taking Scale (DOSPERT)—This version of the DOSPERT (Blais & Weber, 2006) measures risk attitudes in five commonly encountered content risk domains (ethical, health/safety, investing, recreational, and social). It is a 48-item questionnaire that assesses both likelihood to engage in domain-specific risky activities and perceptions of the magnitude of the risks. Sample items include "Having an affair with a married man/woman," "Investing 10% of your annual income in a new business venture" and "Driving a car without a seatbelt." To assess likelihood to engage in the stated risky

behavior a 7-point rating scale ranging from 1 (*Extremely unlikely*) to 7 (*Extremely likely*) was used. Item ratings were summed within the five domains to obtain subscale scores. Higher scores indicate greater risk taking in the domain of the subscale. To assess risk-perception subjects responded to the same items but instead assess how risky they thought the behavior was, on a 7-point scale ranging from 1 (*Not at all*) to 7 (*Extremely risky*). Item ratings were summed within each domain to yield subscale scores, with higher scores suggesting perceptions of greater risk in the domain.

Probabilistic Choice Questionnaire (PCQ)—The PCQ (Madden & Bickel, 2010) measures probability discounting behavior. It is a questionnaire with 10 questions in each of three blocks, assessing preference between two outcomes: a smaller amount of money delivered "for sure" and a larger amount delivered with a probability of less than 100%, in mixed order. For example, one item asks participants "Would you rather have $20 for sure or a 1-in-10 chance (10%) of winning $80." In Block 1 the certain smaller amount was $20 and the probabilistic larger amount $80. In Block 2 the certain smaller amount was $40 and the probabilistic larger amount $100. In Block 3 the certain smaller amount was $40 and the probabilistic larger amount $80. Each probability reflects predetermined discounting functions, which permit inferring a value for the parameter *h.*

Behavioral Measures

Probability Discounting Task—The PDT (Richards et al., 1999) measures the relative value of certain smaller amounts money versus larger probabilistic amounts of money. All rewards were immediate. A computerized procedure was used to present 70 items in which participants repeatedly chose between $100 with a probability (1.0, 0.9, 0.75, 0.5 and 0.25) and a smaller amount for certain ($10, $20, $30, $40, $50, $60, $70, $80, $90, or $99). Indifference points were calculated, or points at which two options are perceived as equal in value to an individual, and these were used to plot hyperbolic discount curves. The hyperbolic discount functions for probability discounting are calculated as follows:

$$V = \frac{A}{1 + h\theta}, \theta = \frac{1}{P} - 1$$

The V represents the subjective value (the certain smaller amount of money), the A represents the larger amount money ($100). The P represents the probability of receiving the money, the θ stands for odds against receiving the money, and the *h* represents the rate of discounting as a function of decreasing probability. Lower *h* values represent a less rapid rate of discounting based on increasing odds against, reflecting riskier options. To maximize validity and incentivize the task, subjects were told that they would receive the monetary outcome from one of their choices, chosen at random (Kirby et al., 1999).

Balloon Analogue Risk Task (BART)—The BART (Lejuez et al., 2002) is a validated behavioral measure of risk taking (Hunt, Hopko, Bare, Lejuez, & Robinson, 2005; Lejuez et al., 2007). Participants view a balloon on a screen, which they can increase in size with a key press. Each key press increases the balloon size and increases a counter on the screen, with points redeemable for money. However, as the balloon increases in size the probability that it

will explode increases, at which time all accumulated points are lost. The number of pumps before a balloon pops varies randomly between 30 and 120 pumps. The subject can make an alternative response to stop pumping before the balloon explodes and redeem the points. Thus, this task provides a measure of willingness to take risk, at the expense of a possible loss. Each subject had 30 trials. The adjusted average number of pumps on unexploded balloons is the indicator of risk.

Data Analysis

Initially, for all measures, distributions were examined, and log transformations were performed to normalize data with a skew outside the range of −2 to +2 (Supplementary Figures 1.1, 1.2, 1.3, 2). Sex differences across age, years of education, and all risk measures were determined using independent sample *T* tests. Then, internal reliability of risk measures was examined using Cronbach's alpha analyses and Pearson's correlations between measures and subscales were evaluated with a Bonferroni correction for multiple comparisons. Finally, the latent structure of the measures of risk taking was examined using principal components analyses (PCAs). To identify related latent components, the PCAs used an oblique rotation (direct oblimin, $\delta = 0$), permitting correlated components. Two criteria were used to determine the appropriate number of components to retain: eigenvalues >1, and scree plot discontinuity. Significant loadings were defined as >|.30| on the pattern matrix. After performing a full sample PCA, a sex-adjusted PCA was run to determine if the structure was robust across each sex. Sex-adjusted measures were created by regressing each risk measure with sex and saving the standardized residuals. Additionally, a site-adjusted PCA was run to determine if the structure was robust across each site as well. Site-adjusted measures were created by regressing each risk measure with site and saving the standardized residuals. All data analysis was performed in SPSS (v24).

Results

Self-Report and Behavioral Measures

Table 2 provides frequencies of response to the SCF IRQ and summary values for the participants' responses for each DOSPERT subscale, for the 3 blocks of the PCQ, for the PDT, and the BART, separately for men and women, and denotes significant sex differences with a Bonferroni correction for multiple comparisons and Cohen's *d* effect sizes. The values are within the normative range reported for the DOSPERT (Blais & Weber, 2006), PCQ (Madden & Bickel, 2010), the PDT (Richards et al., 1999), and the BART (Lejuez et al., 2002). After the Bonferroni correction, women and men differed on all DOSPERT subscales except social risk-taking behavior. On perception of risk on the DOSPERT, women perceived the risks to be greater than males in all domains and reported being less likely to engage in these behaviors. On the PDT, women had significantly larger discounting *h* values than men, meaning women displayed more discounting (i.e., displayed lower propensity for risk taking). Site differences across risk measures are listed in Supplementary Table 2.

Preliminary Analyses

Before conducting the PCAs, we examined both the internal reliability of the DOSPERT using Cronbach's alpha analyses (see Table 2) and the Pearson's correlation coefficients between all measures and their subscales with a Bonferroni correction for multiple comparisons (see Table 3).

Full sample analysis—A PCA was conducted on the full sample utilizing an oblique rotation. The analysis yielded five components (see Table 4), accounting for 64.40% of the variance (1 = 25.79%, 2 = 15.28%, 3 = 9.48%, 5 = 6.60%; Table 4). Component 1 consisted of DOSPERT Ethical Risk Taking, Ethical Risk Perception, Health/Safety Risk Taking, and Health/Safety Risk Perception. Risk taking component loadings were negative while risk perception component loadings were positive due to their different coding (i.e., where higher or lower scores can indicate higher risk taking). This component reflected commonalities in risk taking and risk perception for health-related and ethical risks, and so we label this component "Health and Ethics." Component 2 consisted of the PDT and the PCQ's *h* values. The component reflects value preferences under varying degrees of likelihood of receipt that are clearly defined and explicit and summarized the probability discounting behaviors so we label this component "Probability Discounting." Component 3 consisted of DOSPERT Financial Risk Taking, Financial Risk Perception, and the SCF IRQ. DOSPERT Financial Risk Taking was positively related to the component while DOSPERT Financial Risk Perception and SCF IRQ were negative due to their different coding. This component reflects a distinct form of risk preference involved in personal finances when monetary outcomes are more unclear (unlike for probability discounting), and so we label this component "Financial Risk." Component 4 consisted of DOSPERT Recreational Risk Taking, Recreational Risk Perception, and Social Risk Taking. This component appears to reflect commonalities among risk preference in recreational or social settings, and so we label this component "Social Risk." Component 5 consisted of DOSPERT Social Risk Perception and the BART. The Social Risk Perception was positively loaded while the loading for the BART was negative. This final component appears to reflect behavior in the presence of manipulated risk and judgment or perception of the stakes in social interactions. This component is difficult to label so we refer to it as "Social/BART."

Sex-adjusted analysis—A PCA was then conducted using sex-adjusted measures of each risk measure. Sex-adjusted measures were created by regressing each risk measure with sex and saving the standardized residuals. The analysis yielded six components (see Table 5), accounting for 70.13% of the variance (1 = 24.64%, 2 = 15.42%, 3 = 9.64%, 4 = 7.41%, 5 = 6.74%, 6 = 6.28%; Table 5) and which were substantially similar to those seen in the full sample without accounting for sex. Component 1 and component 2 consisted of the same measures as the full sample PCA. Component 3 consisted of only DOSPERT Financial Risk Taking and the SCF IRQ. Component 4 consisted of only DOSPERT Recreational Risk Taking and Recreational Risk Perception. Component 5 consisted of DOSPERT Financial Risk Perception and Social Risk Perception. Component 6 consisted of DOSPERT Social Risk Taking and the BART. Thus, with minor variations in the latter components, the component structure was not significantly altered when sex was taken into account.

Site-adjusted analysis—A PCA was also conducted using site-adjusted measures of each risk measure. Site-adjusted measures were created by regressing each risk measure with site and saving the standardized residuals. This analysis yielded five components (Supplementary Table 3), accounting for 63.55% of the variance (1 = 26.03%, 2 = 14.28%, 3 = 8.96%, 4 = 7.52%, 5 = 6.76%; Supplementary Table 3). Component 1, component 2, and component 4 consisted of the same measures as the full sample PCA. Component 3 consisted of only DOSPERT Financial Risk Taking and the SCF IRQ. Component 5 consisted of DOSPERT Social Risk Perception, DOSPERT Financial Risk Perception, and the BART. Thus, with minor variations in the latter components, the component structure taking into account the site differences was similar to that seen in the whole sample.

Discussion

The PCA of several indices of risk preference across 1058 individuals with low levels of substance use revealed a latent structure of five distinct components. Loadings within each of the components were of moderate to large magnitude. Component 1 consisted of DOSPERT Ethical Risk Taking, Ethical Risk Perception, Health/Safety Risk Taking, and Health/Safety Risk Perception, reflecting commonalities in both risk taking and risk perception for health-related and ethical risks. The common theme in the items for these scales pertains to personal and interpersonal responsibility. Component 2 consisted of the PDT and the PCQ's *h* values, the measures of discounting of probabilistic monetary rewards. This component reflects monetary value preferences under varying degrees of likelihood of receipt using clearly defined and explicit choices. Component 3 consisted of several indices of financial risk-taking and perception, and included the DOSPERT Financial Risk Taking, Financial Risk Perception, and the SCF IRQ. This suggests that there are commonalities to both perceptions and likelihood of engaging in risks related to real-life personal finances. Component 4 consisted of DOSPERT Recreational Risk Taking, Recreational Risk Perception, and Social Risk Taking, reflecting risk preferences in hobbies and social interactions, and component 5 consisted of DOSPERT Social Risk Perception and the BART, reflecting behavioral risk taking and judgment of the stakes in interpersonal interactions. This latent structure supports the idea that both perception of risk and likelihood of engaging in risky behaviors are specific to certain domains of experience.

There were several notable differences between men and women. Men reported to be more likely to engage in risky behaviors, whereas women reported a higher perception of risk. Despite these differences, the component structures in men and women remained generally robust. The sex-adjusted PCA revealed a six-component structure to the full sample analysis, one that was very similar overall with only minor differences in the latter components. Our findings add to our understanding of sex differences in risk preference. It has previously been reported that males are more inclined to take risks across a variety of domains, including financial to lifestyle, whereas women are more risk averse (Hudgens & Fatkin, 1985; Powell & Ansic, 1997; Pawlowski, Atwal, & Dunbar, 2008; Charness & Gneezy, 2012). This was also seen in our results. Women perceived greater risk in all domains of the DOSPERT, except social, and they were less likely to take the risks in all domains. Thus, women perceived risks as riskier and were more risk averse. Despite these sex differences, the sex-adjusted PCA indicated nearly the same five components as our full sample

unadjusted PCA, suggesting similar underlying component structures in men and women. The only differences between the full sample and sex-adjusted PCAs were the loadings of DOSPERT Social Risk Taking, Social Risk Perception, and Financial Risk Perception. It remains to be determined whether these reflect true and robust differences in the factor structures.

Although the two sites differed in demographic characteristics and measures of both perception and likelihood of engaging in risky behaviors, the factor structure did not differ substantially when adjusting for site. Individuals at the UC differed from those at the UGA in age and years of education. UGA individuals reported a higher perception of risk on all domains and differed on all risk-taking domains from UC individuals except for the Recreational domain. The site-adjusted PCA yielded nearly the same five components as our full sample unadjusted PCA, suggesting a robust component structure across site. The only difference between the full sample and site-adjusted PCAs was the loading of the DOSPERT Financial Risk Perception. It is important to note that this subscale appeared to load nearly equally to component 3 and 5, just with opposing signs. The similarity in factor structure across site with different demographic characteristics attests to the robustness of the underlying structure.

These results substantially support the contemporary view that risk preference, whether risk perception or behavior in the presence of risk, is multidimensional and domain-specific. Although risk preference was previously considered a unitary personality trait (i.e., risk-taking or risk averse) a growing body of evidence suggests that risk-taking consists of different components or domains (Blais & Weber, 2001, 2006; Weber, Blais, & Betz, 2002). Our findings support this, indicating, for example, that both perceptions of risk and risky ethical or health and safety behaviors are independent of perceptions and likelihood of engaging in financial, recreational or social behaviors. In addition, our findings also fit with those of Reynolds, Ortengren, Richards, and de Wit (2006) suggesting that the type or format of a risk-taking measure may influence participants' responses and thus influence the correlation among measures. This is seen in components 2 and 3 of our full sample PCA, in which financial risk-taking measured by the DOSPERT and SCF IRQ yielded related scores, whereas those were directly related to financial risk-taking but with highly similar formats (i.e., the PDT and the PCQ) were related. The covariation of the PDT and PCQ was likely influenced by close similarities in the structure of the items (e.g., choices between certain and probabilistic monetary rewards). The similarities and differences in the format of the measures should be taken into account when interpreting the loadings on separate components. Nevertheless, the present results provide good evidence for domain-specific components of risk-taking among measures with similar formats (e.g., within the DOSPERT), especially components distinguishing health-related risk from financial risk.

The BART, which was a primary behavioral index of risk-taking, was not related to most other outcome measures. Previous studies have reported mixed results on the relationship between BART performance and either real-life risk-taking or performance on other risk measures. Lejuez et al. (2002) reported that the BART was correlated with several real-life risk-taking behaviors including addictive, health, and safety risk behaviors. Others have reported that populations thought to be risk-takers exhibit riskier behavior on the BART

(e.g., smokers vs. nonsmokers, individuals high on self-reported impulsivity or psychopathy, jailed inmates, cocaine users; Hunt et al., 2005; Lejuez et al., 2003, 2007; Swogger, Walsh, Lejuez, & Kosson, 2010; Tull et al., 2009), but there have also been reports of associations in the opposite direction (Courtney et al., 2012; Ryan, Mackillop, & Carpenter, 2013). The present study is one of the first to investigate the BART in relation to other indices of risk-taking using a latent variable approach in a well-powered sample of adults. The findings supported the idea that the BART measures a different underlying construct than self-report measures or, in the present study, probabilistic discounting.

Our findings can be examined in relation to the findings by Frey et al. (2017) who conducted a comprehensive analysis of 39 measures of risk (compared to our seven). First, they identified an overall general risk factor that was related to frequency of engaging in real-life risky behaviors such as smoking. This overall risk factor was not clearly apparent in our analysis, although we did not use health behaviors to define the risk trait. Second, in their study self-report measures of risk were not strongly related to behavioral measures of risk. This is consistent with observation in our study that neither the BART nor the PDT were strongly correlated with self-report measures such as the DOSPERT. Not surprisingly, in both studies perception of risk was related to likelihood of engaging in risky behaviors. Although Frey et al. (2017) do not report on sex differences within their measures, they do note, consistent with our findings, that the factor structure among the measures was similar in men and women. It is important to distinguish the Frey study from the present report, on theoretical and methodological grounds. Whereas Frey et al. (2017) included individuals with drug and alcohol use allowing them to examine relationships between risk and substance use, our study characterized the latent structure of risk measures not directly related to substance use and in individuals with relatively light levels of substance use. Because we aimed to understand risk-propensity as a determinant of future substance use we did not include substance use itself as a predictor. In addition, attribution about personal risk on nonsubstance use items on self-report risk inventories (e.g., DOSPERT) can similarly be contaminated by personal recollections of substance use behavior. For example, a person may endorse risk taking tendencies because of actions they engage in when intoxicated, making a link between the tendency and their personal substance use potentially tautological. The goal of the current study was to address these issues in characterizing the latent structure of risk preference indicators. Nevertheless, there are commonalities between the Frey findings and our own. Both studies support the idea that risk (including perception of risk or likelihood of engaging in behaviors involving risk) is multifactorial and should be assessed using a range of measures.

The present study had several limitations. First, it included only a subset of possible indices of risk-taking. Further research using additional indices of risk, both self-report and behavioral, such as the Risk Perception Scale (Benthin, Slovic, & Severson, 1993), or the Wheel of Fortune Task (Ernst et al., 2004), or some of the many other measures included by Frey et al. (2017) will help refine the underlying constructs. Although we included some of the most widely used indices, latent structure is inherently a function of the indicators included. The sex- and site-adjusted structures were very similar to the overall findings, but not perfectly identical, suggesting that demographic characteristics could exert subtle influences. Clarifying this may be a target for future studies. Finally, it is important to note

that the intentional focus on individuals with low levels of substance use means the latent structure may not extend to individuals with addictive disorders. This is a clear priority for future studies.

Our study extended knowledge about perception of risk, likelihood of engaging in behaviors involving risk, and laboratory measures of risk preference in several ways. We identified five distinct components reflecting apparently separate forms of risk-related behaviors and identified which measures fell under each component. Additionally, we ascertained these constructs in participants who were screened for psychiatric symptomatology or addictive behaviors, which minimized possible confounds that these variables might contribute to the data. Ultimately, furthering our understanding of risk-taking behaviors and how to reliably and effectively measure them will help to design prevention strategies to minimize risky behaviors with negative outcomes such as substance use leading to dependence.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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Public Health Significance

This study suggests that the perception of risk and likelihood of engaging in behaviors involving risk are not unitary and can be domain specific. Refining these measures will help to identify key components of risk that lead to harmful behaviors

Table 1

Participant Characteristics by Sex

Characteristic	Males (*n* = 398)	Females (*n* = 660)	*p*, Cohen's d	Full Sample (*n* = 1058)
Age	21.5 (0.16)	20.92 (0.12) **	0.004 (0.185)	21.14 (0.1)
Race				
Caucasian	79.1%	79.4%		79.5%
African American	6.8%	7.4%		7.2%
Asian	8.5%	8.5%		8.5%
Other	5.1%	4.7%		4.9%
Years of Education	14.3 (0.11)	14.17 (0.08)	0.257 (0.069)	14.22 (0.07)

Note. Age and years of education are listed as mean (SEM), Sex differences comparisons

** $p < 0.005$.

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Table 2

Risk Measures by Sex

Measure outcome	Males	Females	*P* (Cohen's *d*)	Full Sample
SCF IRQ				
"Substantial financial risks expecting to earn substantial returns"	2.4%	3.5%		4.5%
"Above-average financial risks expecting to earn above-average returns"	16.8%	24.8%		18.7%
"Average financial risks expecting to earn average returns"	57.9%	54.8%		54.9%
"No financial risks"	22.9%	16.9%		21.9%
DOSPERT				
Ethical Perception (.701, 6)	26.74 (6.03)	28.79 (6.04) *	.000 (.340)	28.02 (.19)
Financial Perception (.779, 6)	29.35 (5.81)	31.21 (6.19) *	.000 (.310)	30.51 (.19)
Health/Safety Perception (.728, 6)	27.68 (5.77)	30.64 (5.93) *	.000 (.506)	29.53 (.19)
Recreational Perception (.660, 6)	22.84 (6.45)	25.30 (6.60) *	.000 (.377)	24.38 (.2)
Social Perception (.541, 6)	16.14 (4.91)	17.42 (4.93) *	.000 (.260)	16.94 (.15)
Ethical Taking (.541, 6)	13.12 (4.47)	12.22 (4.71) *	.002 (.196)	12.55 (.14)
Financial Taking (.758, 6)	16.64 (6.52)	13.43 (5.36) *	.000 (.538)	14.63 (.19)
Health/Safety Taking (.600, 6)	19.2 (6.71)	16.74 (6.5) *	.000 (.372)	17.66 (.21)
Recreational Taking (.838, 6)	25.24 (9.48)	21.93 (9.1) *	.000 (.356)	23.18 (.30)
Social Taking (.621, 6)	30.45 (5.49)	30.02 (5.54)	.228 (.078)	30.18 (.17)
PDT[1] (*h*) (.836, 80)[2]				
Log Transformed	.3244 (.51)	.4606 (.64) *	.000 (.237)	.4093 (.02)
PCQ[1] (*h*) (.998, 100)[3]				
Log Transformed				
Block 1	.2534 (.33)	.3049 (.39)	.022 (.143)	.2855 (.01)
Block 2	.1915 (.33)	.2396 (.37)	.029 (.136)	.2215 (.36)
Block 3	.2146 (.4)	.2167 (.44)	.934 (.005)	.2159 (.43)
BART[4]	32.91 (16.43)	31.12(16.89)	.092 (.107)	31.8 (.516.7)

Note. SCF IRQ = survey of consumer finances investment risk question; DOSPERT = Domain-Specific Risk-Taking Scale; PDT = The Probability Discounting Task; PCQ = Probabilistic Choice Questionnaire; BART = Balloon Analogue Risk Task. Frequencies of SCF IRQ responses listed as percentage of total sample, split by sex. All other scores are listed as Mean (*SD*).

[1] All measures with a skew value greater than 2 were log transformed.

[2] (R^2, *N* of items).

[3] (Consistency, N of items).

[4] BART has no measure of internal reliability, Sex differences comparisons with Bonferroni correction for multiple comparisons

* $p < .003$.

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Table 3

Correlation Matrix for All Risk Measures and Subscales

Measure outcome	SCF IRQ	PDT	PCQ Block 1	PCQ Block 2	PCQ Block 3	DOSPERT Ethical Risk Taking	DOSPERT Financial Risk Taking	DOSPERT Health/ Safety Risk Taking	DOSPERT Recreational Risk Taking	DOSPERT Social Risk Taking	DOSPERT Ethical Risk Perception	DOSPERT Financial Risk Perception	DOSPERT Health/ Safety Risk Perception	DOSPERT Recreational Risk Perception	DOSPERT Social Risk Perception	BART
SCF IRQ	1	.132* (.000)	.152* (.000)	.154* (.000)	.102* (.001)	−.120* (.000)	−.434* (.000)	−.106* (.001)	−.211* (.000)	−.038 (.212)	.032 (.305)	.183* (.000)	.068 (.027)	.117* (.000)	−.024(441)	−.007 (.808)
PDT Log H		1	.544* (.000)	.579* (.000)	.476* (.000)	−,159* (.000)	−.202* (.000)	−.141* (.000)	−.159* (.000)	−.026 (401)	.077 (.012)	.187* (.000)	.101* (.001)	.119* (.000)	.025 (.411)	.041 (.178)
PCQ Block 1 Log			1	.773* (.000)	.481* (.000)	−.154* (.000)	−.155* (.000)	−,139* (.000)	−.129* (.000)	−.071 (.012)	.160* (.000)	.178* (.000)	.148* (.000)	.154* (.000)	.048 (.119)	−.051 (.099)
PCQ Block 2 Log				1	.647* (.000)	−.128* (.000)	−.173* (.000)	−.125* (.000)	−.146* (.000)	−.070 (.023)	.109* (.000)	.167* (.000)	.106* (.001)	.137* (.000)	.052 (.092)	−.019 (.546)
PCQ Block 3 Log					1	−.104* (.001)	−.123* (.000)	−,089(.004)	−.140* (.000)	−.034 (.269)	.073 (.018)	.104* (.001)	.035 (.255)	.113* (.000)	.009 (.760)	−.014 (.654)
DOSPERT Ethical Risk Taking						1	.273* (.000)	.444* (.000)	.156* (.000)	.175* (.000)	−.503* 0000)	−.205* (.000)	−.338* (.000)	−.171* (.000)	−.125* (.000)	.072 (.019)
DOSPERT Financial Risk Taking							1	.211* (.000)	.350* (.000)	.101* (.001)	−.103* 0001)	−.485* (.000)	−.114* (.000)	−.174* (.000)	−,016(.606)	−.016 (606)
DOSPERT Health/ Safety Risk Taking								1	.399* (.000)	.292* (.000)	−.324* (.000)	−.171* (.000)	−.605* (.000)	−.338* (.000)	−.151* 0000)	.108* 0000)
DOSPERT Recreational Risk Taking									1	.267* (.000)	−,090(.003)	−.172* (.000)	−.219** (.000)	−.535* (.000)	−.112* (.000)	.026 (.396)
DOSPERT Social																

Measure outcome	SCF IRQ	PDT	PCQ Block 1	PCQ Block 2	PCQ Block 3	DOSPERT Ethical Risk Taking	DOSPERT Financial Risk Taking	DOSPERT Health/ Safety Risk Taking	DOSPERT Recreational Risk Taking	DOSPERT Social Risk Taking	DOSPERT Ethical Risk Perception	DOSPERT Financial Risk Perception	DOSPERT Health/ Safety Risk Perception	DOSPERT Recreational Risk Perception	DOSPERT Social Risk Perception	BART
Risk Taking										1	−.221* (.000)	−.098* (.001)	−.218* (.000)	−.175* (.000)	−.359* (.000)	.159* 0000)
DOSPERT Ethical Risk Perception											1	.368* (.000)	.600* (.000)	.386* (.000)	.372* (.000)	−.204* (.000)
DOSPERT Financial Risk Perception												1	.353* (.000)	.337* (.000)	.218* (.000)	−.068 (.027)
DOSPERT Health/ Safety Risk Perception													1	.538* (.000)	.341* 0000)	−.167* 0000)
DOSPERT Recreational Risk Perception														1	.365* (.000)	−.106* 0001)
DOSPERT Social Risk Perception															1	−.117* 0000)

Note. SCF IRQ = survey of consumer finances investment risk question; DOSPERT = Domain-Specific Risk-Taking Scale; PDT = The Probability Discounting Task; PCQ = Probabilistic Choice Questionnaire; BART = Balloon Analogue Risk Task. Pearson's correlation coefficients presented as Pearson's Correlation (*p* - value),

* Correlation is significant at the Bonferroni multiple comparisons corrected α =.003 level.

Table 4

Full Sample Principal Components Analysis: Pattern Matrix Loadings

	Full Sample Loadings				
Measure outcome	**Component 1: "Health and Ethics" 25.79% of variance**	**Component 2: "Probability Discounting" 15.28% of variance**	**Component 3: "Financial Risk" 9.48% of variance**	**Component 4: "Social Risk" 7.25% of variance**	**Component 5: "Social/ BART" 6.60% of variance**
DOSPERT Ethical Risk Taking	**−.845**	−.044	.091	−.122	.095
DOSPERT Health/Safety Risk Taking	**−.725**	−.018	−.075	.427	.173
DOSPERT Ethical Risk Perception	**.586**	.024	−.065	.15	.527
DOSPERT Health/Safety Risk Perception	**.587**	−.01	−.016	−.185	.364
PCQ Block 1 LogH	.029	**.849**	.006	.037	.065
PCQ Block 2 LogH	−.034	**.92**	.013	0	.03
PCQ Block 3 LogH	−.046	**.798**	.059	−.034	−.033
PDT LogH	.042	**.753**	−.062	.006	−.063
DOSPERT Financial Risk Taking	−.076	−.01	**.829**	.088	.096
DOSPERT Financial Risk Perception	.05	.039	**− .694**	.137	.479
SCFIRQ	−.027	.03	**− .667**	−.1	−.165
DOSPERT Recreational Risk Taking	−.021	−.048	.225	**.83**	.174
DOSPERT Social Risk Taking	−.043	−.011	−.112	**.526**	−.253
DOSPERT Recreational Risk Perception	.068	.04	−.179	**− .552**	.374
DOSPERT Social Risk Perception	−.111	−.002	.004	−.241	**.752**
BART: Mean Adjusted Pumps (for unpopped balloons)	−.058	−.008	−.08	−.006	**−.4**

Note. SCF IRQ = survey of consumer finances investment risk question; DOSPERT = Domain-Specific Risk-Taking Scale; PDT = The Probability Discounting Task; PCQ = Probabilistic Choice Questionnaire; BART = Balloon Analogue Risk Task. All values over .3 are in bold.

Table 5

Sex-Adjusted Principal Components Analysis: Pattern Matrix Loadings

Measure outcome	Sex-Adjusted Loadings					
	Component 1: 24.64% of variance	**Component 2: 15.42% of variance**	**Component 3: 9.64% of variance**	**Component 4: 7.41% of variance**	**Component 5: 6.74% of variance**	**Component 6.28% of variance**
DOSPERT Ethical Risk Taking	**−.832**	−.039	.164	−.142	.124	.041
DOSPERT Health/Safety Risk Taking	**−.729**	−.017	−.035	.405	.201	.059
DOSPERT Ethical Risk Perception	**.609**	.031	.071	.186	.467	−.114
DOSPERT Health/Safety Risk Perception	**.623**	−.001	.162	−.191	.38	.015
PCQ Block 1 LogH	.03	**.849**	.011	.051	.033	−.049
PCQ Block 2 LogH	−.034	**.919**	.009	.012	.007	−.04
PCQ Block 3 LogH	−.045	**.794**	.03	−.034	−.043	−.017
PDT LogH	.036	**.759**	−.031	−.019	−.011	.107
DOSPERT Financial Risk Taking	−.067	−.004	**.844**	.092	−.098	−.035
SCF IRQ	−.042	.027	**−.725**	−.064	−.077	−.101
DOSPERT Recreational Risk Taking	−.016	−.048	.226	**.839**	.046	.037
DOSPERT Recreational Risk Perception	.096	.052	.036	**−.602**	.523	.071
DOSPERT Financial Risk Perception	.085	.045	−.495	.091	**.678**	.108
DOSPERT Social Risk Perception	−.091	.005	.157	−.137	**.632**	−.365
BART: Mean Adjusted Pumps (for unpopped balloons)	−.053	−.002	.04	−.219	−.025	**.734**

Note. SCF IRQ = survey of consumer finances investment risk question; DOSPERT = Domain-Specific Risk-Taking Scale; PDT = The Probability Discounting Task; PCQ = Probabilistic Choice Questionnaire; BART = Balloon Analogue Risk Task. All values over .3 are in bold.

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