



A review of behavioral and biological correlates of sensation seeking

Jonathan W. Roberti

*New College of Florida and the University of South Florida-Sarasota, Parkview House,
5700 North Tamiami Trail, Sarasota, FL 34243, USA*

Abstract

The purpose of this paper is to provide a review of studies related to sensation seeking. A description of sensation seeking and methodology to measure various preferences for sensation seeking is identified. In addition, the relation of sensation seeking with other personality factors is also examined. Various behavioral expressions of sensation seeking in the domains of vocational choices, habits, hobbies, risk perception, and risk appraisal are explored. Furthermore, biological characteristics related to sensation seeking are highlighted. Lastly, areas for future research are suggested, especially the investigation of non-risky forms of sensation seeking in young adults.

© 2003 Elsevier Inc. All rights reserved.

Keywords: Sensation seeking; Behavioral; Biological correlates

1. Introduction

Sensation seeking is “a trait defined by the seeking of varied, novel, complex, and intense sensations and experiences, and the willingness to take physical, social, legal, and financial risks for the sake of such experience” (Zuckerman, 1994, p. 27). Sensation seeking traits can be measured via standard self-report questionnaires (e.g., SSS-V). These traits can be partitioned into four dimensions: thrill and adventure seeking, experience seeking, disinhibition, and boredom susceptibility (Zuckerman, Eysenck, & Eysenck, 1978). Currently, the explanation for sensation seeking is based on a model influenced by genetic, biological, psychophysiological, and social factors

E-mail address: Jroberti@ncf.edu.

(Zuckerman, 1983, 1984, 1990, 1994, 1996; Zuckerman, Buchsbaum, & Murphy, 1980), which influence certain behaviors, attitudes, and preferences.

Sensation seeking individuals tend to engage in behaviors that increase the amount of stimulation they experience. Such behaviors (e.g., interest in stimulating occupations, drug use, driving recklessly, etc.) involve seeking out arousal. The activities to fulfill the preferred arousal vary in the amount of risk associated with them. Risk taking is a correlate of sensation seeking but is not a primary motive in behavior (Zuckerman, 1994). Sensation seekers accept risk as a possible outcome of obtaining this arousal, yet do not seek out risk for its own sake (Zuckerman, 1994).

Satisfying a preference for stimulation can be accomplished through many behaviors, activities, and attitudes (Arnett, 1991; Irwin & Millstein, 1986; Zuckerman, 1985, 1994; Zuckerman & Neeb, 1980). These areas include such things as occupational choice, recreation, lifestyle choices, sports, and social interactions. The purpose of this paper is to examine how sensation seeking preference is associated with preference for certain behaviors, attitudes, and activities. Additionally, biological correlates associated with preference for sensation seeking are identified. To assist the reader, Table 1 provides magnitude of experimental effects for various studies reviewed in this paper.

2. Sensation seeking characteristics

Sensation seeking is a constellation of personality traits related to a primary group of personality traits (Glicksohn & Abulafia, 1998; Zuckerman, 1994; Zuckerman et al., 1993). Because there is no agreement about how many broad personality traits exist, two common taxonomies exist. The “Big Five” measures five difference dimensions labeled: neuroticism, extraversion, openness, agreeableness, and conscientiousness. The “Big Three” measures the traits of psychoticism, extraversion, and neuroticism. These broad traits of personality are typically measured with questionnaires, including the Neuroticism, Extraversion, and Openness Personality Inventory, Revised (NEO-PI-R; Costa & McCrae, 1992) and the Eysenck Personality Questionnaire (EPQ-R; Eysenck, Eysenck, & Barrett, 1985a).

Sensation seeking is a dimension of personality that is related to factors in the five-factor model of personality (Aluja, Garcia, & Garcia, 2002). Zuckerman (1994) reports that Costa and McCrae (1990, as cited in Zuckerman, 1994) found a positive correlation ($r = .45, p < .01$) between the sensation seeking total score on the SSS-V and the NEO-PI-R scale of Openness to Experience. Furthermore, all subscales on the SSS-V, especially the experience seeking (ES) subscale, correlated significantly with the Openness to Experience scale on the NEO-PI. In addition, the Agreeableness scale of the NEO-PI correlated with the total sensation seeking score, the Disinhibition subscale, and Boredom Susceptibility subscale. Zuckerman et al. (1993) found similar results, associating the Openness scale of the NEO-PI-R with the Experience Seeking scale ($r = .43, p < .01$) of the SSS-V and Agreeableness with the SSS-V subscales of Disinhibition ($r = -.40, p < .01$) and Boredom Susceptibility subscale ($r = -.048, p < .01$).

Table 1
Magnitude of experimental effect for selected studies of sensation seeking

Selected studies of sensation seeking	
<i>Age and gender</i>	
High	Caspi et al. (1997), Zuckerman, Kuhlman, Thornquist, and Kiers (1991), and Zuckerman and Neeb (1980)
Medium	Ball, Farnill, and Wangeman (1984), Newcomb and McGee (1991), and Rolison and Scherman (2002)
Low	
<i>Alcohol usage</i>	
High	
Medium	Beck, Thombs, Mahoney, and Fingar (1995), Cohen and Fromme (2002), Earleywine and Finn (1991), Earleywine, Finn, and Martin (1990), MacDonald, Fleming, and Barry (1991), and Read, Wood, Kahler, Maddock, and Palfai (2003)
Low	
<i>Substance usage</i>	
High	Martin et al. (2002) and Stephenson et al. (2002)
Medium	Baker and Yardley (2002), Comeau, Stewart, and Loba (2001), Donohew, Clayton, Skinner, and Colon (1999a, 1999b), and Gendaszek and Graff (2002)
Low	
<i>High risk sports</i>	
High	
Medium	Malkin and Rabinowitz (1998)
Low	Gomà-I-Freixanet (1991), Robinson (1985), and Wagner and Houlihan (1994)
<i>Risky sexual situations</i>	
High	Arnold, Fletcher, and Farrow (2002) and Cooper, Shapiro, and Powers (1998)
Medium	Seal and Agostinelli (1994), Wiederman and Hurd (1999), Williams et al. (1992), and Zuckerman, Tushup, and Finner (1976)
Low	
<i>Gambling</i>	
High	Breslin, Sobell, Cappell, and Poulos (1999)
Medium	McDaniel (2002)
Low	
<i>Stimulating vocations</i>	
High	Biersner and LaRocco (1983) and Kish and Donnenwerth (1969)
Medium	Best and Kilpatrick (1977), Oleszkiewicz (1982), and Waters, Ambler, and Waters (1976)
Low	Roberti (2003) and Zaleski (1984)
<i>Other risky forms of sensation seeking</i>	
High	Bradley and Wildman (2002), D'Silva, Harrington, Palmgreen, Donohew, and Lorch (2001), Stanford, Greve, Boudreaux, Mathias, and Brumbelow (1996), Vermeiren et al. (2003), and Zuckerman (1985)

Table 1 (continued)

Selected studies of sensation seeking	
Medium	Arnett (1991), Foxcroft and Lowe (1995), Iversen and Rundmo (2002), Pfefferbaum and Wood (1994), and Smith, Ptacek, and Smoll (1992)
Low	Irwin and Millstein (1986) and Roberti, Storch, and Bravata (2003a, 2003b)
<i>Sports involvement</i>	
High	
Medium	Malkin and Rabinowitz (1998), Joireman, Fick, and Anderson (2002), O'Sullivan, Zuckerman, and Kraft (1998), Wagner and Houlihan (1994), and Zuckerman, Kuhlman, Joireman, Teta, and Kraft (1993)
Low	
<i>Risk perception and risk appraisal</i>	
High	Franken, Gibson, and Rowland (1992), Horvath and Zuckerman (1993), and Zuckerman (1991a)
Medium	Donohew et al. (1999a, 1999b)
Low	
<i>Other non-risky forms of sensation seeking</i>	
High	
Medium	Kass and Vodanovich (1990), McNamara and Ballard (1999), Rawlings (2003), and Zelenski, Rusting, and Larsen (2003)
Low	Trice and Ogden (1986)
<i>Biological correlates of sensation seeking</i>	
High	Daitzman and Zuckerman (1980) and Dellu, Piazza, Mayo, Le Moal, and Simon (1996)
Medium	Balada, Torrubia, and Maria Arque (1993), Ballenger et al. (1983), Carrasco, Saiz-Ruiz, Diaz-Marsa, Cesar, and Lopez-Ibor (1999), Gerra et al. (1999), Longato-Stadler, af Klinteberg, Garpenstrand, Orelund, and Hallman (2002), Netter, Hennig, and Roed (1996), Piazza et al. (1993), and Ruegg et al. (1997)
Low	Fulker, Eysenck, and Zuckerman (1980) and Neary and Zuckerman (1976)
None	Zuckerman (1984, 1990, 1991a) and Zuckerman et al. (1980)

Note. Two groups of magnitude of experimental effect were identified in the above studies: standardized mean differences (Glass' Δ , Hedges' g , and Cohen's d) and uncorrelated/correlated variance accounted for (r^2 , R^2 , η^2 , ω^2 , Cohen's D , and squared interclass correlation).

When an effect size was not reported, effect size was computed, provided sufficient statistics were available. Magnitudes of experimental effect are arranged from high, medium, to low (Cohen, 1988).

Sensation seeking traits are associated with a variety of other personality features from the "Big Three" model of personality. Glicksohn and Abulafia (1998) utilized factor analysis to determine the relation between the EPQ-R-S (Eysenck et al., 1985a, 1985b) and the SSS-V (Zuckerman et al., 1978). The Psychoticism (P) scale of the EPQ-R-S tends to relate to experience-seeking scores whereas the Extraversion (E) scale of the EPQ-R-S relates with Thrill and Adventure Seeking scores. Lastly, Zuckerman et al. (1993) found a relation between the Psychoticism dimension of

the Eysenck Personality Questionnaire (EPQ) and all of the sensation seeking scales of the SSS-V.

Association of certain sensation seeking traits with broader factors of personality leads to a debate about “good” and “bad” forms of sensation seeking. Zuckerman (1994) defined impulsive, unsocialized sensation seeking (ImpUSS) and non-impulsive, socialized sensation seeking as two forms of sensation seeking. Glicksohn and Abulafia (1998) suggest that impulsive, unsocialized sensation seeking (ImpUSS) is comprised of three subcategories on the SSS-V (Disinhibition, Experience Seeking, and Boredom Susceptibility) and the Psychoticism (P) scale from the EPQ-R-S. Non-impulsive, socialized sensation seeking is comprised of the Thrill and Adventure Seeking (TAS) subscale of the SSS-V. Furthermore, high sensation seekers who have elevated scores on Disinhibition and Boredom Susceptibility subscales are more conniving, nonconforming, nonconventional, and lack planning skills (Glicksohn & Abulafia, 1998). When impulsivity is combined with a high sensation seeking profile, there may be less sensitivity to risk and a lack of planning by the individual. For example, prison inmates have been found to exhibit hostility, impulsivity, negative emotions, and anger (Knust & Stewart, 2002).

Various measures of sensation seeking have been proposed: the Barratt Impulsiveness Scale—Version 1.0 (BIS; Barratt, 1985; Patton, Stanford, & Baratt, 1995), the Eysenck Impulsiveness Scale (EIS; Eysenck, Pearson, Easting, & Allsopp, 1985b), and the Behavioral Constraint factor of the Multidimensional Personality Questionnaire (MPQ; Tellegen, 1982). Each of these measures capture narrowly defined variants of the sensation seeking construct and do not provide the most detailed way to identify sensation-seeking characteristics. A more detailed analysis of sensation seeking can be obtained with two self-report instruments—the Sensation Seeking Scale V (SSS-V; Zuckerman et al., 1978) and the Zuckerman–Kuhlman Personality Questionnaire (ZKPQ; Zuckerman et al., 1993). The SSS-V provides an operational measure of a general factor of sensation seeking composed of four broader subscales.

The Sensation Seeking Scale (SSS-V) is a valid and reliable method for determining an individual’s behavioral expressions of sensation seeking traits (Brocke, Beauducel, & Tasche, 1999; Cronin, 1995; Zuckerman, 1994; Zuckerman, Bone, Neary, Mangelsdorff, & Brustman, 1972). Previous studies validated the scale content with data from self and/or peer rating of behavior and laboratory measures theoretically associated with the behavior (Brocke et al., 1999; Cronin, 1995; Zuckerman, 1994; Zuckerman et al., 1972). Using the SSS-V, the characteristics of sensation seeking are a combination of four narrower subcomponents: Thrill and Adventure Seeking, Experience Seeking, Disinhibition, and Boredom Susceptibility. Factor replication of the SSS-V has been demonstrated with clinical and non-clinical US, British, Australian, French, and Canadian samples (Ball et al., 1984; Loas et al., 2001; Roberti et al., 2003a; Rowland & Franken, 1986; Zuckerman et al., 1978). Concerns about internal reliability of the subscales has been raised in a recent reliability generalization study which found marginal reliability coefficients for the subscales of the SSS-V (Deditius-Island, Heide, & Caruso, 2002), especially in younger samples. Therefore, continued efforts to assess the factor structure and reliability of items in younger samples are warranted.

The Zuckerman–Kuhlman Personality Questionnaire (ZKPO) is considered an “alternative” five-factor model of personality (Zuckerman et al., 1993) that measures five factors of personality: (Impulsive Sensation Seeking, Neuroticism-Anxiety, Aggression-Hostility, Activity, and Sociability). Impulsive sensation seeking is a general type of sensation seeking based on impulsive activities with strong convergent validity with general forms of sensation seeking (Roberti et al., 2003a). Based on measurement of traits from these two instruments, various behavioral expressions of sensation seeking can be explored and can be predictive of many different life experiences, preferences, behaviors, and thoughts (Zuckerman, 1994).

3. Behavioral expressions of sensation seeking

Sensation seeking preferences measured by self-report questionnaires are related to engagement in various sensation seeking behaviors (Brocke et al., 1999). A preference to seek out varied, novel, and complex sensations and experience, typically has a risk factor associated with it. Risks can be physical, legal, financial, or social according to the definition of sensation seeking (Zuckerman, 1994). For some individuals the rewards of the sensation outweigh any possible punishments from engaging in the activity and there is a willingness to take risks for the sake of the experience. Risk is not the primary source of arousal for high sensation seekers and they do not engage in activities for that purpose. Most try to minimize the risk by taking precautions (Zuckerman, 1979b, 1991b, 1994).

However, for those that do engage in risky activities, the options can take various forms including: use of alcohol, use of other drugs, promiscuous sexual activities, gambling, high-risk sports, and other forms of recreation. The review that follows illustrates these preferences. Scores on sensation seeking questionnaires are associated with: alcohol usage (Cohen & Fromme, 2002; Earleywine & Finn, 1991; Earleywine et al., 1990), other drug use (Donohew et al., 1999a, 1999b), high risk or extreme sports (Gomà-I-Freixanet, 1991; Malkin & Rabinowitz, 1998; Robinson, 1985; Wagner & Houlihan, 1994), unprotected sexual activities (Williams et al., 1992; Zuckerman et al., 1976), impulsivity (Pfefferbaum & Wood, 1994; Stanford et al., 1996), and excessive gambling (Breslin et al., 1999; McDaniel, 2002).

3.1. Stimulating vocational choices

Vocations with new, novel, and stimulating occupational demands are an attractive source of stimulation for sensations seekers. Analysis of sensation seeking reveals that more adventurous and non-conventional vocational choices are ideally suited for individuals with sensation seeking preferences. Numerous studies have found sensation seeking characteristics to be associated with vocational interests and choices (Best & Kilpatrick, 1977; Biersner & LaRocco, 1983; Kish & Donnerwerth, 1969; Oleszkiewicz, 1982; Roberti, 2003; Waters et al., 1976; Zaleski, 1984).

A stimulating occupation can be a source of arousal for high sensation seekers. Kish and Donnerwerth (1969) found that certain occupations on the Strong

Vocational Interest Blank (SVIB) correlated with scores on a sensation seeking scale. High sensation seeking scores positively correlated with vocational interest patterns associated with novel situations, stimulating surroundings, unstructured tasks, and flexibility in their approach as major components of their occupational demands. Males with high sensation seeking scores tended to choose scientific or social service careers (e.g., psychologist, psychiatrist, and social worker). In contrast, low sensation scores were related to structured, well-defined tasks with order and routine in the occupation. For females, traditional vocations (e.g., housewife and home economics teacher) were negatively related to sensation seeking scores, whereas sensation seeking scores were positively related to occupations with stimulating occupational demands.

Investigation of personality traits of individuals already in a chosen occupation has been completed. Zaleski (1984) found that sensation seeking scores were related to certain chosen professions. Occupations including firefighters, mountain rescue, and mine rescue squads tended to have higher thrill and adventure seeking scores when compared with sportsmen professions (e.g., race car drivers, mountain climbers, and parachutists). The sportsmen group also had elevated thrill and adventure seeking scores of the SSS-V. Furthermore, both groups had elevated scores on the disinhibition scale when compared with a matched control group.

Various individuals are attracted to vocations with a higher degree of risk. In a study investigating US Navy divers, Biersner and LaRocco (1983) found that the divers had an internal locus of control, socialized less with others outside of their profession, and had fewer reports of chronic anxiety than norm male groups. The sensation seeking scores for this sample revealed a preference for thrill and adventure seeking through risky activities associated with danger. They also displayed a low level of disinhibition and experience seeking indicating minimal preference for mental or social activities that are novel or unconventional. These results are consistent with prior findings indicating that sensation seeking declines with age. Results from this study suggest that individuals in this occupation prefer stimulation that is more external, or derived from the environment, with a moderate degree of risk.

Although some occupations are risky, many are non-risky yet stimulating. In a study by Waters et al. (1976), it was found that pre-flight students in the US Navy indicated high external sensation seeking and thrill and adventure seeking preferences, yet have low disinhibiting and experience seeking behaviors. Similarly, Roberti (2003) recently found that sensation seeking characteristics are related to undergraduates interested in forensic identification. Forensic identification is a scientific occupation focused on documenting, collecting, analyzing criminal evidence with occupational demands that are constantly changing with high external stimulation. Furthermore, stress responses to an acute psychological challenge were associated with sensation seeking scores. This set of findings indicates that forensic identification students can find adequate, non-risky stimulation in their occupational choices.

A similar finding was discovered with crisis rape counselors. Best and Kilpatrick (1977) compared the personality profiles of 14 female pediatric nurses and 20 female counselors who worked with rape victims. The counselors in this study had a variety

of occupational demands. These counselors worked in the field in crowded emergency rooms with high levels of sensory stimulation (e.g., multiple individuals, chaotic surroundings, and exposure to individuals with trauma). Using objective personality tests and inventories (e.g., MMPI and SSS-V), counselors indicated more openmindedness and flexible attitudes towards patients. Differences in sensation seeking traits revealed that these counselors had significantly higher scores on the disinhibition scale and experience seeking scale of the SSS-V than the pediatric nurses. These results also support that these counselors enjoy stimulating work environments, are non-anxious, and prefer disinhibiting behaviors.

In a study of vocational preference, Oleszkiewicz (1982) determined that occupations providing new sensations and experiences (e.g., journalist, movie double, sportsman, and surgeon) attracted individuals with elevated scores of general sensation seeking, thrill and adventure seeking and boredom susceptibility (SSS-V). Out of a list of 44 different occupations, high school seniors were asked to pick the three most and three least desired occupations. Individuals choosing vocations that involved some level of risk (e.g., aircraft pilot, policeman, and army officer) had elevated levels of thrill and adventure seeking behaviors. In summary, these results indicate that sensation seekers, based on their varying preference for stimulation, have an interest in or chose certain careers.

3.2. Habits: Alcohol, drugs, sex, and excessive gambling

A variety of demographic variables are related to sensation seeking traits. Two variables in particular that are related with sensation seeking are age and gender (Ball et al., 1984; Zuckerman & Neeb, 1980). In accordance with past information (Zuckerman, 1979a, 1994), age and sex tend to be a large source of variance on the total sensation seeking scale. Beginning with gender, males significantly out-scored females on total sensation seeking, thrill and adventure seeking, and disinhibition in the United States (Zuckerman et al., 1991). Males and females show similar scores on the experience seeking subscale. Similar gender differences were found on total sensation seeking, thrill and adventure seeking and boredom susceptibility, with males having higher scores than females in Australia, Canada, and Spain (Zuckerman, 1994).

Besides gender, age is also related to sensation seeking. Typically, there are declines in sensation seeking throughout an individual's lifetime (Ball et al., 1984; Zuckerman et al., 1991). Yet, not all scales of sensation seeking are sensitive to age-related declines. Boredom susceptibility represents a factor of sensation seeking that is consistent across age (Zuckerman & Neeb, 1980). Items comprising the Boredom Susceptibility subscale represent sensation seeking preferences that are not susceptible to age related changes.

It is clear that age is a significant factor in engaging in sensation seeking behaviors and activities. Newcomb and McGee (1991) gathered data from 595 males and females over the course of five years (late adolescence to young adulthood) and found that sensation seeking was correlated with general deviance at various ages (e.g., licit and illicit drug use, precocious sexual behavior, and criminal behavior). In this

longitudinal study, males in grades 10–12 had higher scores on the thrill and adventure seeking scale and disinhibition scale of the SSS-V than females. Whereas, females at the same grade levels had higher scores on experience seeking than males. Over the course of 2 years, both genders were engaging in various risky behaviors (licit/illicit drug usage, and sexual events). In most cases these early risky behaviors were associated with sensation seeking scores and predictive of engaging in specific forms of deviance later in life. Experiencing negative consequences of engaging in these activities was not enough to deter future engagement in these activities (Newcomb & McGee, 1991).

Besides age and gender differences, marital status is also associated with scores on the sensation seeking scale. **Divorced males score higher on total sensation seeking and all subscales than married or single males (Zuckerman & Neeb, 1980).** Furthermore, educational level and occupational choice showed a lesser relation to sensation seeking preferences, especially for females. Lastly, driving habits (speed) was linearly related to sensation seeking levels based on self-reported speed on a 55-mph highway for both genders.

There are indications that engaging in risky behaviors can be predicted and influenced in early development. A longitudinal epidemiological study conducted by Caspi et al. (1997) found that personality temperament styles, personality traits, and childhood developmental history were related to different health-risk behaviors in adulthood. A representative birth cohort had their temperament styles assessed at the age of three. The participants were then administered the Multidimensional Personality Questionnaire (MPQ) at the age of 18. The personality profiles obtained by the MPQ indicate that certain personality traits are related to engaging in health-risk behaviors (e.g., alcohol dependence, violent crime, sexual behaviors, and driving habits) at age 21. Personality traits such as: low traditionalism, low harm avoidance, low control, and low social closeness and high levels of alienation and aggression were predictive of engaging in health-risk behaviors at 21. Furthermore, the temperament styles, especially undercontrolled children (described as irritable, impulsive, and impersistent), at age 3 were predictive of involvement in health-risk behaviors at age 21.

Engaging in risky activities may be relevant to how an individual perceives their family environment. Foxcroft and Lowe (1995) found that perceived family environment was related to engagement in certain risky sensation-seeking behaviors (drinking alcohol, smoking, and usage of other drugs). Individuals who characterized their home as being “neglectful or authoritarian” typically engaged in risky sensation seeking behaviors. Furthermore, many of the activities in which high sensation seekers engage are impulsive.

Impulsivity is associated with engaging in risky behaviors such as fighting, drug usage, drunk driving, and reckless driving behaviors (Pfefferbaum & Wood, 1994; Stanford et al., 1996). Furthermore, impulsive behaviors, such as suicide, potentially put the individual and others at risk for personal injury (Vermeiren et al., 2003). Stanford et al. (1996) was interested in the relation between delinquent behaviors, personality traits, and impulsivity in high school ($n = 568$) and college students ($n = 592$). Results indicated that males tended to engage in more risky behaviors

than females at both age levels. When the groups were examined with regard to impulsivity, high scores on the Barratt Impulsiveness Scale (BIS-II) were strongly related to engaging in risk-taking behavior (e.g., fighting, drug usage, drunk driving, and seatbelt usage). Similarly, Iversen and Rundmo (2002) found that high sensation seekers ignore speed limits and traffic rules and take more risks that lead to near-accidents and/or crashes resulting in personal and other driver injuries.

In a related study of impulsivity and risk taking, Pfefferbaum and Wood, 1994 found similar results. In undergraduate college students, it was found that self reported indications of thrill seeking were correlated highly with property delinquency ($r = .393, p < .01$), self-control with interpersonal delinquency ($r = -.361, p < .01$), and socialization with substance delinquency ($r = -.435, p < .01$) for both genders. A stepwise regression model using the predictors of “joy riding,” thrill seeking, and socialization accounted for 45% of the variance in Self-Control. In the above literature, many of the individuals prefer external stimulation, or stimulation derived from sources in the environment.

When external stimulation is absent, many individuals become bored with the surroundings. This preference for varied environmental stimulation is associated with proneness to boredom (Kass & Vodanovich, 1990). A lack of activity or unstimulating environments leads many individuals to utilize substances. This is especially true with adolescents exhibiting high sensation seeking scores on the SSS-V (Baker & Yardley, 2002; Comeau et al., 2001; Martin et al., 2002). A major substance of choice for many individuals is alcohol. Earleywine et al. (1990) utilized correlational analysis and confirmatory factor analysis, revealing that a correlation exists between certain personality measures and alcohol consumption. An undergraduate sample of male students ($n = 220$) revealed that quantity of alcohol consumption and frequency of alcohol consumption were positively related to the MacAndrew scale and negatively related to the Socialization scale. In confirmatory factor analysis, the observed variables of the MacAndrew and Socialization scales served as a latent construct of “behavioral inhibition” and quantity and frequency of drinking as “drinking.” Confirmatory analysis estimated the latent variables (drinking and behavioral inhibition) accounted for 63% of the variance.

One of the major personality variables related to alcohol usage is sensation seeking (Cohen & Fromme, 2002; Zuckerman, 1994). Various researchers have found a correlation between alcohol usage and scores on the sensation seeking scale, especially the subscales of disinhibition and experience seeking. Earleywine and Finn (1991) replicated the findings of the Earleywine et al. (1990) study and found that latent construct of “behavioral disinhibition” was related to drinking habits. Furthermore, the latent construct of “sensation seeking,” comprised of the Experience Seeking and Disinhibition scales of the SSS-V and Novelty Seeking from the Tridimensional Personality Questionnaire (Cloninger, 1987) was related to drinking habits and behavioral disinhibition. Therefore, the relation between behavioral disinhibition and drinking habits appears to be the result of a connection with each other and a preference for sensation seeking.

It is important also to emphasize that drinking habits are affected by other important factors. Familial patterns, gender, family history of alcohol usage, deviant

behavior before the age of 15, and symptoms of hyperactivity in childhood are associated with alcohol consumption (MacDonald et al., 1991). Furthermore, many of these early factors are related to social influence and sensation seeking preferences. Beck et al. (1995) found that social context and sensation seeking preferences influence when a sample of college students ($n = 811$) drank alcohol. Participants were assessed on the following criteria to classify drinkers: drinking intensity (high intensity: drink alcohol weekly, consume at least five drinks on a typical occasion, become drunk at least once a month or low intensity), alcohol impaired or nonimpaired driver (drove drunk at least once during the preceding 12 months), and passenger of impaired or nonimpaired driver (passenger in a motor vehicle driven by a drunk driver). Male high intensity drinkers were associated with sex seeking behaviors (searching for and attracting a sexual partner), whereas high intensity female drinkers utilized alcohol when emotionally distressed. Even though the context for why the high-intensity individual is drinking is different for the genders, both had high levels of disinhibition. It is clear that social influences are a significant factor in drinking behaviors.

Sensation seeking and social influence provide a complementary explanation of drug usage, especially alcohol usage (Read et al., 2003). Donohew et al. (1999a, 1999b) found results indicating that peer sensation seeking preferences predict individual drug usage. Furthermore, individuals socialize with others who have similar sensation seeking preferences which further influences peer alcohol and marijuana usage. This would indicate that high sensation seekers tend to cluster with one another in mutual attraction to various experiences, especially with substances.

Another high-risk activity that sensation seekers tend to have preference for is risky sexual situations. High sensation seekers have more sexual partners and have more permissive sexual attitudes (Zuckerman et al., 1976). Furthermore, high sensation seekers tend to engage in sexual acts without proper protection against disease, such as condom usage (Arnold et al., 2002; Zuckerman, 1994). Males under the influence of alcohol tend to recurrently seek out sexual partners (Beck et al., 1995). Williams et al. (1992) found that college students use an implicit model (partner whom individuals know and like are perceived as not being risky) to determine the risk of potential sexual partners. Students are not using objective information about the risks of transmitting HIV, but personally relevant material about potential partners. Although the previous study utilized college age students, individuals in the general population may also have biased judgments about partners. These findings are supported by the fact that impulsive individuals with low harm avoidance (tendency to engage in risk-taking behavior) have a strong likelihood of engaging in unprotected sex (Seal & Agostinelli, 1994).

Sensation seeking is related to dating style and risky sexual activities. Wiederman and Hurd (1999) were interested in the rates of extradyadic dating and sexual activity in a sample of college students ($n = 691$) involved in dating relationships. Extradyadic dating and sexual involvement included such activities as: going out on a date, engaging in sexual relations, making out, or romantic kissing with another partner when the participant was involved in a serious dating relationship. Extradyadic dating and extradyadic sexual involvement was related to ludic dating styles. Ludic

dating was defined as “tendencies toward experiencing romantic love relationships with a partner kept guessing about the status of the relationship” (p. 268). Individuals with a ludic love style had higher frequency of sexual partners. Furthermore, sexual sensation seeking was related to extradyadic dating and extradyadic sexual involvement. Such as in the case of extradyadic dating, having sex for different reasons predicts various patterns of sexual risk taking (Cooper et al., 1998). Engaging in risky sexual situations is partially related to sensation seeking traits, especially the trait of disinhibition.

The reviewed literature thus far indicates that sensation seekers prefer particular social arenas and contexts in which individuals are engaging in activities that they enjoy. Furthermore, these activities have an element of physical, legal, financial, or social risk. To decrease the preference for high sensation seekers to engage in risky activities, other non-risky stimulating activities need to be available. Various non-risky activities including sports, recreation, and music preference are explored in the following section. Additionally, as previously mentioned before, certain occupations can provide this stimulating environment with minimal risk to the individual.

3.3. Hobbies: Sports and recreation

Sensation seekers can achieve an adequate level of arousal via socially acceptable means. The definition of sensation seeking identifies that stimulation can be in the form of socially acceptable activities and behaviors. A variety of non-risky and socially acceptable, yet stimulating activities and preferences are discussed in this section.

One stimulating activity that high sensation seekers prefer is to listen to arousing music, such as hard rock versus classical instrumental (McNamara & Ballard, 1999). Additionally, high sensation seekers are more likely than other individuals to volunteer for experiments (Trice & Ogden, 1986), especially if the experiment is described as dangerous in nature. Furthermore, what time of day a participant decides to take part in a study is associated with varying levels of sensation seeking (Zelenski et al., 2003). High sensation seekers also travel more and to less familiar places and have less anxiety in risky situations (Zuckerman, 1994). High sensation seekers also enjoy unusual or unpleasant art forms (Rawlings, 2003).

One socially acceptable expression of sensation seeking is engaging in certain high impact sports, such as rock climbing, scuba diving, hang gliding, and parachute jumping. Sports are a modality for individuals to obtain an increased level of arousal. High sensation seekers generally participate in sports in general at a higher rate than low sensation seekers (Zuckerman, 1994). Individuals with high Thrill and Adventure Seeking score enjoy non-risky, stimulating recreational activities (Joireman et al., 2002). Participants engaging in high-impact sports, such as the ones previously mentioned, generally have elevated total scores and thrill and adventure seeking scores on the SSS-V (Zuckerman, 1994). Although certain sports may be risky, high sensation seekers develop skills and planning to reduce risk that may occur with participation (Zuckerman, 1994).

Certain sports have more inherent risk (e.g., bungee jumping, rock climbing, sky diving, scuba diving, sky surfing, and street-luge racing). There is a tendency for high

sensation seekers to prefer these risky recreational activities (Wagner & Houlihan, 1994). In addition, Malkin and Rabinowitz (1998) reviewed high-risk recreational activities and the relation to sensation seeking profiles. Mountain sports, rock climbing, skiing, white water canoeing, and kayaking are sports associated with individuals having high thrill and adventure seeking scores on the SSS-V.

Besides high-impact sports and recreation, team sports are also a modality for increasing stimulation. Sensation seeking differences are evident in the members of contact and non-contact sports in college athletes (O'Sullivan et al., 1998). O'Sullivan et al. (1998) recruited 176 males and females from non-contact (baseball and equestrian) and contact (football and field hockey/lacrosse) sports. Individuals were given the ZKPQ (Zuckerman et al., 1993) and comparisons were made across non-contact (baseball and equestrian) and contact sports for the subscales on the ZKPQ. Both males and females in contact and non-contact sports scored higher on the activity subscale of the ZKPQ and lower on neuroticism-anxiety subscale when compared with published normative data. Levels of impulsiveness were not associated with sport participation. The key findings from this study suggest that individuals who prefer to engage in team sports are active individuals with moderate emotional stability.

The previous review of the literature indicates that sensation seekers have a variety of risky and non-risky choices for obtaining stimulation. Risky options include the use of licit and illicit substances, gambling, risky driving, and varying sexual experiences. Sensation seekers also have non-risky options for stimulation, such as occupations, music, travel, art, media, and sports. With a multitude of circumstances and life events, how do sensation seekers appraise life events and situations? The following section will indicate that the sensation seeker appraises life events and situations different from the non-sensation seeker.

3.4. Risk perception and risk appraisal of sensation seekers

High sensation seekers interpret the world differently than non-sensation seekers (Franken et al., 1992; Horvath & Zuckerman, 1993). Low sensation seekers generally appraise risky or stressful situations as threatening and leading to negative consequences and anticipate longer time to recover. Yet, high-sensation seekers appraise the environment as less threatening (Zuckerman, 1994).

Are sensation seekers likely to rate activities they have not engaged in before as less risky than low sensation seekers? Horvath and Zuckerman (1993) investigated the risk appraisal of low and high sensation seekers. In a study of 447 undergraduates, Horvath and Zuckerman (1993) found that total score on the SSS-V (Zuckerman et al., 1978) was negatively correlated with risk appraisal for "crime risk," "minor violations risk," and "sports risk." Individuals with high sensation seeking scores (SSS-V) rated these activities as less risky than did low sensation seekers. Participants who rated their risk as low, self-reported that they were more likely to engage in risky behaviors. Furthermore, impulsivity was negatively correlated with risky appraisal and positively correlated with engagement in "crime risk," "minor violations risk," and "sports risk." In a multiple regression analysis, 50% of the

variance in “crime risk” and “minor violations risk” were accounted by the predictors of perceived peer behavior and sensation seeking. Perceived peer behavior was the strongest predictor to enter the equation (β s ranging from .39 to .54), with sensation seeking levels entering next. This study indicates that high sensation seekers do not perceive engaging in risky behaviors as having negative consequences.

Similar results by Franken et al. (1992) illustrate that high sensation seekers do not view the environment as threatening and leading to negative consequences. High sensation seekers typically do not view fear eliciting objects and situations as threatening. Furthermore, fear eliciting objects and situations and physical and psychological risky situations are not viewed as threatening. Therefore, engaging in these actions in the future will not be appraised as threatening, risky, or dangerous. How an individual perceives and appraises risk is related to certain personality characteristics and biological makeup. High sensation seekers have differing responses of the sympathetic nervous system, which affects the behavioral-inhibition system leading to less fear, anxiety, and stress.

One potential source of fear, anxiety, and stress for some individuals is social situations. Sensation seekers seem to prefer certain types of friends and activities congruent with their preference for varied, novel, and complex interactions (Zuckerman, 1991a, 1994). Peer influence is related to how sensation seekers perceive the risk of a situation. Furthermore, they tend to surround themselves with others that have similar sensation seeking characteristics. Donohew et al. (1999a) found that individuals with high sensation seeking characteristics engage in certain high-risk behaviors only when interacting with socialization sources (e.g., friends).

Furthermore, Donohew et al. (1999a) suggest that persons with sensation seeking preferences select peers of similar sensation seeking levels, and the sensation-seeking level of these peers tends to influence alcohol and marijuana use. The findings suggest a moderator effect involving both sensation seeking and peer influence drug use. Although Donohew et al. (1999a) propose their model with drug usage, the model may generalize to other stimulating activities and preferences. For high sensation seekers, a career in forensic identification may be a source of stimulation and place them around others that are similar. Donohew et al. (1999a) suggest that high sensation seekers attempt to replace risky behaviors with more healthy alternatives of sensation seeking (e.g., video games, sports, hobbies, and occupations). It is clear from the previous literature that high sensation seekers do not view the world as dangerous, risky, or threatening.

4. Biological characteristics related to sensation seeking

Understanding the biological aspects of sensation seeking in humans is achieved by comparative strategies of brain–behavior relation (Zuckerman, 1983, 1984, 1990, 1994). Using comparative approaches for understanding human behavior is necessary because of constraints on biological experimentation with humans. Therefore, biological experimentation with animals is typically compared with certain human behaviors to formulate certain correlational relations.

Zuckerman (1994, 1996) has proposed a multi-level approach in which sensation is a product of interactions between neurotransmitter systems (Zuckerman, 1996). Agonistic and antagonistic interactions of biological correlates are related to sensation seeking. Biochemical mechanisms provide major support for the relation of sensation seeking and associated biological systems (Balada et al., 1993; Ballenger et al., 1983; Daitzman & Zuckerman, 1980; Dellu et al., 1996; Gerra et al., 1999; Netter et al., 1996; Piazza et al., 1993; Ruegg et al., 1997; Zuckerman, 1984, 1991a; Zuckerman et al., 1980). **In this section, literature focusing on the dopamine systems, serotonergic systems, and gonadal hormones are discussed. Particular emphasis is on examining the neuroendocrine system and its relation to sensation seeking and acute psychological challenges.**

A model for understanding sensation seeking can be based on behavioral characteristics and certain biological markers isolated in rats (Dellu et al., 1996; Piazza et al., 1993). Dellu et al. (1996) and Piazza et al. (1993) separated 2-month-old rats into two groups based on locomotor reactivity after 2 h of forced exploration of a novel environment. High responders (HR) had high locomotor reactivity (above the median) in forced exploration of a novel environment and the low responders (LR) had a locomotor response below the median. Additional trials investigating this pattern of locomotor activity remained for 2 and 16 month old rats but differences disappeared at 24 months.

Exploratory behaviors in animals (e.g., rats) and humans is considered a central dimension of novelty seeking (Zuckerman, 1979a, 1994). Rats were also observed in free exploration situations. HR rats, in comparison to LR rats, were more responsive to novelty as evident by the results to be described. In the forced exploration situation, HR rats, compared with LR rats, made more visits to novel arms of a free-choice maze. Furthermore, HR rats visited more arms in complex mazes (16 arm mazes). Drug self-administration was also examined in HR and LR rats. **High responder (HR) rats were found to self-administer more amphetamines over 5 days and made higher numbers of injections over the different days. Lastly it was found that HR rats ate more food pellets in less time.**

Corticosteroids (stress hormone) were also examined in HR and LR rats after exposure to a physical stressor (tail pinch). **HR rats had heightened levels of corticosterone 2 h after exposure to a physical stressor. When exposed to a physical stressor, HR rats revealed a heightened catecholamine release in the dopaminergic system.** Additionally, Dellu et al. (1996) found post-autopsy that HR rats had higher dopaminergic activity in the nucleus accumbens and lower activity in the prefrontal cortex when compared with LR rats. Results suggest that corticosterone has reinforcing properties for HR rats and may have influence on the dopamine pathways of the brain.

These results were supported by the research of Piazza et al. (1993). It was concluded that corticosterone has euphoric and reinforcing properties in HR rats. HR rats self-administer more intravenous corticosterone, self-administer of corticosterone similar to plasma levels comparable to those induced by stress, prefer and are more reactive to novel environments, and have increased dopaminergic activity in the nucleus accumbens. It could be concluded that HR rats seeking novelty have

increased sensitivity to corticosterone. Piazza et al. reveals that both HR rats and humans with high sensation seeking scores have upregulated (increased release) dopaminergic systems, based on exposure to stressors. Furthermore, increased release from dopaminergic systems usually correlate with decreased release from serotonergic systems and norepinephrine systems.

The reinforcing properties of corticosterone (high levels) in animal models are contradictory to human models of stress hormones (Netter et al., 1996). The different between animal and human models may suggest cognitive appraisal of stressors is related to stress responses. Although animal models of stress response show a heightened level of stress hormones in novelty seeking rats, this is not conclusive in human models. In human models of sensation seeking, it has been found that high sensation seekers have lower levels of cortisol in response to an acute stressor (Netter et al., 1996).

Netter et al. (1996) found that activity in certain biological systems, such as dopamine and serotonin, are associated with particular subscales of sensation seeking scale (SSS-V) in humans. Netter et al. (1996) discovered a relation between Dis (Disinhibition) and ES (Experience Seeking) factors of the SSS-V (Zuckerman et al., 1978), and dopamine systems and serotonergic systems in humans. Netter et al. (1996) used the hormonal response (cortisol and prolactin) to assess the effects of a neurotransmitter challenge (ipsapirone) on the serotonergic system of the brain. In a two-part study, Netter et al. (1996) found that high experience seeking participants had lower cortisol responses to an ipsapirone challenge versus low experience seeking participants, but no relation was found to the disinhibition subscale (a factor of impulse control) of the SSS-V (Zuckerman et al., 1978). In addition, a frequent side effect of the ipsapirone challenge is emotional arousal. Yet, no emotional arousal was noted in high experience seeking and disinhibition individuals when contrasted to lower experience seeking and disinhibited participants. In study 2, high disinhibited individuals, when compared with low disinhibited participants, had blunted (low) cortisol responses to an ipsapirone challenge in a game designed to produce aggression. This finding is similar to others illustrating blunted cortisol release for high experience seekers in response to stressors.

Furthermore, Netter et al. (1996) investigated the dopamine system and found that among individuals with high experience seeking scores, those who indicated nicotine usage, tolerated smoking deprivation better than low experience seeking individuals with nicotine usage. Lower levels of cortisol in high experience seeking individuals provide possible evidence for increased activity in dopamine systems and decreased activity in serotonergic systems in humans. Individuals with high experience seeking scores have high stress resistance that minimizes the effects of psychological and physical stressors. High experience seeking individuals have a higher threshold of sensitivity to aversive stimulation, lower hypersensitivity, and lower irritability.

This pattern of cortisol response to other forms of stressors has been replicated. Ruegg et al. (1997) investigated the relation between the serotonergic system with Cloninger's Tridimensional Personality Questionnaire examining harm avoidance, novelty seeking, and reward dependence. An intravenous injection of clomipramine

(physiological stressor) was used to determine the responsiveness of the serotonergic system. The “clomipramine challenge test” and scores on inventories indicating a dimension of personality were examined for association. Metabolites of the serotonin system (cortisol and prolactin) were assayed. It was determined that cortisol levels were positively associated with scores on the harm avoidance scale. This means that individuals with high avoidance of novelty have high levels of cortisol. Additionally, there was no association between scores on the novelty seeking and reward dependence scales and cortisol levels from the clomipramine challenge. These results support earlier research associating human models of sensation seeking and neuroendocrine responses to a stressor.

It is interesting to note that cortisol levels have been associated with scores on personality inventories without the individual having any exposure to a psychological or physical stressor. Ballenger et al. (1983) was interested in how various biological correlates are associated with personality traits in individuals. Norepinephrine (NE) and various metabolites along with cortisol were assessed in the urine, cerebral spinal fluid (CSF), or blood serum of the participant. CSF cortisol levels were negatively associated with the disinhibition scale of the SSS-IV. That is individuals with preference for disinhibiting behaviors and activities had low levels of CSF cortisol. This provides further support that sensation seeking preferences are related to cortisol levels.

Other metabolites of biological systems are associated with sensation seeking scores. Gerra et al. (1999) found that novelty seeking and sensation seeking scores were positively correlated with levels of norepinephrine, testosterone, and prolactin in 74 healthy male participants. However, there was no relation found with sensation seeking scores and cortisol. This finding could be related to sampling or could be that norepinephrine is the result of novelty seeking not the cause. Further experimentation needs to be done in this area.

In addition, gonadal hormones and scores on sensation seeking scales in humans are associated (Balada et al., 1993; Daitzman & Zuckerman, 1980; Daitzman, Zuckerman, Sammelwitz, & Ganjam, 1978). Daitzman et al. (1978) studied a group of undergraduate college males and females for differences in hormonal levels and the relation to sensation seeking characteristics. Daitzman et al. (1978) found that males revealed a positive correlation of the disinhibition subscale (SSS-V) with androgen and estrogen levels. The disinhibition subscale was positively correlated with follicular and luteal estrogens in females. These findings support that gonadal hormones are related to certain sensation seeking scales.

Additionally, Daitzman and Zuckerman (1980) found differences between males with high and low scores on the sensation seeking scale when compared on testosterone, β -17-estradiol, and estrone levels. Replication of the previous study was confirmed—that high disinhibiting males had higher concentrations of androgens and estrogens. Furthermore, Daitzman and Zuckerman found that these hormones are related to scores on personality inventories (e.g., California Psychological Inventory, Bem Sex Role Inventory, EASII-III, and Eysenck Personality Questionnaire) indicating: impulsive extraversion, sociability, dominance, activity deviant social attitudes, and certain psychopathology. These findings provide support that certain sensation seeking characteristics are based partially on gonadal systems.

It is clear so far that certain biological systems, such as the neuroendocrine and gonadal systems are associated with sensation seeking levels. Furthermore, attempts have been made to determine the relation between monoamine-oxidase (MAO) and personality characteristics (Longato-Stadler et al., 2002; Murphy et al., 1976; Zuckerman, 1984, 1985). Monoamine oxidase (MAO) is the major catabolism for the monoamine neurotransmitters. MAO has typically been utilized to determine the level monoamine neurotransmitters because these transmitters cannot be measured directly. Since high levels of gonadal hormones reduce the levels of MAO, MAO levels are a negative correlate of sensation seeking. From a review of the literature, Zuckerman (1984, 1985) concluded that there is a direct negative correlation between MAO levels and sensation seeking characteristics.

In addition, Carrasco et al. (1999) utilized a sample of 16 professional bullfighters with an age matched control group. Carrasco et al. examined scores on the SSS-V, Eysenck Personality Questionnaire, and the Cloninger Tridimensional Personality Questionnaire and activity of the monoamine system. It was determined that bullfighters were more extroverted and had higher thrill and adventure seeking scores (TAS) on the SSS-V (Zuckerman et al., 1978). Bullfighters also had lower levels of MAO activity when compared with age matched controls.

5. Conclusions and future research directions

The purpose of this paper was to review behavioral and biological studies associated with sensation seeking. It is a personality trait easily measured, providing valuable information about various preferences for risky and non-risky forms of arousal. In the studies reviewed, the majority of effect sizes suggest that sensation seeking is a strong determinant of interest in stimulating attitudes, behaviors, and activities (Table 1). The amount of variance accounted for by behavioral and biological correlates of sensation seeking, suggest that it is of practical significance. The relation of sensation seeking to behavioral and biological correlates makes it a key personality variable deserving continued empirical study.

It is clear from past empirical studies that engaging in certain risky behaviors can have negative health consequences. Engaging in certain risky activities and behaviors can expose individuals to physical, social, legal, and financial risks. This is particularly true with young adults. Compared with other age groups, young adults have higher involvement in risk taking behaviors (Arnett, 1992; Bradley & Wildman, 2002; Jessor, 1992; Zuckerman, 1994). Epidemiological investigations indicate that age is an important predictor of involvement in risky behaviors (Center for Disease Control, 2003). This has led researchers and clinicians to focus on young adults involvement in risky forms of sensation seeking (Arnold et al., 2002; Gendaszek & Graff, 2002; Martin et al., 2002; Perry & Mandell, 1995; Roberti et al., 2003b). Studying the involvement of adolescents and young adults in risky and non-risky forms of sensation seeking should continue.

The definition of sensation seeking reveals that it is not based solely on high-risk behaviors. Many activities that individuals with a preference for sensation seeking

choose are very safe and effective in increasing their arousal level. Early identification of risky behaviors, attitudes, and preferences in young adults, such as engaging in promiscuous sexual activities, reckless drinking habits, use of illicit drugs, gambling, and high-risk sports and replacing those with non-risky options is essential in reducing negative health consequences. Recommending appealing, non-risky forms of sensation seeking to individuals that once engaged in risky behaviors is one way of reducing negative health consequences. The effectiveness of using alternative arousal sources that are non-risky but are equally stimulating has yet to be determined and would be a fruitful line of research. Future studies that focus on developing programs to substitute risky or unhealthy behaviors with equally arousing options would be beneficial. Furthermore, updating literature with regards to types of non-risky, stimulating vocations is warranted given many studies were completed from the 1960s to 1980s and cohort differences may exist.

The way in which non-risky stimulating activities are presented to high sensation seekers is important. Although prior attempts have been made to assess the role of peer socialization in sensation seeking, assessing the influence of peer socialization on promoting non-risky forms of sensation seeking is necessary. Because sensation seekers enjoy the company of others with similar stimulation preferences, designing these programs so that peer socialization can be incorporated is essential. Utilization of recent attempts to understand how sensation seekers perceive messages may be helpful in designing programs promoting non-risky activities (Stephenson et al., 2002). Efforts to understand factors that influence how sensation seekers make decisions, perceived benefits, and costs are essential (Rolison & Scherman, 2002). This information can be advantageous in tailoring health communication messages to reduce risk taking behaviors. By using existing programs/organizations in the community (e.g., Boys and Girls Club, YMCA, recreational centers, etc.), interested community leaders can secure local, state, and federal funding to expand programs and provide stimulating activities. Community-based programs may be the catalyst for providing an adequate source of stimulation to reduce boredom and subsequent involvement in other forms of risky taking. Future research that evaluates the effectiveness of providing stimulating alternative activities to young adults and possible reduction in risk taking are warranted.

Lastly, findings indicate that sensation seeking is associated with various biological correlates, including neurotransmitters, enzymes, and hormones. Yet, conflicting empirical findings in relation to reactivity to stressors and neuroendocrine responses in humans (cortisol) and animals (corticosterone) suggest that continued studies are warranted. Psychobiological studies that interface appraisal of stressors, sensation seeking, and subsequent release of cortisol may advance our understanding of stress reactivity and possible buffering effects of sensation seeking.

References

- Aluja, A., Garcia, O., & Garcia, L. F. (2002). A comparative study of Zuckerman's three structural models for personality through the NEO-PI-R, ZKPQ-III-R, EPQ-RS and Goldberg's 50-bipolar adjectives. *Personality and Individual Differences*, 33, 713–726.

- Arnett, J. (1991). Still crazy after all these years: Reckless behavior among young adults aged 23–27. *Personality and Individual Differences, 12*, 1305–1313.
- Arnett, J. (1992). Reckless behavior in adolescence: A developmental perspective. *Developmental Review, 12*, 339–373.
- Arnold, P., Fletcher, S., & Farrow, R. (2002). Condom use and psychological sensation seeking by college students. *Sexual and Relationship Therapy, 17*, 355–366.
- Baker, J. R., & Yardley, J. K. (2002). Moderating effect of gender on the relationship between sensation seeking-impulsivity and substance use in adolescents. *Journal of Child and Adolescent Substance Abuse, 12*, 27–43.
- Balada, F., Torrubia, R., & Maria Arque, J. (1993). Gonadal hormone correlates of sensation seeking and anxiety in healthy human females. *Neuropsychobiology, 27*, 91–96.
- Ball, I. L., Farnill, D., & Wangeman, J. F. (1984). Sex and age differences in sensation seeking: Some national comparisons. *British Journal of Psychology, 75*, 257–265.
- Ballenger, J. C., Post, R. M., Jimerson, D. C., Lake, C. R., Murphy, D., Zuckerman, M., & Cronin, C. (1983). Biochemical correlates of personality traits in normals: An exploratory study. *Personality and Individual Differences, 4*, 615–625.
- Barratt, E. S. (1985). Impulsiveness subtraits arousal and information processing. In J. T. Spence, & C. E. Itard (Eds.), *Motivation emotion and personality* (pp. 137–146). Amsterdam: Elsevier.
- Beck, K. H., Thombs, D. L., Mahoney, C. A., & Fingar, K. M. (1995). Social context and sensation seeking: Gender differences in college student drinking motivations. *International Journal of the Addictions, 30*, 1101–1115.
- Best, C. L., & Kilpatrick, D. G. (1977). Psychological profiles of rape crisis counselors. *Psychological Reports, 40*, 1127–1134.
- Biersner, R. J., & LaRocco, J. M. (1983). Personality characteristics of US Navy divers. *Journal of Occupational Psychology, 56*, 329–334.
- Bradley, G., & Wildman, K. (2002). Psychosocial predictors of emerging adults risk and reckless behaviors. *Journal of Youth and Adolescence, 31*, 253–267.
- Breslin, F. C., Sobell, M. B., Cappell, H., & Poulos, C. X. (1999). The effects on alcohol, gender, and sensation seeking on the gambling choices of social drinkers. *Psychology of Addictive Behaviors, 13*, 243–252.
- Brocke, B., Beauducel, A., & Tasche, K. G. (1999). Biopsychological bases and behavioral correlates of sensation seeking: Contributions to a multilevel validation. *Personality and Individual Differences, 26*, 1103–1123.
- Carrasco, J. L., Saiz-Ruiz, J., Diaz-Marsa, M., Cesar, J., & Lopez-Ibor, J. J. (1999). Low platelet monoamine oxidase activity in sensation seeking bullfighters. *CNS Spectrums, 4*, 21–24.
- Caspi, A., Begg, D., Dickson, N., Harrington, H., Langley, J., Moffitt, T. E., & Silva, P. A. (1997). Personality differences predict health-risk behaviors in young adulthood: Evidence from a longitudinal study. *Journal of Personality and Social Psychology, 73*, 1052–1063.
- Center for Disease Control (2003). *Health topic: Adolescents and teens*. Retrieved February 4, 2003. Available: <http://www.cdc.gov/health/adolescent.htm>.
- Cloninger, C. R. (1987). Neurogenetic adaptive mechanisms in alcoholism. *Science, 23*, 410–436.
- Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. Academic Press: New York. 2nd.
- Cohen, E. S., & Fromme, K. (2002). Differential determinants of young adult substance use and high-risk sexual behavior. *Journal of Applied Social Psychology, 32*, 1124–1150.
- Comeau, N., Stewart, S. H., & Loba, P. (2001). The relations of trait anxiety, anxiety sensitivity and sensation seeking to adolescents' motivations for alcohol, cigarette and marijuana use. *Addictive Behaviors, 26*, 803–825.
- Cooper, M. L., Shapiro, C. M., & Powers, A. M. (1998). Motivations for sex and risky sexual behavior among adolescents and young adults: A functional perspective. *Journal of Personality and Social Psychology, 75*, 1528–1558.
- Costa, P. T., & McCrae, R. R. (1992). *NEO-PI-R professional manual*. Odessa, FL: PAR.
- Cronin, C. (1995). Construct validation of the strong interest inventory adventure scale using the sensation seeking scale among female college students. *Measurement and Evaluation in Counseling and Development, 28*, 3–8.

- D'Silva, M. U., Harrington, N. G., Palmgreen, P., Donohew, L., & Lorch, E. P. (2001). Drug use prevention for the high sensation seeker: The role of alternative activities. *Substance Use and Misuse*, 36, 373–385.
- Daitzman, R. J., & Zuckerman, M. (1980). Disinhibitory sensation seeking and gonadal hormones. *Personality and Individual Differences*, 1, 103–110.
- Daitzman, R. J., Zuckerman, M., Sammelwitz, P. H., & Ganjam, V. (1978). Sensation seeking and gonadal hormones. *Journal of Biosocial Science*, 10, 401–408.
- Deditius-Island, V., Heide, K., & Caruso, J. C. (2002). An examination of the reliability of scores from Zuckerman's Sensation Seeking Scales, Form V. *Educational and Psychological Measurement*, 62, 728–735.
- Dellu, F., Piazza, P. V., Mayo, W., Le Moal, M., & Simon, H. (1996). Novelty-seeking in rats: Biobehavioral characteristics and possible relationship with the sensation seeking trait in man. *Neuropsychobiology*, 34, 136–145.
- Donohew, L., Clayton, R. R., Skinner, W. F., & Colon, S. (1999a). Peer networks and sensation seeking: Some implications for primary socialization theory. *Substance Use and Misuse*, 34, 1013–1023.
- Donohew, R. L., Hoyle, R. H., Clayton, R. R., Skinner, W. F., Colon, S. E., & Rice, R. E. (1999b). Sensation seeking and drug use by adolescents and their friends: Models for marijuana and alcohol. *Journal of Studies on Alcohol*, 60, 622–631.
- Earleywine, M., & Finn, P. (1991). Sensation seeking explains the relation between behavioral disinhibition and alcohol consumption. *Addictive Behavior*, 16, 123–128.
- Earleywine, M., Finn, P., & Martin, C. S. (1990). Personality risk and alcohol consumption: A latent variable analysis. *Addictive Behavior*, 15, 183–187.
- Eysenck, S. B. G., Eysenck, H. J., & Barrett, P. (1985a). A revised version of the psychoticism scale. *Personality and Individual Differences*, 6, 21–29.
- Eysenck, S. B. G., Pearson, P. R., Easting, G., & Allsopp, J. F. (1985b). Age norms for impulsiveness, venturesomeness, and empathy in adults. *Personality and Individual Differences*, 6, 613–619.
- Foxcroft, D. R., & Lowe, G. (1995). Adolescent drinking, smoking, and other substance use involvement: Links with perceived family life. *Journal of Adolescence*, 18, 159–177.
- Franken, R. E., Gibson, K. J., & Rowland, G. L. (1992). Sensation seeking and the tendency to view the world as threatening. *Personality and Individual Differences*, 13, 31–38.
- Fulker, D. W., Eysenck, S. B. G., & Zuckerman, M. (1980). A genetic and environmental analysis of sensation seeking. *Journal of Research in Personality*, 14, 261–281.
- Gendaszek, K., & Graff, A. E. (2002). Illicit use of psychostimulants among college students: A preliminary study. *Psychology, Health & Medicine*, 7, 283–287.
- Gerra, G., Avanzini, P., Zaimovic, A., Sartori, R., Bocchi, C., Timpano, M., Zambelli, U., Delsignore, R., Gardini, F., Talarico, E., & Brambilla, F. (1999). Neurotransmitters, neuroendocrine correlates of sensation-seeking temperament in normal humans. *Neuropsychobiology*, 39, 207–213.
- Glicksohn, J., & Abulafia, J. (1998). Embedding sensation seeking within the big three. *Personality and Individual Differences*, 25, 1085–1099.
- Gomà-I-Freixanet, M. (1991). Personality profile of subjects engaged in high physical risk sports. *Personality and Individual Differences*, 12, 1087–1093.
- Horvath, P., & Zuckerman, M. (1993). Sensation seeking, risk appraisal, and risky behavior. *Personality and Individual Differences*, 14, 41–52.
- Irwin, C. E., & Millstein, S. G. (1986). Biopsychosocial correlates of risk-taking behaviors during adolescence. *Journal of Adolescent Health Care*, 7, 82–96.
- Iversen, H., & Rundmo, T. (2002). Personality, risky driving and accident involvement among Norwegian drivers. *Personality & Individual Differences*, 33, 1251–1263.
- Jessor, R. (1992). Risk behavior in adolescence: A psychosocial framework for understanding and action. *Developmental Review*, 12, 374–390.
- Joireman, J. A., Fick, C. S., & Anderson, J. W. (2002). Sensation seeking and involvement in chess. *Personality & Individual Differences*, 32, 509–515.
- Kass, S. J., & Vodanovich, S. J. (1990). Boredom proneness: Its relationship to type A behavior pattern and sensation seeking. *Psychology: A Journal of Human Behavior*, 27, 7–16.
- Kish, G. B., & Donnenwerth, G. V. (1969). Interests and stimulus seeking. *Journal of Counseling Psychology*, 16, 551–556.

- Knust, S., & Stewart, A. L. (2002). Risk-taking behaviour and criminal offending: An investigation of sensation seeking and the Eysenck Personality Questionnaire. *International Journal of Offender Therapy & Comparative Criminology*, *46*, 586–601.
- Loas, G., Verrier, A., Flament, M. F., Perez-Diaz, F., Corcos, M., Halfon, O., Lang, F., Bizouard, P., Venisse, J. L., Guelfi, J. D., & Jeammet, P. (2001). Factorial structure of the Sensation-Seeking Scale-Form V: Confirmatory factorial analyses in nonclinical and clinical samples. *Canadian Journal of Psychiatry*, *46*, 850–855.
- Longato-Stadler, E., af Klinteberg, B., Garpenstrand, H., Orelund, L., & Hallman, J. (2002). Personality traits and platelet monoamine oxidase activity in a Swedish male criminal population. *Neuropsychobiology*, *46*, 202–208.
- MacDonald, R., Fleming, M. F., & Barry, K. L. (1991). Risk factors associated with alcohol abuse in college students. *American Journal of Drug and Alcohol Abuse*, *17*, 439–449.
- Malkin, M. J., & Rabinowitz, E. (1998). Sensation seeking and high-risk recreation. *Parks and Recreation*, *33*, 34–40.
- Martin, C. A., Kelly, T. H., Rayens, M. K., Brogli, B. R., Brenzel, A., Smith, W. J., & Omar, H. A. (2002). Sensation seeking, puberty, and nicotine, alcohol, and marijuana use in adolescence. *Journal of the American Academy of Child & Adolescent Psychiatry*, *41*, 1495–1503.
- McDaniel, S. R. (2002). Investigating the roles of gambling interest and impulsive sensation seeking on consumer enjoyment of promotional games. *Social Behavior & Personality*, *30*, 53–64.
- McNamara, L., & Ballard, M. E. (1999). Resting arousal, sensation seeking, and music preference. *Genetic, Social, and General Psychology Monographs*, *125*, 229–251.
- Murphy, D. L., Wright, C., Buchsbaum, M. S., Nichols, A., Costa, J. L., & Wyatt, R. J. (1976). Platelet and plasma amine oxidase activity in 680 normals: Sex and age differences and stability over time. *Biochemical Medicine*, *16*, 254–265.
- Neary, R. S., & Zuckerman, M. (1976). Sensation seeking, trait and state anxiety, and the electrodermal orienting reflex. *Psychophysiology*, *13*, 205–211.
- Netter, P., Hennig, J., & Roed, I. S. (1996). Serotonin and dopamine as mediators of sensation seeking behavior. *Neuropsychobiology*, *34*, 155–165.
- Newcomb, M. D., & McGee, L. (1991). Influence of sensation seeking on general deviance and specific problem behavior from adolescence to young adulthood. *Journal of Personality and Social Psychology*, *61*, 614–628.
- Oleszkiewicz, Z. Z. (1982). Demand for stimulation and vocational preferences. *Polish Psychological Bulletin*, *13*, 185–195.
- O'Sullivan, D. M., Zuckerman, M., & Kraft, M. (1998). Personality characteristics of male and female participants in team sports. *Personality and Individual Differences*, *25*, 119–128.
- Patton, J. H., Stanford, M. S., & Barratt, E. S. (1995). Factor structure of the Barratt Impulsiveness Scale. *Journal of Clinical Psychology*, *51*, 768–774.
- Perry, M. J., & Mandell, W. (1995). Psychosocial factors associated with the initiation of cocaine use among marijuana users. *Psychology of Addictive Behaviors*, *9*, 91–100.
- Pfefferbaum, B., & Wood, P. B. (1994). Self-report study of impulsive and delinquent behavior in college students. *Journal of Adolescent Health*, *15*, 295–302.
- Piazza, P. V., Deroche, V., Deminiere, J. M., Maccari, S., Le Moal, M., & Simon, H. (1993). Corticosterone in the range of stress-induced levels possesses reinforcing properties: Implications for sensation seeking behaviors. *National Academy of Science*, *90*, 11738–11742.
- Rawlings, D. (2003). Personality correlates of liking for 'unpleasant' paintings and photographs. *Personality and Individual Differences*, *34*, 395–410.
- Read, J. P., Wood, M. D., Kahler, C. W., Maddock, J. E., & Palfai, T. P. (2003). Examining the role of drinking motives in college student alcohol use and problems. *Psychology of Addictive Behaviors*, *17*, 13–23.
- Roberti, J. W. (2003). Sensation seeking characteristics and neuroendocrine responses to an acute psychological challenge for undergraduates with career interests in forensic sciences. *Journal of Applied Psychology* (under review).
- Roberti, J. W., Storch, E. A., & Bravata, E. (2003a). Further psychometric support for the Sensation Seeking Scale—Form V. *Journal of Personality Assessment* (in press).

- Roberti, J. W., Storch, E. A., & Bravata, E. (2003b). Sensation seeking, exposure to psychosocial stressors, and body modifications. Submitted for publication.
- Robinson, D. W. (1985). Stress seeking: Selected behavioral characteristics of elite rock climbers. *Journal of Sport Psychology*, 7, 400–404.
- Rolison, M. R., & Scherman, A. (2002). Factors influencing adolescents' decisions to engage in risk-taking behavior. *Adolescence*, 37, 585–596.
- Rowland, G. L., & Franken, R. E. (1986). The four dimensions of sensation seeking: A confirmatory factor analysis. *Personality and Individual Differences*, 7, 237–240.
- Ruegg, R. G., Gilmore, J., Ekstrom, R. D., Corrigan, M., Knight, B., Tancer, M., Leatherman, M. E., Carson, S. W., & Golden, R. N. (1997). Clomipramine challenge responses covary with tridimensional personality questionnaire scores in healthy subjects. *Biological Psychiatry*, 42, 1123–1129.
- Seal, D. W., & Agostinelli, G. (1994). Individual differences associated with high-risk sexual behaviour: Implications for intervention programmes. *AIDS Care*, 6, 393–397.
- Smith, R. E., Ptacek, J. T., & Smoll, F. L. (1992). Sensation seeking, stress, and adolescent injuries: A test of stress buffering, risk-taking, and coping skills hypotheses. *Journal of Personality and Social Psychology*, 62, 1016–1024.
- Stanford, M. S., Greve, K. W., Boudreaux, J. K., Mathias, C. W., & Brumbelow, J. L. (1996). Impulsiveness and risk-taking behavior: Comparison of high-school and college students using the Barratt Impulsiveness Scale. *Personality and Individual Differences*, 21, 1073–1075.
- Stephenson, M. T., Morgan, S. E., Lorch, E. P., Palmgreen, P., Donohew, L., & Hoyle, R. H. (2002). Predictors of exposure from an santimarijuana media campaign: Outcome research assessing sensation seeking targeting. *Health Communication*, 14, 23–43.
- Tellegen, A. (1982). *Brief manual for the Multidimensional Personality Questionnaire*. University of Minnesota, Minneapolis (unpublished manuscript).
- Trice, A. D., & Ogden, E. P. (1986). Informed consent: The institutional non-liability clause as a liability in recruiting research subjects. *Journal of Social Behavior and Personality*, 1, 391–396.
- Vermeiren, R., Schwab-Stone, M., Ruchkin, V. V., King, R. A., Van Heeringen, C., & Deboutte, D. (2003). Suicidal behavior and violence in male adolescents: A school-based study. *Journal of the American Academy of Child & Adolescent Psychiatry*, 42, 41–48.
- Wagner, A. M., & Houlihan, D. (1994). Sensation seeking trait anxiety in hang-glider pilots and golfers. *Journal of Personality and Individual Differences*, 16, 975–977.
- Waters, C. W., Ambler, R., & Waters, L. K. (1976). Novelty and sensation seeking in two academic training settings. *Educational and Psychological Measurement*, 36, 453–457.
- Wiederman, M. W., & Hurd, C. (1999). Extradynamic involvement during dating. *Journal of Social and Personal Relationships*, 16, 265–274.
- Williams, S. S., Kimble, D. L., Covell, N. H., Weiss, L. H., Newton, K. J., Fisher, J. D., & Fisher, W. A. (1992). College students use implicit personality theory instead of safer sex. *Journal of Applied Social Psychology*, 22, 921–933.
- Zaleski, Z. (1984). Sensation seeking and risk taking behaviour. *Personality and Individual Differences*, 5, 607–608.
- Zelenski, J. M., Rusting, C. L., & Larsen, R. J. (2003). Consistency in the time of experiment participation and personality correlates: A methodological note. *Personality and Individual Differences*, 34, 547–558.
- Zuckerman, M. (1979a). *Sensation seeking: Beyond the optimal level of arousal*. Hillsdale, NJ: Erlbaum.
- Zuckerman, M. (1979b). Sensation seeking and risk taking. In C. E. Izard (Ed.), *Emotions in personality and psychopathology* (pp. 163–197). New York: Plenum.
- Zuckerman, M. (1983). Sensation seeking: A biosocial dimension of personality. In A. Gale, & J. Edwards (Eds.), *Physiological correlates of human behavior: Vol. 3. Individual differences* (pp. 99–115). New York: Academic Press.
- Zuckerman, M. (1984). Sensation seeking: A comparative approach to a human trait. *Behavioral and Brain Sciences*, 7, 413–471.
- Zuckerman, M. (1985). Sensation seeking, mania, and monoamines. *Neuropsychobiology*, 13, 121–128.
- Zuckerman, M. (1990). The psychophysiology of sensation seeking. *Journal of Personality*, 58, 313–341.
- Zuckerman, M. (1991a). *Psychobiology of personality*. New York: Cambridge University Press.

- Zuckerman, M. (1991b). Sensation seeking: The balance between risk and reward. In L. P. Lipsitt, & L. L. Mitnick (Eds.), *Self regulatory behavior and risk taking: Causes and consequences* (pp. 143–152). Norwood, NJ: Ablex Publishing Corporation.
- Zuckerman, M. (1994). *Behavioral expressions and biosocial bases of sensation seeking*. New York: Cambridge Press.
- Zuckerman, M. (1996). The psychobiological model for impulsive unsocialized sensation seeking: A comparative approach. *Neuropsychobiology*, *34*, 125–129.
- Zuckerman, M., Bone, R. N., Neary, R., Mangelsdorff, D., & Brustman, B. (1972). What is the sensation seeker? Personality trait and experience correlates of the Sensation Seeking Scales. *Journal of Consulting and Clinical Psychology*, *39*, 308–321.
- Zuckerman, M., Buchsbaum, M. S., & Murphy, D. L. (1980). Sensation seeking and its biological correlates. *Psychological Bulletin*, *88*, 187–214.
- Zuckerman, M., Eysenck, S., & Eysenck, H. J. (1978). Sensation seeking in England and America: Cross-cultural, age, and sex comparisons. *Journal of Consulting and Clinical Psychology*, *46*, 139–149.
- Zuckerman, M., Kuhlman, D. M., Joireman, J., Teta, P., & Kraft, M. (1993). A comparison of three structural models for personality: The big three, the big five, and the alternative five. *Journal of Personality and Social Psychology*, *65*, 757–768.
- Zuckerman, M., Kuhlman, D. M., Thornquist, M., & Kiers, H. (1991). Five (or three) robust questionnaire scale factors of personality without culture. *Personality and Individual Differences*, *12*, 929–941.
- Zuckerman, M., & Neeb, M. (1980). Demographic influences in sensation seeking and expressions of sensation seeking in religion, smoking and driving habits. *Personality and Individual Differences*, *1*, 197–206.
- Zuckerman, M., Tushup, R., & Finner, S. (1976). Sexual attitudes and experience: Attitude and personality correlates and changes produced by a course in sexuality. *Journal of Consulting and Clinical Psychology*, *44*, 7–19.