

HETEROGENEITY IN ADDICTION:

When similarity makes a difference.

Jakob Linnet

Denne artikel fokuserer på heterogenitetsforholdet i sensationssøgende adfærd. Sensationssøgning er et begreb, som er omgærdet med megen interesse, men som også er kontroversielt i litteraturen. I denne artikel vil jeg anvende eksempler fra ludomaniforskningen til at belyse den heterogene kompleksitet inden for afhængighedstilstandene, samt belyse aspekter af begrebet sensationssøgning. Først introduceres begrebet sensationssøgning med særlig vægt på ludomani. Derefter præsenteres tre nylige eller igangværende studier af sensationssøgning inden for ludomani: 1.) en klinisk undersøgelse af over 300 behandlingssøgende ludomaner, 2.) en neurovidenskabelig undersøgelse af sammenhængen mellem sensationssøgning og bindingspotentialet af neurotransmitterstoffet dopamin i hjernen, og 3.) en neuro-kognitiv undersøgelse af sensationssøgning og beslutningsprocesser i spillesituationer blandt ludomane og ikke-ludomane. Endelig diskuteres interaktionen mellem sensationssøgende adfærd og bio-psyko-sociale faktoreres betydning for heterogenitetsspørgsmålet inden for ludomani og andre afhængighedstilstande.

Acknowledgements

This paper was supported by grant 2049-01-0009 and 2049-03-0002 from the Danish Research Agency.

Heterogeneity in addiction: When similarity makes a difference

The heterogeneity of addictions is clear to anyone familiar with the field. Elsewhere in this issue on addictive behavior Griffiths (page 9) accounts for the need for a bio-psycho-social approach to addictions. Both within and across addictions the heterogeneity of the addictive behavior calls for differentiated models of research and treatment, which can account both for the similarities and differences of the addictive behavior.

This chapter focuses on the heterogeneity of sensation seeking, which is a construct met with great interest as well as controversy. In the following, I will use the example of sensation seeking in pathological gambling to illus-

trate the complexity of heterogeneity in addiction, and address some of the controversies about the construct. I will start with introducing the sensation seeking construct, as it has been described by Marvin Zuckerman, followed by a presentation of the literature on sensation seeking in pathological gambling. I will also present data from three recent studies on sensation seeking in pathological gambling: 1.) a clinical study of more than 300 pathological gamblers; 2.) a neuroimaging study of dopamine binding potential in relation to sensation seeking and pathological gambling; and 3.) a decision making study of pathological gamblers and non-gambling controls. Finally, I will present a model for understanding sensation seeking as a construct with both biological, psychological and social correlates. I will argue, that bio-psycho-social factors may affect the different types or patterns of addiction, even though each individual factor may not distinguish pathological gamblers from non-gambling controls, and that these differences hold important implications for treatment considerations.

The sensation seeking construct

Sensation seeking addresses the phenomenon that when we are presented with a novel stimulus, we tend to differ in our reaction of approaching or avoiding the stimulus. Some people are more predisposed to react with approach, while others are more predisposed to react with withdrawal. Neither of the two predispositions can be said to be better than the other, but will lead to different types of reactions, decision making, and behavioral patterns. Generally speaking a higher level of sensation seeking is associated with a predisposition towards approaching new stimuli, while a lower level of sensation seeking is associated with a predisposition towards avoiding new stimuli (Zuckerman, 1994, pp. 124-29).

The most widely used measure of sensation seeking is presented by Marvin Zuckerman (1979, 1994, 2000), who defines sensation seeking as »...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 experiences« (Zuckerman, 1994, p. 17). In the definition Zuckerman emphasizes, that increased sensation seeking doesn't necessarily mean that the person is more reckless, but that the person is more willing to take risks than others, in order to achieve a certain goal. For instance, parachute jumpers are mostly very careful about their equipment, and the added risk of jumping doesn't lead to carelessness in preparation. Similarly, there is a direct correlation between sensation seeking and average speed on the freeway (high sensation seekers drive faster), but that doesn't imply that high sensation seeking individuals are less likely to use their seatbelt.

Historically, sensation seeking has been used to describe different psychological processes. Dating back to the early 20th century, sensation seeking

was seen as a primary drive, i.e. a state dependent need such as hunger, tiredness or sexual urges (Zuckerman, 1994). It was not considered whether there would be stable individual differences in the level of 'excitability' or 'arousal'. It wasn't until Eysenck's formulation of introversion and extroversion in optimal arousal, that the concept of sensation seeking was put into a human biological and personality difference context (Zuckerman, 1994).

Eysenck suggested that introverts and extroverts were located at each end of a continuum of stimulation, such that at a low level of stimulation or arousal, introverts would have a more positive hedonic response (i.e. feel better) than extroverts. Extroverts on the other hand would feel better than introverts at a higher level of stimulation or arousal. The optimal arousal theory was later revised by Zuckerman (1979), mainly for two reasons: First while the arousal theory accounted for the hedonic response seen in substance abuse disorders like amphetamine and cocaine abuse, it did not explain the hedonic response to »arousal depressants« such as alcohol, opiates and barbiturates. While these types of substances were just as addictive and pleasure inducing, they did not lead to an increase in arousal, but contrarily to a decrease in the arousal level.

Second, the cortical arousal, which up until that point had been the focal point of the arousal theory, did not include genetic factors or neurochemical transmitters such as dopamine, serotonin or nor-epinephrine, substances which are all related with excitement inducing behaviors. Zuckerman therefore aimed at writing a more comprehensive theory of sensation seeking, which included more bio-psycho-social factors.

Like Eysenck, Zuckerman's idea was to formulate an inventory, i.e. a questionnaire, which not only would measure the personality trait of sensation seeking, but also the underlying biological predispositions for increased arousal and hedonic response. Such personality differences and biological predispositions would affect the persons social and behavioral performance and their approach or avoidance of both negative (substance abuse and stress reactions) and positive (artistic and creative expressions) activities. The clear advantage of formulating a more coherent bio-psycho-social model, was to enable heterogenetic differentiation of sub-groups in pathological and non-pathological populations. The risk involved was that the approach would not be specific to any one type of addiction or pathology, thereby rendering little predictability of vulnerability factors towards pathology. Indeed, this is exactly the controversy that surrounds the concept today, and defines the vantage points of proponents and opponents of the construct.

The Zuckerman Sensation Seeking Scale (SSS) was developed in 1979 (Zuckerman, 1979; Zuckerman *et al.*, 1978) and revised in 1994 (Zuckerman, 1994, 1996). The current version of SSS (Form V) consists of 40 binary questions where the person in a forced-choice has to decide whether s/he is closer to one or the other of two statements (e.g. (A.) »I like 'wild'

uninhibited parties«, or (B.) »I prefer quiet parties with good conversations«. The scale consists of a total score and four sub scales: 1.) Thrill and Adventure Seeking (TAS), which measures the desire to engage in sports or risky physical activities which often involve speed or defiance of gravity (e.g. parachuting, scuba diving or skiing). An example of a typical TAS item is 'I sometimes like to do things that are a little frightening'; 2.) Experience Seeking (ES) measures the desire to seek novel experiences and sensations through the mind and senses, such as music, art and travel. It also includes a dimension of non-conformity through engaging in marginalized or minority groups of society such as artists, hippies or homosexuals. An example of a typical ES item is 'I like to try new foods that I have never tasted before'; 3.) Disinhibition (DIS) measures sensation seeking through the desire to engage in social activities such as parties, social drinking and sexual relations. A typical DIS item is 'I like to have new and exciting experiences even if they are a little unconventional or illegal'; 4.) Boredom Susceptibility (BS) describes the degree of (in)tolerance for repetitive experiences of any kind, including routine work and boring other people. A typical BS item is 'The worst social sin is to be a bore' (vs. 'The worst social sin is to be rude'). Each subscale consists of 10 questions with a maximum score of 10. The maximum score for the Total SSS index is 40. The SSS has been translated into Danish, and a validation study shows satisfactory validity and reliability with the American norms (Ripa *et al.*, 2001).

Empirical findings of sensation seeking

Cross-cultural studies of sensation seeking suggest that it is a trait which is stable across western countries, English and non-English speaking (Zuckerman, 1994). They also suggest that there are age and gender differences related to the construct. Both men and women show a decrease in the level of sensation seeking with age from an average of 20 during their teens and early twenties, dropping down to around 15 after the age of 50. Men tend to score higher than women, and these differences remain stable throughout life. The tendency is stronger, however, on the Thrill and Adventure Seeking subscale, while scales like Experience Seeking and Disinhibition show more similar gender distributions.

In a treatment study of over 300 pathological gamblers seen at Center for Pathological Gambling in Odense, we found a significantly negative correlation between sensation seeking at age ($r = -0.29$, $p < 0.001$), see Figure 1. We also found a skew in the age distribution similar to that of alcohol treatment, which is described elsewhere in this issue (xxx, s. xx), see Figure 2. These results are supported by the findings of Gonzalez-Ibanes *et al.* (2005), who found that young pathological gamblers were more sensation seeking, while older pathological gamblers showed more problems with personality

disorders. Sensation seeking therefore seems to have a core age related component which influences the individual differently throughout life.

Figure 1. Correlation between sensation seeking and age among pathological gamblers.

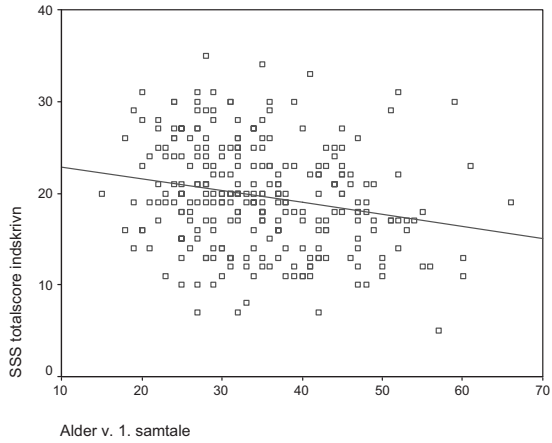
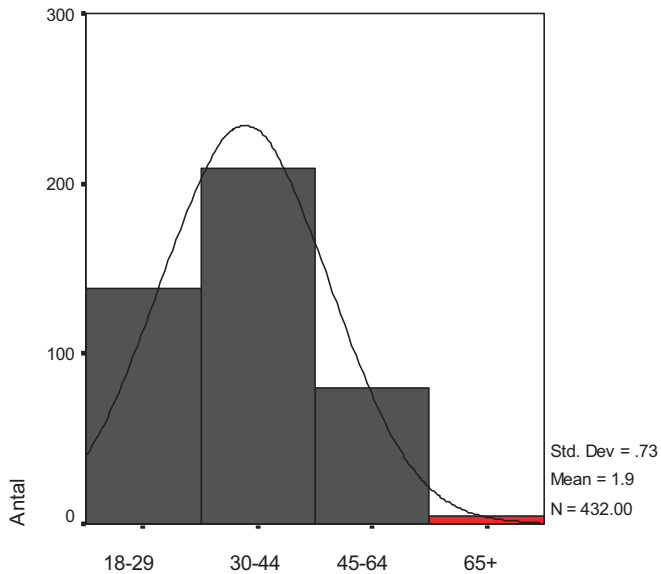


Figure 2. Age distribution of pathological gamblers, when seeking treatment.



Sensation seeking is of specific interest to the study of addiction and abuse such as smoking, drinking and gambling, due to the novelty seeking and arousal associated with the addictive behavior. Zuckerman (1994) suggests, that sensation seeking may be particular salient to substance abuse and addiction during the initial phase of the abuse, since highly sensation seeking individuals are more open towards novel experience. Significant correlations have consistently been found between the use of both legal (e.g. alcohol and tobacco) and illegal (e.g. marihuana and inhalants) substances and higher levels of sensation seeking. Higher levels of sensation seeking in early adolescence have also been found to predict later substance use. Interestingly, some of the strongest correlations have been found between smoking and boredom susceptibility, suggesting that a strong component of smoking is the boredom reducing quality, which may or may not be related with the nicotine dependence and the regulation of physiological reactions associated with the nicotine intake.

While sensation seeking may increase the likelihood of experimenting with various substances, it appears insufficient to predict which individuals later become addicted to certain types of substances. Other factors such as drug liking, craving, inability to inhibit impulses, and social reinforcement may contribute to the risk-prevalence towards substance abuse and dependence. Many high sensation seeking substance using individuals do not end up becoming addicted, and others never initiate regular use of substances in the first place. However, within the addictive behavior population sensation seeking may explain differences in addictive behavior patterns, substance preference, and decision making. Such differences in heterogeneity, it may be important not only to better understand the underlying biology of addictions, but also the phenomenology and clinical implications of addictive behavior. Specifically, differences in sensation seeking level are essential in differentiating between hedonic responses resulting from decreased arousal or activation, and hedonic responses resulting from increased arousal or activation, i.e., whether the person uses the drug or behavior to get 'high' or 'stoned'. Another implication is the importance of comparing both high and low sensation seeking addicted individuals on arousal towards cue-exposure. To illustrate this point, I will present preliminary data from an ongoing study of dopamine receptor binding and release in relation to sensation seeking.

Dopamine and sensation seeking

As mentioned earlier, addictions such as tobacco, alcohol, and gambling dependence are associated with the construct of sensation seeking. The same addictions have also been associated with dopamine mediated reinforcement/reward systems (Dellu *et al.*, 1996; Hutchison *et al.*, 1999; Spunt, 2002).

In an ongoing study of dopamine neurotransmission, we are using the dopamine receptor ligand [^{11}C]raclopride to measure the binding potential and dopamine release during gambling in high and low sensation seeking pathological gamblers and non-gambling controls. The dopamine binding potential (pB) of raclopride is proportional to the concentration of dopamine receptors in the brain, which are not already occupied by dopamine binding. By comparing the binding potential (pB) in a baseline or rest condition with a pharmacological or behavioral challenge, the dopamine release can be measured as the difference in concentration levels. Since high sensation seeking individuals are more sensitive to dopamine-mediated reward from amphetamine and gambling situations (Bergh et al., 1997; Koeppe et al., 1998; Raylu & Oei, 2002; Volkow et al., 1999; Volkow et al., 2002; Zuckerman, 1979; Zuckerman, 1994), we hypothesize that high sensation seeking individuals have a higher dopamine release during gambling seen as a lower [^{11}C]raclopride binding potential in gambling vs. baseline. In contrast, low sensation seeking individuals are hypothesized to have a lower raclopride binding potential and a lower hedonic response to dopamine release during gambling. Our preliminary data are consistent with the hypothesis (Linnet et al., 2005). If, in term, the hypothesis is supported, it may suggest that high and low sensation seeking pathological gamblers differ in the etiology of their gambling preference and motivation for gambling. For instance, high sensation seeking pathological gamblers may see gambling as a challenge in which the prospect of winning money or being 'the best' at gambling is associated with a euphoric hedonic response (a 'high', 'kick' or 'rush'). This type of gambler is sometimes referred to as a 'fight' gambler. In contrast, low sensation seeking pathological gamblers, may see gambling as a way to escape problems or demands from their surroundings, or from within themselves. These gamblers are sometimes referred to as 'flight' gambler. Their motivation for gambling may be to avoid problems, and they may seek to achieve a 'numbing' hedonic response or stress release ('vent', 'decompress', or 'dissociate'). If our preliminary data are confirmed, they open questions such as: Are there differences between high and low sensation seeking pathological gamblers in the onset or course of the disorder (e.g. early vs. late onset, or rapid vs. gradual onset)? Do they differ with regard to other bio-psycho-social factors, or in their response to treatment (e.g. difference in treatment effect, treatment approach, or focus on motivating factors for gambling)? In order to further answer such questions, it is necessary to take a closer look at sensation seeking and other related factors in pathological gambling.

Sensation seeking in pathological gambling

It has been suggested, that since high sensation seeking individuals respond more favorably to novelty, risk and uncertainty of outcome, they are more susceptible for developing pathological gambling (Brown, 1986). As men-

tioned previously, such a predisposition for stimulus approach does not necessarily lead to a higher risk-prevalence for developing pathological gambling. However, among individuals who do become addicted to gambling, the literature has shown a consistent relationship between sensation seeking and gambling behavior.

A recent review by McDaniel and Zuckerman (2003) reports an interaction between sensation seeking and gambling behavior, including increased betting levels (Anderson & Brown, 1984; Dickerson et al., 1987), intentions to gamble (Wolfgang, 1988), gambling frequency (Kuley & Jacobs, 1988), variety of gambling forms (K. R. Coventry & Brown, 1993), attitudes towards gambling (Breen & Zuckerman, 1999) and loss of control (Coventry & Hudson, 2001). Three sets of hypotheses, however, have met less support: 1.) that pathological gamblers are more sensation seeking than non-gambling controls; 2.) that sensation seeking is related to continued gambling; and 3.) that high sensation seeking pathological gamblers experience higher arousal during gambling.

Lack of support for the first hypothesis is reported by Dickerson et al. (1987) who found that pathological gamblers actually displayed lower sensation seeking levels than non-gambling controls. At the same time the authors found a positive correlation between sensation seeking and involvement of gambling, suggesting a possible threshold of influence of sensation seeking on gambling behavior. In other words, sensation seeking discriminated within group variation, but not between group averages. In support hereof Kuley & Jacobs (1988) found that problem gamblers had significantly higher sensation seeking scores than social gamblers.

Secondly, it has been suggested that sensation seeking may contribute to prolonged gambling, due to a loss of control resulting from a heightened arousal from gambling. Breen & Zuckerman (1999) investigated chasing in a card guessing gambling task in relation to impulsivity and sensation seeking among 248 college students. Participants could choose either to receive \$10 (non-players) or to gamble with the money, and were classified as: Non-players, non-chasers and chasers. The gambling participants could stop whenever they wanted, but the task was designed such that the probability of winning diminished the longer the person continued gambling. Non-chasers were defined as quitting while they still had money; chasers didn't quit until they lost all of their cash. The authors found significant differences in gambling beliefs between non-players and gamblers, but no differences in gambling beliefs between chasers and non-chasers. Chasers and non-chasers showed significant differences in impulsivity but no differences in sensation seeking behavior. The authors conclude that: »The hypothesis that chasers would be higher in sensation seeking received no support. This weakens any arousal theory of problem gambling ... which claims that gamblers lose control over their betting behavior because of a general preference for maintaining an optimal level of stimulation.« (Breen

& Zuckerman, 1999, p. 1107). The authors note, however, that their results may be due to the fact that they used a card guessing game, in which no skill was involved. In other words, there was no way to evaluate the skill level of the game, only the persistency of gambling. The design did not allow for looking at various degrees of chasing or the decision making processes of gambling, two variables which, theoretically, are very important with regard to sensation seeking. For instance, high sensation seekers are known to be willing to take larger risks faced with the possibility of higher rewards (Zuckerman, 1994). Persistence of high risk choices, could therefore possibly be a better measure of sensation seeking within gambling sessions, than the continuation of gambling.

Thirdly, the sensation seeking arousal hypothesis, which states that high sensation seeking individuals are more aroused by wins or losses than low sensation seeking individuals, has met limited support. In a series of studies of heart rate during fruit machine gambling (Kenny R. Coventry & Constable, 1999; Kenny R. Coventry & Hudson, 2001), the authors found no support for the hypothesis. Instead, winning or losing was a better predictor of arousal than sensation seeking. However, following the argument of Breen and Zuckerman, the lack of decision making and skill level in the design may not have allowed for relevant analyses of sensation seeking. If the increase of arousal in high sensation seekers is characterized by a willingness to engage in risk taking strategies, one would not necessarily expect to find differences in arousal in a no-skill game where the outcome is random or fixed. Rather, one would expect to find differences in arousal as a result of high sensation seeking individuals making more high risk choices. In other words, high sensation seeking individuals may not differ in their physiological response per se, to a random or forced outcome. Instead, they may have a higher preference for high risk choices, thereby achieving a higher overall arousal level. Such an analysis would only be possible in a situation which involved skill and risk choices in the decision making.

Sensation seeking and decision making

In a recent study [Linnet et al., in press], we looked at differences in decision making between pathological gamblers and non-gambling controls in relation to sensation seeking. We measured decision making, using the the Iowa Gambling Task (IGT) by Bechara et al. (2003, 1994, 2002, 2000a, 1998, 2001, 2000b). In addition, participants completed the SSS and the South Oaks Gambling Screen (SOGS), an assessment tool measuring gambling pathology (1993, 1987).

The IGT is a computerized card game, which simulates real-life decision making in the way it factors reward, punishment, and uncertainty of outcomes. It measures impulsivity and decision-making during 100 trials of

card-drawing. The IGT consists of four »decks« of cards labeled A' B' C' and D', where the task is to win as much money as possible. The person is free to draw from whichever deck s/he prefers and can change decks as many times as desired. The game ends after 100 trials. Each time the person draws a card s/he wins money, but sometimes the win is followed by a loss. Deck A' and B' offer immediately higher wins but lead to an overall loss; deck C' and D' have smaller immediate wins, but lead to an overall win. The IGT is scored by subtracting the »bad« cards from the »good« cards: $(C+D) - (A+B)$. The IGT was developed to test Damasio's somatic marker hypothesis (Damasio, 1994) in patients with lesions to the ventromedial prefrontal cortex (A. Bechara et al., 1994; A. Bechara et al., 2000b), the test is now used in substance abuse disorders and pathological gambling (A. Bechara et al., 2001; Cavendish et al., 2002; Grant et al., 2000; Linnet et al., in press; Petry, 2001).

As mentioned earlier, it is possible, that the differentiation of sensation seeking in pathological gambling is related to a higher preference for high risk choices. We therefore had two hypotheses: 1.) that pathological gamblers had a higher degree of chasing, compared to non-gambling controls; and 2.) that pathological gamblers who chase, have a higher level of sensation seeking than non-chasing pathological gamblers.

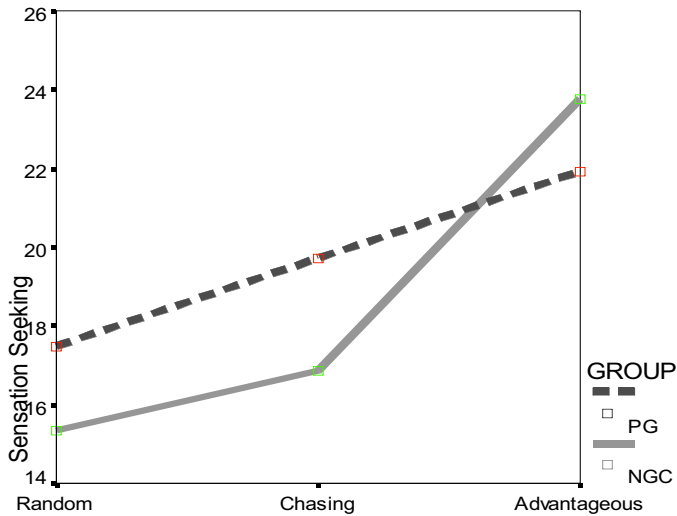
We measured chasing as 'decision episodes' of five consecutive choices from advantageous (C or D) or disadvantageous (A or B) decks. The chance of such an occurrence is $2^{-5} = 0.03125$ ($p < 0.05$). In other words, the chance of such a decision episode happening at random is less than 5%. We therefore used the number of decision episodes as an indication for the degree to which a person would display a *disadvantageous chasing strategy* (a negative number of $(C+D) - (A+B)$ episodes), *advantageous strategy* (a positive number of $(C+D) - (A+B)$ episodes), or a *random strategy* (a number close to zero).

The result showed that pathological gamblers had significantly poorer overall performance on the IGT than non-gambling controls, and that they were significantly more chasing, i.e. had a higher number of disadvantageous decision episodes relative to advantageous decision episodes. The finding was gender specific, however, such that men showed significant differences, while women failed to reach significance level. We found no differences in sensation seeking between pathological gamblers and non-gambling controls, except on the subscale of Experience Seeking.

Next, we looked at the relation between sensation seeking and chasing within pathological gamblers and non-gambling controls. A chi-square test showed that random and 'chasing' players were significantly more likely to have a low sensation seeking score than 'advantageous' players ($\chi^2 = 16.60$, $p < 0.01$). When divided into pathological gamblers and non-gambling controls, the results remained significant for pathological gamblers ($\chi^2 = 12.52$, $p < 0.01$) but did not reach significance level for non-gambling controls: ($\chi^2 = 7.27$, *NS*), A univariate analysis of covariance (ANCOVA) with age as the

covariate showed that these differences were significant for men ($F = 3.03$, $p < 0.02$), but not women ($F = 0.98$, N.S.). No main group differences were found between male pathological gamblers and non-gamblers, see Figure 3.

Figure 3. Relation between sensation seeking and decision making in pathological gamblers and non-gambling controls.



The results suggest, that random players have lower sensation seeking than players who adhere to a particular strategy, whether good or bad. This is consistent with the notion that low sensation seeking pathological gamblers are ‘flight’ gamblers, who are less interested in the skill level or challenge of the game. The results that medium to high sensation seeking is associated with both advantageous and disadvantageous strategies, suggest that sensation seeking is associated with a preference for adherence. It is possible that individuals with higher sensation seeking prefer to ‘approach’ the task and stick to their strategy, whether it leads to an advantageous outcome or not. Alternatively, it is possible that high sensation seeking individuals with poorer performance get a ‘kick’ out of risky choices, and would rather prefer big losses with a (perceived) ‘long shot’ chance of winning, than minor losses with a (perceived) certainty of losing. In this way sensation seeking would be associated with a particular predisposition for decision making (approach vs. avoidance) rather than the performance of decision making (good vs. poor).

Discussion

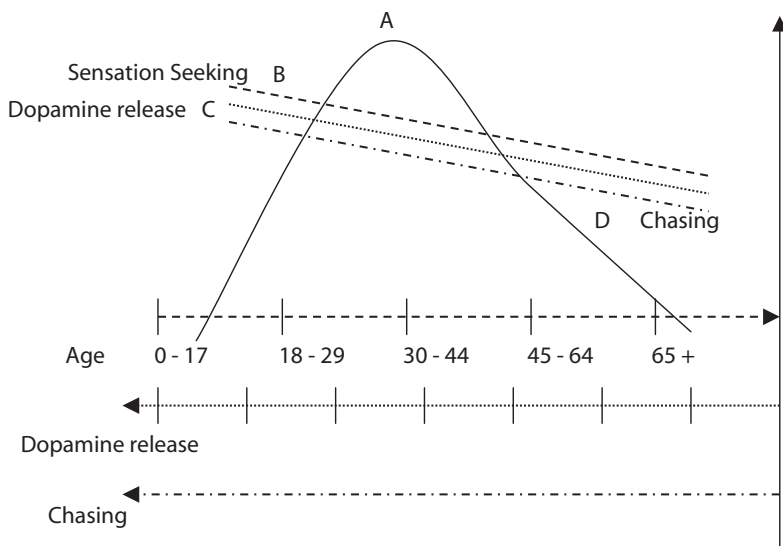
As mentioned previously, sensation seeking is a construct characterized by differences in approach and avoidance towards new stimuli. Throughout the article, I have argued that Zuckerman's sensation seeking construct is a psychological measure with biological and temperamental predispositions, which hold social consequence, in the way it affects the individuals approach to use of substances and addictive behavior. Sensation seeking is related with differences in age and dopamine release, as well as decision making. While it appears that sensation seeking is *sensitive* to addictions such as pathological gambling, it is also clear that sensation seeking is not *specific* to addictions. In other words, sensation seeking appears to be relevant with regard to distinguishing subgroups of pathological gamblers, but less relevant with regard to distinguishing between pathological gamblers and non-gambling controls. In addition, sensation seeking appears to affect the types of decisions that individuals perform, but not the performance level (i.e. good vs. bad decisions).

What implications does this type of heterogeneity hold for the study of addictions, in this case pathological gambling? First, sensation seeking should be used for differentiating the heterogeneity of addictions, i.e. distinguishing the bio-psycho-social behavior between sub-groups of individuals suffering from addictive disorders. Second, sensation seeking may be a 'marker' of decisions and behavior, rather than an indication of advantageous or disadvantageous decisions and behavior. Therefore, decision making should be addressed separately in distinguishing high and low sensation seeking sub-groups of addiction.

Figure 4 summarizes the data presented in the current article, together with some clinical and research considerations for further studies of pathological gambling and addictions. The figure is a hypothetical illustration of the bio-psycho-social factors presented in this article.

First, there is a skew in the age distribution for treatment seeking of addiction, coinciding with a peak in the early to late 20s and a gradual decrease with age (see Figure 4 A). The data are likely a true reflection of a relation between age and addiction, which means that addictive behavior has a particular developmental salience. This salience may transform into other forms of addiction or problems in older age. Many factors may affect the relation between age and addiction, among the two mentioned here sensation seeking (see Figure 4, B) and dopamine release (see Figure 4, C). The interaction between sensation seeking and age (Figure 4, B) is illustrated as the top linear correlation and X-axis. The interaction between sensation seeking and dopamine binding potential (Figure 4, C) is illustrated as the middle linear correlation and X-axis. To avoid the confusion of opposite directions of positive and negative correlations, the X-axis in Figure 4, and C is inverted. The slopes are hypothetical, and may not be parallel.

Figure 4. Hypothetical model of heterogeneity of sensation seeking: Relation between age at treatment seeking, dopamine binding potential, decision making and sensation seeking.



Sensation seeking, dopamine release and age are interrelated factors, and the tenor of the literature is that both sensation seeking and dopamine binding release with age. Furthermore, the basis of the sensation seeking theory is that increased sensation seeking in younger individuals, seen as an increased approach towards new stimuli, is mediated by a higher dopamine release among young people. This coincides with the notion that higher sensation seeking is associated with a higher propensity for trying new activities, including substance use, even though this propensity does not predict later abuse or addiction. The sensation seeking model thus incorporates a biological explanation for the increased activity level. It is possible that both neurological and psychological factors associated with repeated exposure, cause the dopamine release to decrease over time. For instance, there may be a 'first time effect' among younger individuals vs. a 'seen it before' in which experiencing for instance a new city may be different for a seasoned traveler and a 'first time' traveler. It is possible, that the nervous system and/or psychological contextualization from developmental habituation increasingly categorize stimuli as 'known' stimuli, rather than 'new' stimuli. In other words, new stimuli may faster be put in a category of 'known' stimuli, thereby reducing the activation associated with novel stimuli. There may be

other explanations for the decrease in dopamine binding potential as well.

Finally, the relation between decision making and sensation seeking (see Figure 4, D) is illustrated as the hypothetical bottom linear correlation and X-axis. In our data, we found a significant correlation between sensation seeking and strategy adhering, but no correlation with age. As these are cross sectional data, it (fortunately) cannot be directly inferred that while we become less sensation seeking with age, we don't seem to be making any better decisions. Instead, the results may suggest, that older and younger individuals do seem to differ in their decision making strategies.

The implications from our data are consistent with the clinical picture of diversity seen in pathological gamblers seeking treatment, and may help the direction of treatment for different sub-groups of gamblers. From clinical observations, it appears that young pathological gamblers who are highly sensation seeking 'over-engage' in gambling activities, often by playing many different types of games or gambling activities simultaneously (e.g. gambling on more than one slot machine at the time). Sometimes they are also involved in other excitement evoking activities such as illicit drug use or motor sports. A key component of treatment is to find ways to channel their approach willingness into more constructive activities, and for them to learn to find satisfaction in such activities, even though it may not bring them the immediate gratification that they otherwise seek.

In contrast older pathological gamblers who are low sensation seekers may 'under-engage' in constructive activities, and use gambling as an escape or avoidance mechanism. The core problem for these gamblers may be the long haul of re-engaging in a neglected family, facing up to the challenge of re-committing or making new commitments. Common for the latter group is that they have often have earlier experiences with gambling, but also some periods in their life with a higher functioning level than their current state. Whether the challenge for them is to re-engage with an alienated spouse, engage in a new relationship or find new activities, these individuals often have a previous functional level, from which they can work. The challenge here is not so much to learn new coping strategy, but to find the motivation and desire to engage in life changes. In contrast younger gamblers are often desperately looking to learn meaningful coping strategies, which can lead them to satisfactory outcomes.

From a research perspective, studies of the dopamine binding potential and dopamine release in decision making between high and low sensation seeking pathological gamblers, is needed in order to better understand how sensation seeking affects decision making in gambling pathology. We are currently collecting data to answer these questions at Center for Integrative Neuroscience in Århus. The project is expected to be concluded in 2006.

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