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Heavy smokers choose large, immediate rewards with large penalties on a simulated task of gambling

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HEAVY SMOKERS CHOOSE LARGE, IMMEDIATE REWARDS WITH LARGE PENALTIES ON A SIMULATED TASK OF GAMBLING

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Abstract

The Gambling Task is a complex neuropsychological test (in the form of a card game) that examines the ability of individuals to assess potential immediate gains over long-term losses. Gambling Task performance has been examined in previous studies with individuals who are dependent on alcohol, cocaine, heroin, and amphetamine. These studies have shown that those who are dependent on the aforementioned substances perform more poorly on the Gambling Task than controls. Specifically, in relation to controls, drug/alcohol dependent individuals show impairment by tending to pick more cards that have large immediate gains and very large delayed punishers. The delayed punisher is larger than the immediate gain, so there is a net loss in play money. Individuals who are not dependent on substances tend to choose cards that yield small immediate gains and very small delayed punishers. The delayed punisher is smaller than the immediate gain, so there is a net increase in play money. In order to test the hypothesis that heavy smokers display the same pattern of decision-making, the Gambling Task was administered to a sample of 40 participants (23 heavy smokers and 17 never-smokers). Results indicated that heavy smokers performed more poorly on the Gambling Task than non-smoking controls. Specifically, heavy smokers chose more cards from the decks with large delayed punishers than did the control group.

Introduction

Researchers have speculated that addictive behaviors, including substance dependence and gambling, share a common etiology (Wilcox & Erickson, 2000). Wilcox and Erickson suggested that addictions are a result of changes in brain chemistry and learning. They theorized that two factors must be present in order for an addiction to develop. First, after a drug is ingested, the medial forebrain bundle region of the brain must be activated. Second, after ingesting a drug, it must affect neural conduction quickly, and neural activity must drop below normal levels before returning to baseline. This drop in neural activity has been termed the "rebound effect" and is thought to be a major cause of withdrawal. Other researchers argue that addictions are more complex than the theory proposed by Wilcox and Erickson. For example, Koob, Sanna, and Bloom (1998) argued that other brain regions are active in the development of addictions. Specifically, they hypothesized that the extended amygdala is pivotal to the development of addictions.

Structural and Functional Brain Abnormalities in Substance Abusers

Jentsch and Taylor (1999) suggested that drug seeking behavior can be explained, in part, by impaired inhibitory control of behavior. They theorized that this impairment stems from dysfunction in the frontal cortical area. Jentsch and Taylor hypothesized that drug seeking behavior may be the result of two distinct phenomena acting synergistically. First, long-term exposure to a substance may increase the salience of the substance by activating prefrontal cortical dopamine release. This idea has been supported by research that suggests that repeated use of drugs decreases dopamine stores in the prefrontal cortex (Jentsch, Verrico, Le, & Roth, 1998; Sorg, Davidson, Kalivas, & Prasad, 1997). Animal research has shown that drug administration will lead to an immediate increase of dopamine in the prefrontal cortex

(Moghaddam & Bunney, 1989; Nisell, Nomikos, Hertel, Panagis, & Svensson, 1996). Secondly, the individual may be less able to inhibit their behavior because of damage to the prefrontal cortex. If repeated use of drugs of abuse affect the frontal cortex in such a way to diminish the ability for individuals to inhibit responses, and the drug of abuse becomes a dominant reinforcer, then these "reward related stimuli could virtually dominate responding" (Jentsch and Taylor, 1999). Their model purports that drug consumption is a direct consequence of deficits in inhibitory control and enhancements in stimulus-reward learning.

Several studies have detected structural abnormalities in the brains of those who abuse substances. Liu, Matochik, Cadet, and London (1998) found that the prefrontal cortex of the polysubstance abuser is comparatively smaller than that of non-drug abusing controls. Harper and Kril (1990) found that alcoholics have a smaller volume of gray matter in their frontal lobes than non-alcoholics. Although the origin of these structural abnormalities is not completely clear, some possible explanations have been suggested. There is substantial empirical evidence that supports the idea that children of alcoholics may inherit a vulnerability to develop the disorder themselves (Bohman, Cloninger, Sigvardsson, & von-Knorring, 1987). Wiers, Sergeant, and Gunning (1994) suggested that this vulnerability may be related to congenital brain defects in the prefrontal cortex. Alternatively, neuropathological studies have suggested that repeated exposure to drugs of abuse may result in atrophy of neurons in the prefrontal cortex (Harper & Kril, 1990). Collectively, these studies suggest that a combination of congenital defects and atrophy of neurons in the prefrontal cortex may be related to the structural brain abnormalities found in substance abusers.

A number of studies that have examined Positron Emission Tomography (PET) and Single-Photon Computed Tomography (SPECT) scans of the brains of cocaine abusers have shown marked decreases in the amount of cerebral blood flow in the prefrontal cortex (Tumeh, Nagel, English, Moore, & Holman, 1990; Volkow, Mullani, Gould, Adler, & Krajewski, 1988; Weber et al., 1993). Individuals who abuse cocaine have been shown to exhibit differences in metabolic activity in their orbitofrontal cortex when compared with matched controls (Volkow et al., 1991). Hommer et al. (1997) detected similar abnormalities in alcohol abusers. Volkow et al. (1992) found reduced cerebral blood flow in the frontal cortices of cocaine abusers up to 4 months after cocaine use terminated. Volkow et al. (1992) also found that this reduction in cerebral blood flow was positively correlated with the dose and number of years of cocaine use. These findings consistently suggest that repeated use of addictive substances is associated with changes in the way the brain functions, especially the prefrontal cortex.

Dysfunction of the frontostriatal systems is thought to be related to the planning deficits seen in other psychological disorders (Frith, 1987). It appears that this area of the brain is very important in the inhibition of impulses. Damasio (1996) suggested that damage to the ventromedial prefrontal cortex leads to deficits in planning. Damage to the ventromedial prefrontal cortex has also been shown to lead to impairment in the extinction of an operant response in monkeys (Rosenkilde, 1979). These findings, along with the brain abnormalities already mentioned, suggest that there may be a relationship between drug abusers' impaired decision making and impairments in their ventromedial prefrontal cortex. Substance abusers may impulsively use their drug of choice, even after they have received repeated negative consequences, partially because of damage to their ventromedial prefrontal cortex (Bartzokis et al., 2000; Bechara et al., 2001; Grant, Contoreggi, & London, 2000; Petry, Bickel, & Arnett, 1998). This damage may impair a person's ability to learn to inhibit previously reinforcing behaviors or to recognize future consequences.

Performance on the Delayed Discounting Task

Individuals vary greatly in their preferences for immediate versus delayed rewards. Those who prefer immediate rewards may be more likely to develop addictions (Bickel & Marsch, 2001; Vuchinich & Tucker, 1988). Discounting of delayed rewards has been suggested as a way to measure impulsivity in substance abusers. Delay discounting refers to the phenomenon where a delayed reinforcer has subjectively less value than an immediate reinforcer. By using a measure of discounting of delayed rewards, Petry (2001a) found that heavy drinkers seem to be more impulsive than light drinkers and abstainers. Heavy drinkers were more likely to choose smaller, short-term rewards instead of larger, delayed rewards. For example, heavy drinkers were more likely than light drinkers to prefer a smaller amount of money awarded immediately, rather than a larger sum of money given at some point in the future.

Mitchell (1999) showed that smokers were more impulsive on a delayed discounting task than subjects who had never smoked. Smokers were also more likely to score higher on the Eysenck Impulsivity Questionnaire (Eysenck, & Eysenck, 1968) than non-smokers. In addition, smokers scored higher than non-smokers on the Barratt Impulsiveness Scale (Patton, Stanford, & Barratt, 1995) – a three subscale test that assesses “non-planning”, “cognitive complexity”, and “motor impulsiveness.” The results of this study support the idea that smokers, like other drug abusers, are more impulsive than non-drug users.

Bickel, Odum, and Madden (1999) suggested that smokers display the same impulsiveness that other drug users do. The authors tested their hypothesis by examining whether current smokers discounted the value of delayed money more than a comparison group of nonsmokers. They found that the subjective value of delayed reinforcement is quickly diminished in smokers, as it is in individuals who are dependent on other drugs. The authors also found that never and ex-smokers did not differ in their discounting rates. Two possible reasons for this finding were suggested. First, the level of delayed discounting that occurs in smokers may be malleable. After the individual remains abstinent for some period of time, their level of delayed discounting may return to pre-smoking levels. The alternate explanation for this finding is that there may have been a selection bias in the ex-smoker group. The ex-smoker group may have been made up of people who were less likely to discount delayed rewards, even before they quit smoking, which theoretically, would have made it easier for this group to quit smoking in the first place.

Many substance abusers are eventually able to stop abusing drugs. It has long been known that with abstinence, physical health improves. More recently, there has been consistent scientific evidence that discounting of delayed rewards may also decrease when the substance abuser stops smoking cigarettes, using intravenous drugs, or drinking alcohol (Bickel et al., 1999; Bretteville-Jensen, 1999; Petry, 2001b). The reasons for this decrease in delay discounting, and possibly impulsivity, are not entirely understood.

Bickel and Marsch (2001) conducted a review of the literature that examined the role of delayed discounting on impulsivity and loss of control in drug users. They suggested that delayed discounting in substance abusers may account for both their tendency to respond impulsively and their apparent loss of control. The authors suggested that drug abusers are impulsive in that a smaller, immediate reinforcer (i.e., drugs) becomes more important than larger, delayed reinforcers (e.g., better grades, better relationship with family). The authors also stated that drug abusers display a loss of control concerning whether or not they will use drugs. Bickel and Marsch defined this loss of control as a reversal of preference from a delayed, larger reward (e.g., abstinence, better health) to a smaller, more immediate reward (e.g., high from drugs). For example, when a drug abuser attempts to quit or decrease his level of drug consumption, he chooses a delayed, larger reward over a smaller, more immediate reward. When the drug abuser relapses or uses more than he intends to use, he has reverted back to choosing smaller, more immediate rewards over the larger, delayed rewards.

Heyman (1996) suggested that delay discounting may help explain the phenomenon of preference reversals (i.e., initially deciding to choose a long-term reward over a smaller short-term reward but later, when the immediate reward is available, electing to accept the smaller reward). The nicotine-addicted individual may decide to decrease the number of cigarettes he/she smokes each day because being healthier is very important to him/her. Later, he may decide that smoking will not hurt his health very much in the short run and he may return to smoking at his normal level.

Immediate gratification can be obtained in a number of ways, including drug use, gambling, or other addictive behaviors. Petry (2001b) found that pathological gamblers were more likely to discount delayed rewards than non-gamblers. Also, gamblers who had comorbid substance abuse problems were more likely to discount delayed rewards than gamblers without substance abuse problems. These results support the idea that the discounting of delayed rewards is related to impulse control in dependence to substances as well as other addictive behaviors.

The common co-occurrence of pathological gambling and substance abuse has led to the hypothesis that a common etiological process may occur within these populations. Evidence suggests (McCormick, 1993; Petry & Casarella, 1999) that the etiological process involves impairment of impulse control. Petry (2001b) suggested that individuals who have moderate levels of impulsivity may develop only one behavior that appears impulsive (e.g., drugs or gambling), but with more severe impulsivity, individuals may engage in multiple impulsive behaviors.

Impairment on the Gambling Task

Substance abusers have shown impairments on a number of tests that measure brain functioning. Beatty, Katzung, Moreland, and Nixon (1995) found that individuals who have abused cocaine or alcohol have significant impairments on neuropsychological tests that measure learning and memory, problem solving and abstraction, and perceptual motor speed. The authors found that these neuropsychological deficits remain for at least three to five weeks after drug or alcohol use has stopped. Some research, however, suggests that these changes in brain functioning can be reversed. A study conducted by Azrin, Millsaps, Burton, and Mittenberg (1992) found that some recovery of function may occur after cocaine abusers abstain from drug use.

Bechara, Damasio, Damasio, and Anderson (1994) developed a gambling task that is sensitive to damage in the ventromedial prefrontal cortex. The authors showed that subjects who had lesions on their ventromedial prefrontal cortex were more likely than controls without such lesions, to select cards that yielded large, immediate rewards and very large delayed punishers, thus incurring a net loss in play money. The authors hypothesized that lesions in this area may result in a lack of concern for future consequences.

There is evidence that the ventromedial prefrontal cortex is activated in decision making. Elliott, Frith, and Dolan (1997) showed that the ventromedial prefrontal cortex is activated in planning and guessing tasks. PET scans of individuals who were not impaired on the Gambling Task have demonstrated that there is increased activity in the ventromedial prefrontal cortex when completing the Gambling Task (Grant, Bonson, Contoreggi, & London, 1999). Bechara, Tranel, and Damasio (2000) found that the ventromedial prefrontal cortex is active when performing the Gambling Task.

Bechara et al. (2000) conducted an experiment to determine if individuals with lesions on their ventromedial prefrontal cortex were impaired on the Gambling Task due to a lack of concern for the future consequences of their behavior. Three possible causes of this decision-making impairment were examined: 1) the individual is oversensitive to rewards, 2) the individual is insensitive to punishment, or 3) the individual is insensitive to the future consequences of his behavior, positive and negative. Results suggested that individuals with lesions on their ventromedial prefrontal cortex tended to be focused on immediate rewards and largely oblivious to future positive and negative consequences.

Bechara et al. (2000) distinguished between two types of impulsivity: motor impulsivity and cognitive impulsivity. Motor impulsivity is defined as responding before all necessary information is obtained, or quickly responding without thinking. Cognitive impulsivity refers to "a failure to delay gratification and evaluate the outcome of a planned action" (Bechara et al., 2000). The authors suggested that the behavior of individuals with ventromedial prefrontal cortex lesions was primarily consistent with the latter definition of impulsivity.

It has been suggested that individuals abuse drugs because the positive consequences of drug use are immediate and the negative consequences are more protracted. To test this hypothesis, Petry et al. (1998) administered the Stanford Time Perception Inventory (STPI; Zimbardo, 1992), the Future Time Perspective task (FTP; Wallace, 1956), and the Gambling Task (Bechara et al., 1994) to a group of individuals who were dependent on heroin. Results showed that individuals dependent on heroin were less likely to think about their future and more likely to focus on short-term rewards than non-drug users. Furthermore, heroin dependent individuals were worse at predicting future events that may occur in their lives, less able to foresee protracted futures for others, and less able to sequentially order the future on the Future Time Perspective task. These findings suggest that drug users may continue to use despite serious consequences because their ability to predict delayed events is impaired (Petry et al., 1998).

Petry et al. (1998) also found that heroin-dependent individuals, who were in treatment for an average of 3.7 months, were more likely than non-drug users to choose cards that resulted in large immediate positive consequences, even when the positive rewards were outweighed by delayed negative consequences. Heroin-dependent subjects were also less likely to pick cards from the decks that yielded small, immediate, positive rewards and smaller negative consequences, even though picking from those decks resulted in net gains. The authors concluded by stating that their findings suggest that drug abusers select short-term rewards (e.g., euphoria, relief from depression) over long-term rewards (e.g., successful career, healthy life) because preference for delayed rewards may require an elaborate time perspective, which substance abusers may lack. Furthermore, drug abusers may discount delayed negative consequences (e.g., being arrested, health problems) because they are delayed in time.

Bechara et al. (2001) compared the performance of three different groups of subjects on the Gambling Task. The first group was made up of subjects who had lesions on their ventromedial prefrontal cortex, the second group was made up of individuals that were dependent on alcohol, cocaine or amphetamine, and the third group of participants was made up of non-substance dependent controls. Results showed that the substance abusers performed as poorly as the lesioned group on the Gambling Task. The control group performed significantly better than both of the other groups. The authors noted that substance abusers often exhibit behaviors similar to that of individuals with lesions on their ventromedial prefrontal cortex. For example, these individuals often engage in behaviors that lead to immediate gratification and ignore the long-term, adverse consequences of their behavior. The authors suggested that the substance abuser group and the ventromedial lesion group may have performed similarly because of a shared defect in the ventromedial prefrontal cortex.

One of the goals of Bechara et al. (2001) was to determine if neuropsychological tests of cognitive ability, other than the Gambling Task, could account for the decision impairments seen in individuals who are dependent on cocaine, amphetamine, or alcohol. To that end, the Wisconsin Card Sorting Task, the Tower of Hanoi, and the Stroop test were administered along with a test of intelligence. Other factors such as demographics, comorbid depression, anxiety, and psychopathy were also examined as possible causes of impaired performance on the Gambling Task. Results revealed that none of the demographic variables or neuropsychological tests accounted for the impaired performance of the substance abuse group and brain lesioned group on the Gambling Task. Thereby, adding evidence that the Gambling Task is sensitive to a specific type of impairment that the other measures do not detect.

Bechara, Damasio, Tranel, and Anderson (1998) successfully demonstrated that lesions centered on the ventromedial prefrontal cortex, but not lesions on the dorsolateral area of the prefrontal cortex, were significantly related to impairment on the Gambling Task. Grant et al. (2000) followed up the previous study by comparing individuals with a history of opioid or stimulant abuse with controls that had no history of substance abuse. The authors' goal was to determine if substance abusers had deficits in a specific portion of the prefrontal cortex rather than a general impairment extending throughout the prefrontal cortex. For this purpose, the Gambling Task and the Wisconsin Card Sorting Task were administered to the subjects. The

Gambling Task, as previously mentioned, has been shown to be sensitive to damage localized on the ventromedial portion of the prefrontal cortex (Bechara et al., 1994), while the Wisconsin Card Sorting Task has been shown to be sensitive to damage in the dorsolateral portion of the prefrontal cortex (Milner, 1963; Robinson, Heaton, Lehman, & Stilson, 1980). They found that substance abusers scored significantly worse on the Gambling Task than individuals with no history of substance abuse. However, there was no difference in the scores of substance abusers and non-substance abusers on the Wisconsin Card Sorting Task. These findings suggest that substance abusers do not have generalized impairment across the entirety of their prefrontal cortex, rather their impairment seems to be localized to the ventromedial area of the prefrontal cortex.

Bartzokis et al. (2000) found that a sample of recently abstinent cocaine-dependent men (RA) preformed better on the Gambling Task than cocaine-dependent men who were not abstinent (NA). The authors administered a number of neuropsychological tests (including the Wisconsin Card Sorting Task, the California Verbal Learning Test, and the Gambling Task) to determine which part(s) of the brain would be affected by recent abstinence from cocaine. The Wisconsin Card Sorting Task measures set shifting and concept formation, and has been shown to be effective in the identification of individuals with dorsolateral prefrontal cortex damage. The California Verbal Learning Test (CVLT) assesses verbal learning and short-term memory related to functions of the left temporal lobe and the right dorsolateral prefrontal cortex (Crosson, Sartor, Jenny, Nabors, & Moberg, 1993; Hildebrandt, Brand, & Sachsenheimer, 1998; Johnson, Saykin, Flashman, McAllister, & Sparling, 2001). Finally, the Gambling Task (Bechara et al., 1994) is used in the detection of high-risk choices and is sensitive to damage in the ventromedial prefrontal cortex. The authors found that the NA group was impaired on the Gambling Task only, while the RA group was not impaired on any of the tasks. Therefore, the NA group showed impairment that was consistent with damage localized to the ventromedial prefrontal cortex. One interpretation of these findings is that the decision-making impairments related to cocaine dependence, may be reversible once the individual becomes abstinent (Bartzokis et al., 2000).

Monterosso, Ehrman, Napier, O'Brien, and Childress (2001) administered three neuropsychological tests (i.e., the Delay Discounting Test, the Gambling Task, and the Rogers Decision Making Task) to cocaine dependent individuals to determine if the tests measure the same construct. The Delay Discounting Procedure (Ainslie & Haendel, 1983; Mazur, 1987) has been used as a behavioral test of impulsivity. In this task the subject chooses between smaller, immediate rewards or larger, delayed rewards. The second task the authors administered was the Gambling Task (Bechara et al., 1994). The third task, the Rogers Decision Making Task (Rogers et al., 1999), was designed, as was the Gambling Task, to measure dysfunction in the ventromedial prefrontal cortex. In this task, a subject is presented with a row of 10 boxes and must decide which color box has a token under it. For some trials, there is an obvious advantage for one color over the other because the number of boxes of each color is not equal. Winning on this task requires sticking to a favorite color (when the number of boxes of each color is equal) and wagering more points on less risky trials.

Monterosso et al. (2001) pointed out that numerous studies have demonstrated that substance abusers show deficits on all three tasks. They stated that if it were determined that these tasks are measuring the same construct, then a clearer understanding of the construct could be gained and a more valid measure could be developed. The relationship between each decision-making task and the Impulsive Sensation Seeking scale of the Zuckerman-Kuhlman Personality Questionnaire (Zuckerman, Kuhlman, Joireman, Teta, & Kraft, 1993) was also assessed. The authors found that there was no significant relationship between impulsive sensation seeking and the Gambling Task or the Rogers Decision Making Task. However, the authors did find a significant relationship between the Delay Discounting Procedure and the Gambling Task. This finding suggests that those who discount future rewards more rapidly on the Delay Discounting Procedure chose fewer cards from the decks that lead to a net gain on the Gambling Task. The Rogers Decision Making Task was marginally related to the Delay Discounting Procedure and the Gambling Task. The authors concluded by stating that there is support that all three tasks are measuring the same, or similar, decision making deficit.

Variables Influencing the Decision to Smoke or Abstain

Eiser (1983) attempted to show that smokers smoke tobacco because of short-term reinforcement contingencies. Eiser suggested that a person's Subjective Expected Utility (Edwards, 1954), the individual's assessment of the positive or negative outcome of a behavior, will determine if he will smoke or not. Before an individual begins smoking, he must weigh short-term reinforcement and long-term negative consequences. However, this decisional balancing is not always a concerted effort. Eiser stated that at some point, a smoker may choose to focus on short-term reinforcing effects of smoking, and dismiss the possible long-term negative consequences.

Sutton, Marsh, and Matheson's (1987) expectancy-value model suggests that a smoker's decision to abstain from smoking is related to his confidence or self-efficacy (Bandura, 1977) that he would be successful. Therefore, the weighing of positive and negative consequences of ceasing to smoke would theoretically play an important role in his decision-making process. Impairments may occur in the ventromedial prefrontal cortex, where it is theorized that the relative weights are applied to short-term rewards and long-term negative consequences (O'Doherty, Kringelbach, Rolls, Hornak, & Andrews, 2001; Rolls, 2000).

In summary, there is empirical evidence that suggests that individuals who abuse substances are more impulsive than individuals who do not abuse drugs. Past studies have found that those who abuse cocaine, alcohol, amphetamine, and heroin have structural and/or functional impairments in a region of the brain known as the ventromedial prefrontal cortex. There is a growing consensus that the ventromedial prefrontal cortex is involved in applying relative weights to short-term and long-term consequences. Furthermore, it has been shown that this area of the brain is active when performing the Gambling Task.

The purpose of this study was to determine whether heavy smokers are impaired on the Gambling task (Bechara et al., 2000), which has been correlated with dysfunction in the ventromedial prefrontal cortex. It was hypothesized that heavy smokers would exhibit impaired decision-making that is similar to the impairment that has been found in individuals who abuse alcohol, cocaine, opiates, and amphetamine. Specifically, it was expected that heavy smokers would choose more cards from the decks that lead to a net loss (decks A' and B') and fewer cards from the decks that result in a net gain (decks C' and D') than a group of controls that have never smoked.

Method

Participants

Participants were recruited by placing an advertisement in a local newspaper in Baton Rouge, Louisiana. The advertisement read "Smokers and nonsmokers needed for paid non-medical research." A total of 40 individuals participated in this study (23 heavy smokers and 17 nonsmokers). Participants were paid $10.00 for their participation. All participants signed an informed consent form approved by the Institutional Review Board at Louisiana State University (LSU).

Instruments

Smoking Status Questionnaire. This form was used to assess demographic characteristics of the sample, including age, sex, and ethnicity, in addition to assessing present and past smoking patterns, such as number of prior quit attempts. It includes the Fagerström Test for Nicotine Dependence to determine level of nicotine dependence (FTND; Heatherton, Kozlowski, Frecker, and Fagerström, 1991).

Carbon Monoxide (CO) analysis. Breath samples were taken with a Vitalograph Breath CO portable CO monitor to verify smoking status. Smokers were identified as having a CO reading of at least 10 parts per million (ppm).

Michigan Alcoholism Screening Test (MAST). The MAST (Selzer, 1971) is a 25-item questionnaire designed to measure a history of problematic alcohol use. The MAST has a test-retest reliability of .84 and an internal consistency of .85 (Skinner & Sheu, 1982).

Drug Abuse Screening Test (DAST). The DAST (Skinner, 1982) is a 28-item questionnaire designed to measure substance abuse history. The DAST has an internal consistency reliability of .92 and significantly discriminates substance abusers from non-abusers (Skinner, 1982).

Drug History. Participants were asked to disclose if they have ever been dependent on or abused any drug. Participants were also asked to list the type, frequency, and age at first and last use for all drugs they have used in the past (see Appendix A).

Gambling Task. The computerized version of the Gambling Task was used in this experiment (Bechara et al., 2000). In this task the participant is seated in front of a computer screen on which there are four decks of cards. The decks are labeled A', B', C', and D'. The participant is prompted to pick a card from one of the decks. The participant uses the mouse to pick a card and he/she is informed of the consequences. Each deck consists of 30 black cards and 30 red cards. The color of the cards is not related to whether a participant will gain or lose money for this task. Also, a distinct sound is made by the computer when the participants win and lose money. The computer keeps track of the cards the participant chooses.

Decks A' and B' pay $100 on average, while decks C' and D' pay $50 on average. However, decks A' and B' yield greater penalties than decks C' and D'. Taking into account rewards and penalties, picking from decks A' or B' yield a net loss of $250 for the first 10-card block. The net loss for picking cards from decks A' or B' increases by $150 for every 10-card block until block six where the net loss is $1,000. The only difference between decks A' and B' is that in deck A' the frequency of punishment increases but the average magnitude of punishment remains constant. In deck B' the magnitude of punishment increases, but the frequency of punishment remains constant. For the purposes of this study, decks A' and B' will be termed "bad decks" and cards from these decks will be termed "bad cards," as choosing cards from these decks result in net losses.

Picking from decks C’ or D’ yields a net gain of $250 for the first 10-card block. This net gain increases by $50 for each 10-card block until block six when the net gain is $375. In deck C’ the frequency of punishment increases, but the average magnitude of punishment remains constant. In deck D’, the magnitude of punishment increases but the frequency of punishment remains constant. For the purposes of this study, decks C’ and D’ will be termed “good decks” and cards from these decks will be termed “good cards,” as choosing cards from these decks result in net gains.

Following Bechara et al. (2001), the participants picked a total of 100 cards and the inter-trial interval between card picks was set at 6s. Each participant’s score was tallied by summing the number of cards picked from decks A’ and B’ for each 20 card block. The number of cards picked from decks C’ and D’ were tallied in the same manner.

Procedure

Individuals who called the Smoking Laboratory at LSU in response to the advertisement underwent a telephone screening. Individuals who were 25 years of age or older were included if they currently smoked at least 20 cigarettes per day (i.e., heavy smokers), and had been smoking for at least 10 years, or if they had never smoked.

Those who met criteria were given a brief description of the study and scheduled for an experimental session on the LSU campus. Participants were given directions to the Psychological Services Center (PSC) in the basement of Johnston Hall. Upon arrival to the PSC, participants were greeted by a research assistant who described the study procedure, answered any questions, and obtained informed consent. Participants were then asked to provide a breath sample for CO analysis to verify self-reported smoking status. The following instruments were then administered: the Smoking Status Questionnaire, MAST, DAST, and Drug History. The participants were instructed (A. Bechara, personal communication, May 18, 2002) on how to complete the computerized Gambling Task (see Appendix B), and the task was administered. Once he/she completed the measures and task, the participant was debriefed, thanked for their participation, and paid $10.

Results

Participant Characteristics

A total of 527 individuals phoned the Smoking Research Laboratory at LSU and left their contact information. Of the two hundred fifty-six individuals that were successfully contacted and assessed over the phone, 159 met criteria for participation in this study. Those that were excluded did not meet age, smoking rate, and years smoking criteria. Fifty-one of the individuals that met criteria declined to participate after the study was explained to them. A testing session was scheduled for the remaining 108 individuals who met inclusion criteria. Sixty-eight individuals no-showed and 40 participants (23 heavy smokers and 17 never-smokers) attended their session and completed the testing measures.

The following two analyses were conducted in order to determine whether the smokers who attended their testing session differed from those that did not attend their testing session in daily smoking rate or number of years smoked. A one-way analysis of variance (ANOVA) was conducted with status (show vs. no show) as the independent variable and number of cigarettes smoked per day as the dependent variable. Results showed that those who attended their testing session were not significantly different from those who did not attend their testing session in the number of cigarettes they smoked per day (25.35 vs. 27.13), $F(1,69) = .58$, *ns*. A one-way ANOVA was conducted with status (show vs. no show) as the independent variable and number of years smoked as the dependent variable. Results showed that the individuals who attended their testing session did not differ in the number of years smoked from those who did not attend (25.48 vs. 21.02), $F(1,69) = 3.21$, *ns*.

A total of 40 participants took part in this experiment (23 heavy smokers and 17 never-smokers). Participants were considered smokers if their CO level was 10 ppm or above. There were no discrepancies between self-reported smoking status and the breath CO analysis conducted on each participant. The characteristics of the smokers and never-smokers are listed in Table 1.

Table 1. Participant Characteristics

	Overall $N = 40$	Smokers $n = 23$	Never-Smokers $n = 17$	p
Age (SD)	43.83 (12.10)	41.65 (8.57)	46.76 (15.49)	*ns*
Sex				
Male	42.5%	60.9%	17.6%	$p < .01$
Female	57.5%	39.1%	82.4%	$p < .01$
Ethnicity				
Caucasian	72.5%	69.6%	76.5%	*ns*
African-American	25.0%	26.1%	23.5%	*ns*
Other	2.5%	4.3%		
MAST (SD)	11.63 (15.64)	16.96 (18.02)	3.47 (4.21)	$p < .01$
DAST (SD)	4.83 (6.38)	7.26 (7.46)	1.53 (1.66)	$p < .01$
CO	19.9 ppm	33.3 ppm	1.8 ppm	$p < .001$

A Chi-square with ethnicity (Caucasian vs. Non-Caucasian) and group (heavy smokers vs. never-smokers) as the factors, revealed that the groups did not differ in ethnicity, $X^2(1, N = 40) = .23$, *ns*. A second Chi-square with sex (male vs. female) and group (heavy smokers vs. never-smokers) as the factors, revealed that the groups significantly differed in sex, $X^2(1, N = 40) = 7.47$, $p < .01$. There were more males in the heavy smoker group and more females in the never-smoker group.

One-way ANOVAs were conducted with group (heavy smokers vs. never-smokers) as the independent variable and the continuous variables (age, MAST scores, and DAST scores) as the dependent variables. Groups did not differ in age, $F(1, 38) = 1.78$, *ns*. However, the groups did differ significantly in MAST scores, $F(1,36) = 8.05$, $p < .01$ and DAST scores, $F(1,38) = 9.62$, $p < .01$, with heavy smokers having higher scores on both measures. See Table 1 for MAST and DAST means and standard deviations. The heavy smokers smoked a mean of 27.52

(*SD* = 6.35) cigarettes per day, and had been smoking for a mean of 25.74 (*SD* = 9.42) years. The mean score on the FTND was 6.39 (*SD* = 1.83), indicating the smoking participants were nicotine dependent.

Performance on the Gambling Task

Each participant chose 100 cards. Following the procedures of Bechara et al. (2001), the cards were broken up into 5 20-card blocks, which were scored separately. That is, each participant received a score for the number of "good cards" that he/she chose in block 1 (cards 1 through 20), block 2 (cards 21 through 40), block 3 (cards 41 through 60), block 4 (cards 61 through 80), and block 5 (cards 81 through 100). The same procedure was followed for the cards chosen from the "bad decks."

A two-way ANOVA was conducted with group (heavy smokers vs. never-smokers) as the between subjects factor, block (5 levels) as the within subjects factor, and number of cards chosen from the "good decks" as the dependent variable. Although the groups differed on MAST scores, DAST scores, and sex at baseline, these variables were not entered as covariates, because they were not significantly correlated with the dependent variable. Results showed that there was a main effect for block, $F(4,152) = 3.13$, $p < .05$. See Table 2 for block means. There was also a significant block by group interaction, in which the never-smokers improved in the number of "good cards" they chose as the task progressed, and the smokers did not, $F(4,152) = 5.68$, $p < .001$ (see Figure 1). See Table 3 for cell means.

Table 2. Block Means for the Number of "Good Cards" Picked

	M
Block 1	9.30
Block 2	9.08_{abc}
Block 3	10.50_{a}
Block 4	10.73_{b}
Block 5	10.93_{c}

Note. Values that share the same subscript differ significantly at $p < .05$.

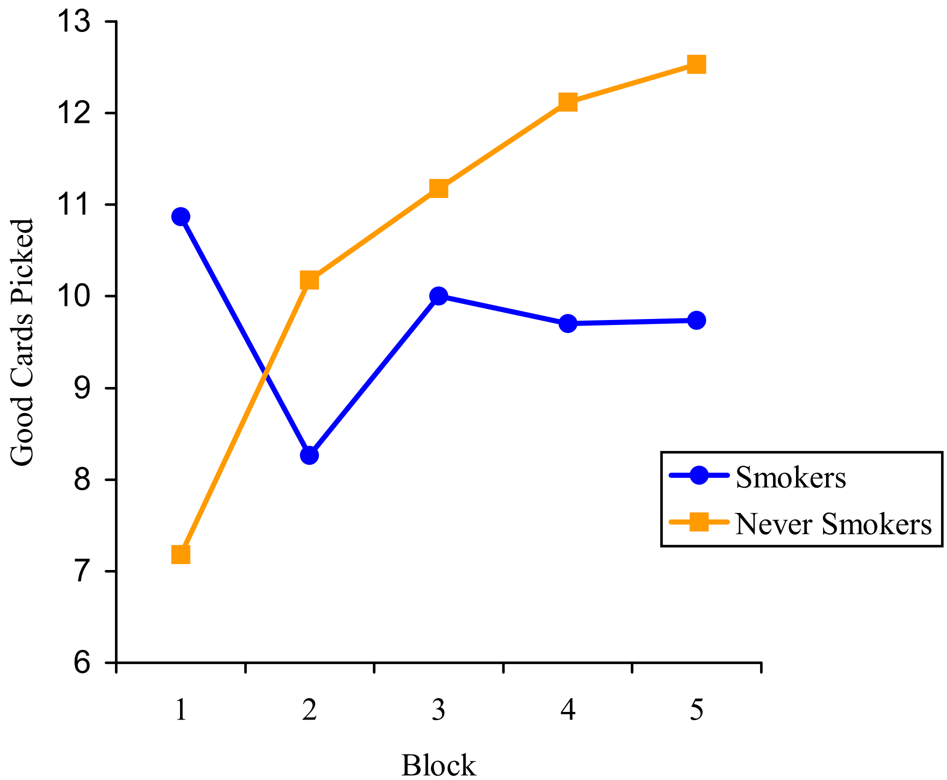

Figure 1. Smokers and never-smokers performance on the Gambling Task.

Monterosso et al. (2001) showed that using only the last 50 trials on the Gambling Task is a more reliable measure of performance, than using all 100 trials. They reasoned that, during the first 50 trials, the participants are learning the reward and punishment schedules. Therefore, if all 100 trials were to be counted, participants' scores could be inflated or deflated, depending on the strategy the participant took in learning the task. Following the suggestion of Monterosso et al., only the last 50 trials of the Gambling Task were used to determine whether the heavy smokers' performance differed from the never-smokers' performance. A one-way ANOVA was conducted with group (heavy smokers vs. never-smokers) as the independent variable and the number of "bad cards" chosen in the last 50 trials as the dependent variable. This analysis revealed that heavy smokers chose significantly more "bad cards" than never-smokers on the last 50 trials (25.70 vs. 19.71), $F(1, 38) = 4.16$, $p < .05$.

Table 3. Cell Means for the Number of "Good Cards" Picked

	Smokers $n = 23$	Never-Smokers $n = 17$	p
Block 1	10.87	7.18	$p < .005$
Block 2	8.26	10.18	$p < .05$
Block 3	10.00	11.17	*ns*
Block 4	9.69	12.12	*ns*
Block 5	9.73	12.53	$p = .07$, *ns*

Discussion

The goal of this study was to determine if heavy smokers choose more cards that yield a net loss and less cards that yield a net gain than never-smokers on a neuropsychological task that tests an individual's ability to weigh immediate gains over long-term losses (Gambling Task). As hypothesized, heavy smokers picked a greater number of cards from the decks that yielded a net loss (decks A' and B'), and fewer cards from the decks that yielded a net gain (decks C' and D'), than did the never-smokers. This pattern of responding has been found in previous research that has used heroin, amphetamine, cocaine, and alcohol dependents as participants (Bartzokis et al., 2000; Bechara et al., 2001; Grant et al., 2000; Monterosso et al., 2001; Petry et al., 1998). The authors of the aforementioned studies suggested that poor performance on the Gambling Task may be due to impairment in decision-making. The cause of this decision-making impairment is not completely clear, however, poor performance on this task has been correlated with damage or dysfunction in the ventromedial prefrontal cortex (Bechara et al., 1994; Bechara et al., 2000; Bechara et al., 2001; Grant et al., 1999).

As expected, there was a block main effect. This effect was consistent with the prediction that participants would learn the contingencies of the task as the trials progressed. A significant interaction between block and group was also found. In the first 20-card block, heavy smokers chose more cards from the "good decks" than did never-smokers; however, never-smokers choose more cards from the "good decks" in each of the four remaining blocks (see Figure 1).

The results of this study are consistent with the findings of previous research that has shown that those dependent on alcohol (Smart, 1968) and heroin (Petry et al., 1998) appear to have a decreased ability to predict their own future life events and the future life events of others. It has been speculated that this diminished ability to predict future events may lead to a decrease in sensitivity to the delayed consequences of one's behavior (Petry et al., 1998). By selecting cards that yielded large rewards and very large delayed punishers rather than cards that yielded small rewards and very small delayed punishers, it can be said that heavy smokers seemed to be more concerned about the immediate (rewards) rather than delayed consequences (punishers) of their behavior. Future research should examine if heavy smokers have a diminished ability to predict the future consequences of their behavior.

One possible limitation of this study is that results showed that the groups were significantly different in sex. However, no significant sex effect has been found in prior research using the Gambling Task (Bechara et al., 2001; Grant et al., 2000; Monterosso et al., 2001; Petry et al., 1998). Thus, there is no evidence that the observed impaired performance of heavy smokers is due to sex differences. In this study, sex was not significantly correlated with the dependent variable. Therefore, consistent with previous findings, sex did not have a significant effect on Gambling Task performance.

Another possible limitation of this study is that MAST and DAST scores were higher for heavy smokers than never-smokers. This result was expected because past research has shown that smokers are more likely than nonsmokers to use drugs and alcohol (Anthony & Echeagaray-Wagner, 2000; Jackson, Sher, & Wood, 2000; John, Hill, Rumpf, Hapke, & Meyer, 2003). MAST and DAST scores were not significantly correlated with the dependent variable (i.e., number of "bad cards" chosen); therefore, they were not entered as covariates.

In summary, heavy smokers were shown to perform more poorly than never-smokers on a test of decision-making (i.e., the Gambling Task). Specifically, heavy smokers chose more cards that yielded large short-term reinforcers and very large punishers (net loss), and fewer cards that yielded small short-term reinforcers and very small long-term punishers (net gain) than did never-smokers. The results of this study are similar to other studies that have examined the performance of individuals who abuse or are dependent on alcohol, cocaine, amphetamine, and heroin.

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Appendix A

Drug History

Have you ever abused any substance (other than nicotine)? YES NO
(Circle one)

What substance? ________________

Have you ever been dependent on a substance (other than nicotine)? YES NO
(Circle one)

What substance? ________________

Please list the type, age at first use, dose used, frequency of use, and the date of last use for all of the drugs (including alcohol) that you have experimented with in your lifetime.

Drug Type	Age of First Use	Dose Normally Used	Frequency of Use	# of Years You Used This Drug	Date of Last Use

Appendix B

Instructions for the Computer Gambling Task

1- In front of you on the screen, there are 4 decks of cards A', B' C' and D'.

2- I want you to select one card at a time, by clicking on the card, from any deck you choose.

3- Each time you select a card, the computer will tell you that you won some money. I don't know how much money you will win. You will find out as we go along. Every time you win, the green bar gets bigger.

4- Every so often, however, when you click on a card, the computer tells you that you won some money, but then it says that you lost some money too. I don't know when you will lose, or how much you will lose. You will find out as we go along. Every time you lose, the green bar gets smaller.

5- You are absolutely free to switch from one deck to another at any time, and as often as you wish.

6- The goal of the game is to win as much money as possible and if you can't win, avoid losing money as much as possible.

7- You won't know when the game will end. You must keep on playing until the computer stops.

8- I am going to give you this $2000 credit, the green bar, to start the game. The red bar here is a reminder of how much money you borrowed to play the game, and how much money you have to pay back before we see how much you won or lost.

9- It is important to know that just like in a real card game; the computer does not change the order of the cards after the game starts. You may not be able to figure out exactly when you will lose money, but the game is fair. The computer does not make you lose at random, or make you lose money based on the last card you picked. Also, each deck contains an equal number of cards of each color, so the color of the cards does not tell you which decks are better in this game. So you must not try to figure out what the computer is doing. All I can say is that some decks are worse than the others. You may find all of them bad, but some are worse than others. No matter how much you find yourself losing, you can still win if you stay away from the worst decks. Please treat the play money in this game as real money, and any decision on what to do with it should be made as if you were using your own money.

Vita

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