

Research In Brief

December 2004

04-4

Delay and Probability Discounting as Related to Different Stages of Adolescent Smoking and Non-smoking

Brady A. Reynolds, Ph.D.

Research Institute on Addictions

University at Buffalo, The State University of New York

Katherine Karraker, Ph.D. and Kimberly Horn, Ph.D.

West Virginia University

Jerry B. Richards, Ph.D.

Research Institute on Addictions

University at Buffalo, The State University of New York

Abstracted from *Behavioural Processes*, 64, 333-344, 2003.

In this task, you will choose between different amounts of money available after different delays, or with different probabilities of receiving the money. There are no right or wrong answers to these questions. . . just pick which you would prefer. You will get \$10 just for participating in the study.

Beyond that, what additional money you receive will be determined by your choices during the task. One of the choices you make will be randomly selected and will determine your additional compensation. If you choose to receive an additional \$10 with a delay attached (e.g., six months), the money will be put in an envelope with your name and address on it and mailed to you in six months. If, however, you choose to receive your additional money today, it will be for a smaller amount.

Alternatively, when you choose a probability or 'chance' question, you will draw a poker chip from a bag to see if you get the additional money or not. For example, if your choice involves having a 25 percent chance of receiving an additional \$10, then three red poker chips and one blue poker chip will be put in a bag for you to draw from. If you draw the one blue poker chip, you will get the \$10, but if you draw one of the three red poker chips, you will not get the money.

Above is an abstracted example of instructions provided to participants in a research study about delay and probability discounting (often considered measures of impulsive behavior) and cigarette-smoking by adolescents. The study included a total of 55 participants (28 females) between the ages of 14 and 16. Nineteen of the participants (10 females) were "never smokers" who had never tried one cigarette. Seventeen (nine females) were "triers" who had just recently tried cigarettes for the first time. Nineteen (nine females) were "current smokers" who smoked a minimum of one cigarette every week for at least the six months prior to the study.

Before reading on, some definitions:

- *Delay discounting* is the extent to which an individual "dis-

continued on page 2

Dual Determinants of Drug Use in Humans: Reward and Impulsivity

Harriet de Wit, Ph.D.

The University of Chicago

Jerry B. Richards, Ph.D.

Research Institute on Addictions

University at Buffalo, The State University of New York

Abstracted from: *Motivational Factors in the Etiology of Drug Abuse*,

Nebraska Symposium on Motivation, Vol. 50, 19-55, 2004.

Drug use is influenced by biological, pharmacological, psychological, and cultural factors. While much of substance abuse research investigates the motivation to use drugs or the rewarding properties of drugs, Drs. de Wit and Richards looked at the factors that deter individuals from using drugs in this paper.

A notable feature of drug abuse is that most drug abusers are aware of the destructive consequences of continuing to abuse drugs and indicate a desire to stop abusing drugs. Despite this knowledge, drug abusers are frequently unable to stop taking drugs. According to these authors, impulsivity plays an important role in the inability of drug addicts to stop taking drugs, even when they are aware of the destructive consequences of drug use.

In order to define impulsivity more precisely, the authors identified two behavioral processes that underlie impulsive behavior. The first process is **delay discounting** and refers to the degree to which immediate consequences have more control over an individual's behavior than consequences that are delayed. The second process is **behavioral inhibition**, and refers to the ability of an individual to appropriately inhibit thoughts or actions.

Delay Discounting. All organisms prefer immediate over delayed rewards. However, the degree to which an individual prefers immediate rewards over delayed rewards can be used as an index of impulsivity. Impulsive individuals exhibit stronger preferences for immediate awards (i.e., taking drugs) over more delayed rewards (e.g., succeeding in work or school) even though the delayed rewards are larger. Similarly, when they are choosing between an immediate positive outcome (e.g., a drug) and the possibility of a delayed negative consequence (e.g., punishment), impulsive individuals may be relatively less sensitive to the possibility of punishment. A number of studies have found that impulsive individuals, such as gamblers, psychiatric outpatients, children with ADHD, and drug abusers, discount the value of delayed rewards more and, therefore, demonstrate poor behavioral inhibition.

continued on page 3

Dual Determinants of Drug Use (cont'd)

Behavioral Inhibition. Poor behavioral inhibition can also lead to the occurrence of impulsive behavior. As was noted above, many drug abusers are aware of the negative consequences of drug taking. For example, impulsive children may use drugs because they are unable to inhibit their behavior (e.g., the inclination to use drugs in response to peer pressure). Alternatively, an alcoholic may be unable to inhibit thoughts or actions which lead to drinking.

Animal and Human Studies. Both delay discounting and behavioral inhibition can be measured using laboratory tasks. Versions of these laboratory tasks can be used with both humans and animals. The ability to measure discounting and behavioral inhibition in both animals and humans is important because studies can be done in animals to explore the neurophysiological basis of impulsivity that cannot be done in humans. Drs. de Wit and Richards have taken advantage of this fact to do parallel drug studies in humans and animals.

Three Stages of Drug Abuse

Drs. de Wit and Richards reviewed how the rewarding effects of drugs and impulsivity each independently contribute to drug use during three stages in the natural history of drug abuse: initial experimentation with drugs (initiation of use), progression to repeated or excessive use (maintenance of use), and use during abstinence (relapse).

- **Initiation of use.** The initial experimentation with drugs is likely to be influenced by positive, reward-seeking tendencies in people. In addition, the tendency to experiment with drugs may be greater in impulsive individuals that are relatively insensitive to possible long term adverse consequences of drug abuse or who have poor behavioral inhibition. Both of these – reward and impulsivity – have been found to be risk factors that lead to drug use.
- **Maintenance of use.** Once an individual experiences the effects of a drug at least once, the direct effects of the drug, and the memories and conditioned responses relating to this experience, come to influence future drug-seeking behavior. Research by Jentsch and Taylor (1999) suggests that chronic use of drugs may increase the rewarding effects of drugs and cause impairments in behavioral inhibition. Thus, chronic use of drugs may impair the individual's ability to refrain from drug use by damaging brain areas involved in inhibitory control. The combined influence of increased rewarding effects and decreased ability to refrain from drug use after chronic drug exposure may contribute to the uniquely compulsive nature of drug-seeking behavior in addicted individuals.
- **Relapse.** One of the most puzzling and persistent issues in substance abuse research and treatment is why former drug users, who have successfully achieved abstinence often for extended periods of time, relapse at such an extraordinarily high rate. It is estimated that up to 80 percent of drug users who achieve initial abstinence return to using drugs (Hunt, Barnett,

& Branch, 1971).

- Reward processes known to precipitate relapse, such as positive affective states (e.g., being in a good mood, feeling of relaxing) and craving (e.g., single doses of alcohol, nicotine, cocaine), increase the likelihood of returning to regular use. Animal studies thought to model events in drug relapse by humans suggest that drug reinstatement is mediated by dopamine mechanisms and to a lesser extent opioid mechanisms in the brain.
- Drug users who are attempting to abstain from drug use must have a battery of skills and strategies to suppress the urge to use drugs. These include distraction, thought-stopping, relaxation, long-term planning, and cue extinction procedures. Stress and negative mood states are likely to precipitate relapse by interfering with the ability to inhibit drug taking responses and be decreasing sensitivity to the delayed negative consequences of relapse. Furthermore, given differences between reward-related and stress-related reinstatement of drug use, there may be different factors associated with the control of relapse and the return to drug-seeking behavior.

Discussion

This analysis makes a case for separate, independent processes of reward and impulsivity, both of which affect the likelihood of using drugs. However, these two processes may interact or be linked by common behavioral or neural processes. For example, reward-sensitivity and impulsivity have been tied to the same underlying process in certain theories of personality. Other researchers have linked reward sensitivity and novelty seeking to impulsivity. By this reasoning, the trait of sensation-seeking or novelty-seeking may result from either susceptibility to rewards or from insensitivity to negative outcomes.

There is empirical evidence that the traits of sensation-seeking and impulsivity are high in substance abusing populations and researchers are continuing to search for an explanation for this co-occurrence. It is possible that high sensitivity to reward and impulsivity are separate processes but that they tend to co-occur in certain individuals. On the other hand, the two processes may be related and substance use could result from the combination of high reward reactivity and high impulsivity.

Implications

- Studies investigating the neurochemistry and neural circuits underlying different forms of impulsive behavior will further delineate the processes that control impulsivity.
- Future research would benefit from attempts to reconcile the personality approach that characterizes impulsivity as a single trait and the behavioral studies that strongly suggest separate forms of impulsive behavior.
- Findings from this area of research could have clinical utility for understanding and treating drug abuse and relapse.

Delay and Probability Discounting (cont'd)

counts” the value of a reward (e.g. money, food, weight loss, etc.) as a function of having to wait for it. An example of delay discounting might be choosing between receiving \$10 after one of the delay periods (i.e., 180 days) or \$2 immediately.

- *Probability discounting* is the extent to which an individual discounts the value of such rewards as a function of a decreasing probability of receiving them. An example of probability discounting might be choosing between an uncertain \$10 (e.g., 25 percent chance) and a smaller amount to be received for sure.

Greater discounting by either delay or probability, i.e., predominantly choosing smaller immediate or smaller certain amounts of money, is often interpreted as impulsive behavior.

Findings

- Results indicated no differences in discounting (impulsivity) between the *current smokers* and *never smokers*.
- The *trier* group (i.e., those who had just recently tried cigarettes for the first time) discounted improbable rewards significantly more (i.e., were more impulsive) than the *never-* and *current-smoker* groups.
- *Triers* and *current smokers* reported having more friends who smoked than *never smokers*.
- Fathers of *never smokers* had significantly more education than fathers of either *triers* or *current smokers*. There were no differences across the three adolescent groups in level of education for mothers.

These results suggest that impulsive discounting may be more related to adolescents trying cigarettes than to their becoming regular smokers. The number of friends who smoke and father level of education seems to differentiate those who have smoked (*triers* and *current smokers*) and those who have never tried cigarettes (*never smokers*).

The Study

- Fifty-five high school students were recruited from one rural high school in West Virginia. All participants were European American except for two who were African American.
- *Never smokers* had not smoked even one cigarette. *Triers* had tried cigarettes for the first time during the previous six months and, on average, had smoked 3.8 cigarettes (between one and six). *Current smokers*, who smoked every week for at least six months prior to the study, averaged 46 cigarettes per week (between 12 and 100). The six month period was used to ensure that the specified pattern of smoking had been stable for an extended amount of time.
- Participants were recruited via letters and descriptive brochures sent home to parents and guardians. An informed consent form was signed by a parent/guardian if the student qualified and wanted to participate. Students were recruited until the three groups — *never smokers*, *triers*, and *current smokers* — each had 20 participants.
- Final screening for participation was based on students’

responses to demographic questions about current smoking behavior and smoking history.

- Total testing time for each student was less than 30 minutes. Data were collected in small groups in a computer lab at the high school where recruitment took place. Participants were given a computerized task for the purpose of assessing delay discounting and probability discounting. The delay discounting program presented a series of questions that asked the participant to decide between \$10 to be received after one of the different delay periods (1, 2, 30, 140, and 365 days) or a smaller amount of money (e.g., \$2) that could be received immediately. Questions for establishing probability discounting required participants to choose between a particular probability of receiving \$10 (e.g., 25 percent chance) or a small amount to be received for sure.
- A demographic questionnaire was provided to collect information about sex, age, ethnicity, current or past smoking, number of friends who smoked, and parent’s level of education.

Discussion

On the measure of delay discounting, none of the three groups differed significantly. On probability discounting however, the *never smokers* and *current smokers* did differ significantly from the *triers*, with *triers* discounting *more* than both other groups. This unexpected finding with *triers* suggests that adolescents who discount at a high rate are more likely than others to try cigarettes. For this age group, higher rates of discounting may not be related to the progression from trying to regularly smoking cigarettes. In that all the *current smokers* were once *triers*, one possible interpretation of this finding is that adolescents who are currently experimenting with cigarettes may be in a particularly impulsive, but temporary, period in their lives.

The results also showed that the *current smokers* reported having more friends who smoked than *never smokers* but not more than *triers*. This is consistent with previous research.

Triers also tended to have more friends who smoked than *never smokers* and fewer friends who smoked than *current smokers*. From this pattern it appears that having friends who smoke is related to trying cigarettes, although the relationship between smoking and having friends who smoke is strongest for the *current smokers*.

Participants in the never-smoker group reported their fathers as having significantly more education than participants in both the *trier* and *current-smoker* groups. The same effect did not exist for level of mothers’ education. This differential effect between father and mother level of education is not consistent with earlier findings where both father and mother characteristics are typically predictive of adolescent smoking (e.g., Fleming et al., 2002; Jackson and Henriksen, 1977).

Discounting does not appear to relate to adult and adolescent cigarette smoking in the same way. Several research studies comparing adult smokers and non-smokers have shown that

Dual Determinants of Drug Use (cont'd)

smokers discount more (i.e., perform more impulsively) than non-smokers by both delay and probability. In this study, adolescent smokers and non-smokers did not differ in rate of discounting, but rather it was those just trying cigarettes who discounted improbable reinforcers the most. A more recent analysis (now in press) by the same research group suggests that heavy cigarette smoking itself may increase rate of delay discounting (i.e., lead to greater impulsive behavior). Therefore, it is possible that the adolescent smokers of the current report did not discount more by delay than non-smokers, because they did not smoke as much as adult smokers.

Implications

- Findings from the present study suggest that discounting may not be a stable dimension of behavior in adolescents.
- For adolescents, discounting may play a larger role in smoking initiation than in continued smoking.
- The relationship between smoking and having friends who smoke is strongest for *regular smokers*.
- Factors associated with high levels of father education may serve to buffer against trying or regular use of cigarettes during adolescence.

Future research might aim to identify more broadly defined behavior changes (e.g., trying cigarettes, trying other drugs, or engaging in more risk-taking behavior) that accompany periods of heightened discounting (impulsivity) during adolescence. Also, identifying possible events leading to heightened impulsivity (e.g., hormone changes accompanying puberty, stress, negative life events, etc.) may be important in better understanding how these events lead to problematic, high risk behaviors in adolescents.

This research was conducted while the first author was affiliated with West Virginia University.

References

- Fleming, C., Kim, H., Harachi, T., & Catalano, R. (2002). Family processes for children in early elementary school as predictors of smoking initiation. *Journal of Adolescent Health, 30*, 184-189.
- Jackson, C., & Henriksen, L. (1997). Do as I say: Parent smoking, antismoking socialization, and smoking onset among children. *Addictive Behaviors, 22*, 107-114.

Delay and Probability Discounting (cont'd)

References

- Hunt, W. A., Barnett, L. W., & Branch, L. G. (1971). Relapse rates in addiction programs. *Journal of Clinical Psychology, 27*, 455-456.
- Jentsch, J. D., & Taylor, J. R. (1999). Impulsivity resulting from frontostriatal dysfunction in drug abuse: Implications for the control of behavior by reward-related stimuli. *Psychopharmacology (Berlin), 146*, 373-390.

PRSR STD
US POSTAGE
PAID
BUFFALO, NY
PERMIT #686

Research Institute on Addictions
1021 Main Street
Buffalo, NY 14203-1016