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Original investigation

Development of a Self-Report Measure of Reward Sensitivity: A Test in Current and Former Smokers

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Abstract

Introduction: Tobacco use or abstinence may increase or decrease reward sensitivity. Most existing measures of reward sensitivity were developed decades ago, and few have undergone extensive psychometric testing.

Methods: We developed a 58-item survey of the anticipated enjoyment from, wanting for, and frequency of common rewards (the Rewarding Events Inventory—REI). The current analysis focuses on ratings of anticipated enjoyment. The first validation study recruited current and former smokers from Internet sites. The second study recruited smokers who wished to quit and monetarily reinforced them to stay abstinent in a laboratory study and a comparison group of former smokers. In both studies, participants completed the inventory on two occasions, 3–7 days apart. They also completed four anhedonia scales and a behavioral test of reduced reward sensitivity.

Results: Half of the enjoyment ratings loaded on four factors: socializing, active hobbies, passive hobbies, and sex/drug use. Cronbach's alpha coefficients were all ≥ 0.73 for overall mean and factor scores. Test-retest correlations were all ≥ 0.83 . Correlations of the overall and factor scores with frequency of rewards and anhedonia scales were 0.19–0.53, except for the sex/drugs factor. The scores did not correlate with behavioral tests of reward and did not differ between current and former smokers. Lower overall mean enjoyment score predicted a shorter time to relapse.

Discussion: Internal reliability and test-retest reliability of the enjoyment outcomes of the REI are excellent, and construct and predictive validity are modest but promising. The REI is comprehensive and up-to-date, yet is short enough to use on repeated occasions. Replication tests, especially predictive validity tests, are needed.

Implications: Both use of and abstinence from nicotine appear to increase or decrease how rewarding nondrug rewards are; however, self-report scales to test this have limitations. Our inventory of enjoyment from 58 rewards appears to be reliable and valid as well as comprehensive and up-to-date, yet is short enough to use on repeated occasions. Replication tests, especially of the predictive validity of our scale, are needed.

Introduction

Several lines of evidence suggest that nicotine use or abstinence can increase, decrease, or not change the efficacy of nondrug rewards.^{1,2} In addition, a central theme in many treatments for drug abuse is an attempt to increase sensitivity to nondrug rewards.^{3,4} Reward sensitivity can be measured by behavioral tests, neuroimaging tests, and self-report scales. Behavioral and neuroimaging tests most often focus on operant measures of reward seeking, whereas self-report measures mostly focus on enjoyment from rewards.⁵ There are many (>21) such self-report measures.^{5–8} These scales typically ask how pleasurable several rewards would be for an individual. The existing scales are often long (survey > 150 rewards),^{9–11} fail to ask about more recent rewards (eg, some scales are > 40 years old),^{9,10} or have undergone limited psychometric testing. For example, one widely used scale is the Pleasant Events Scale (PES). This test has good psychometrics¹⁰ but is lengthy (640 questions, 45–60 minutes to complete), and because it was developed 40 years ago, it does not ask about more recent rewards such as texting, social media, or Internet browsing. The current paper describes a new self-report measure (The Rewarding Events Inventory—REI) that uses more current rewards, is comprehensive, but brief enough (58 questions) that it could be used on a repeated basis, and asks about more up-to-date possible rewards.

Methods

Scale Development

The REI was developed for use in a study on whether smoking cessation decreases reward sensitivity.¹² We began by examining the 21 existing reward inventories, anhedonia scales, and apathy scales to obtain a list of commonly cited rewards. Next, we added newer rewards (eg, browsing the Internet) not included in these scales. This resulted in a list of 476 rewards. We then deleted rewards that we believed would occur rarely and categorized the rewards into specific themes (eg, alcohol/other drug use, consumerism/shopping, and eating) to identify overlapping rewards. All decisions regarding inclusion of rewards were made via consensus of the authors. One challenge was whether questions should refer to (a) past rewards, (b) current rewards, (c) “usual” rewards, or (d) future (anticipated or hypothetical) rewards.^{13,14} We chose to ask about anticipated rewards because they are probably of greater clinical significance than past rewards,^{15,16} plus it allows ratings of rewards that are infrequent or have never occurred. We decided to use broad rather than specific descriptions (“sports” vs. skiing, basketball, etc.), to obtain adequate incidence rates.

This process resulted in 155 rewards. The authors then rated the 155 rewards on enjoyment, wanting, and frequency, as well as clarity. Based on the magnitude, clarity, overlap, and floor/ceiling effects from these ratings, we reduced the number of rewards to 99. Next, to better sample young adults we asked 20 young adults (18–24 years old) to record on a Web site at least five rewards that happened in the previous week on two consecutive weeks. This resulted in no additions, but, did result in two revisions to the existing list of rewards.

We initially developed three response options about the 99 rewards: that is, how much participants enjoyed each reward, how much they wanted it, and how often it occurred. We asked about wanting versus enjoyment because animal research suggests these are different behavioral states.^{17,18} However, although indirect measures can dissociate wanting from enjoying in humans, when asked to rate both wanting and enjoyment humans rarely distinguish between

the two.^{17,18} Consistent with this, we found a very high correlation between enjoyment and wanting and very few instances of discordances between the two. Also, participants in our pilot work appeared to have more difficulty rating wanting than enjoyment. We also noted that there were often discrepancies between the enjoyment and frequency ratings because many factors other than enjoyment; for example, availability, influence the frequency of rewards. For these reasons, the current analysis was based solely on the enjoyment ratings. To assess enjoyment, the REI asked participants to “rate how much you would enjoy each reward using the following categories: “I would extremely enjoy it, I would enjoy it a lot, I would enjoy it some, I would enjoy it a little, I would not enjoy it.”

Validation Studies

We used results from two studies to examine the psychometrics of the REI. Both the development work and these two studies were approved by the University of Vermont Committees on the Use of Human Subjects in Research.

In the first study, we sent invitations via E-mails to current or former smokers who had visited a stop smoking website (www.stop-tabac.ch) developed by one of the authors (JFE). These participants had previously volunteered to participate in surveys without monetary reimbursement. We also posted links on other websites such as stopsmokingcenter.net and virtualmedicalcentre.com. Inclusion criteria were (a) English is native language, (b) aged 18 years or older, (c) current or past daily smoker, and (d) no current psychiatric or neurological problem (eg, Parkinson’s disease or depression) that could influence reward processes. The Web site had participants complete the survey on three occasions over approximately 1 week.

The second study was an experimental test of whether smoking cessation decreases reward sensitivity that is described in a separate paper in this special issue of *Nicotine & Tobacco Research*.¹² During the first week, current smokers smoked as usual, and during the last 4 weeks they were reimbursed to remain abstinent. Smokers completed the REI scale and several other measures twice per week. For the current analysis, we used only the data from the two visits in the first week when smokers were still smoking. The study also included former smokers who completed the REI four times over 2 weeks; again, we used their first two surveys.

We collected several outcomes to test construct validity of the enjoyment ratings: (a) frequency of rewards subscale of the REI, by asking participants to “rate how often the reward has occurred in the last week” from “It occurred every day in the last week, on most days in the last week, on a few days in the last week, on one day in the last week, did not occur in the last week.”, (b) a behavioral measure of decreased reward sensitivity—the Effort Expenditure for Rewards Task (EEfRT)—that examines responding as a function of response cost, reward magnitude, and probability of reward,¹⁹ (c) two anhedonia scales: the Apathy Evaluation Scale (AES) and the Temporal Experience of Pleasure Scale (TEPS),^{5,7,8,14} and (d) a measure of positive affect (PA) via the Positive and Negative Affect Scale (PANAS).²⁰ The major inclusion criteria were the same as the first study except that this study required smoking ≥10 cigarettes per day currently or in the past, and current smokers had to be trying to quit.

We pooled the results of the two studies for two reasons. First, factor analysis requires large sample sizes, especially when testing more than 50 items.²¹ Second, combining studies increased the range of demographics and smoking history outcomes. Exploratory analysis suggests that the results were very similar for current versus former smokers and for Study 1 versus Study 2. The 440 participants

were middle aged, and mostly White/non-Latinos with some college education. About half were women and, among current smokers, half smoked more than 20 cigarettes per day (Table 1).

Data Analysis

After initial inspection of the data from Study 1, we deleted 41 rewards due to a high incidence, of “don’t know/unclear responses,” very low or very high enjoyment rating (to avoid floor and ceiling effects), high correlation with another reward, or very low frequency of occurrence. When different orders of questions were used, there was no difference in results for the 10 rewards at the beginning or end of the scales, suggesting that significant response fatigue did not occur. For the remaining 58 rewards, we examined (a) factor structure, (b) internal reliability via Cronbach’s alpha, (c) test-retest validity by comparing scores between the first two sessions of each study, (d) construct validity by comparing ratings of enjoyment with ratings of the frequency of rewards with the EEfRT, AES, TEPS, and PANAS PA scores, and (d) predictive construct validity by testing whether the REI differed between current and former smokers, and whether baseline REI scores predicted time to relapse among current smokers trying to quit. We conducted several statistical tests and, thus, some of our results may be false positives. We did not correct for *p* values because many statisticians believe this is not appropriate in early research in an area.^{22,23}

For the factor analysis, a polychoric correlation matrix was generated and used in the Factor 9.2 Program²⁴ to determine the number of factors to extract, based on parallel analysis and minimum rank factor analysis²⁵. Maximum likelihood estimates were then generated in SAS 9.4 (PROC FACTOR) (SAS Institute Inc, Cary, NC) using oblique promax rotation. We used relatively stringent criteria for determining factors. Rewards were placed with factors for which rotated loadings were ≥ 0.30 . Rewards with loading < 0.30 on all factors, loading ≥ 0.30 on more than one factor, or loading ≥ 0.30 on different factors for Visit 1 and Visit 2 were not included in any factor but were included in the overall mean reward score.

For each psychometric test, we examined outcomes both for the overall mean score and the factor scores of the enjoyment ratings. For internal reliability, we calculated Cronbach’s alpha. For test-retest reliability, we calculated intraclass correlation coefficients. For construct validity, we examined Pearson product correlations between REI scores and EEfRT, reward frequency, AES, TEPS, and PANAS scores. For predictive validity, we tested (a) whether the REI scores differed between current and former smokers via a linear regression that included baseline differences in the groups as covariates and

(b) whether, in the second study, the REI scores from the first week predicted the probability of relapse when smokers were trying to quit using a proportional hazards regression.

Results

Introductory Remarks

The actual values for the REI, EEfRT, PANAS, TPS, and AES during the first week of the second study are reported in detail in the accompanying paper in this issue.¹² Across the two visits, the mean enjoyment score (*SD*) of the 58 rewards on a scale of 1 = “I would not enjoy it” to 5 “I would extremely enjoy” was 3.6 (0.5) for both visits. The three highest rated rewards were “go on vacation” (4.5), “be told I am loved” (4.4), and “kiss someone romantically” (4.3). The three lowest scores were “use marijuana or other drugs” (1.6), “watch sports” (2.5), and “drink alcohol” (2.6). When we posted the 58-reward REI Scale on a Web site (www.stop-tabac.ch), a new sample of 157 respondents took a median of 4.3 minutes (interquartile range = 3.4–6.0 minutes) to complete the enjoyment scale.

Factor Analysis

Half of the enjoyment ratings (29) loaded onto four factors that we labeled “socializing,” “active hobbies,” “passive hobbies,” and “sex/drug use” (Supplementary Appendix Table 1). The loadings for these rewards were very similar for Visits 1 and 2. Several other rewards loaded on a fifth factor, but item loading on this factor was not consistent between Visit 1 and Visit 2. The four factors included were moderately inter-correlated ($r = 0.26$ – 0.55 for Visit 1 and 0.24 – 0.55 for Visit 2). The mean enjoyment scores for the socializing, active hobbies, and passive hobby factor scores ranged from 3.5 to 3.6 ($SD = 0.5$ – 0.8) across the factors and visits. The mean scores for the sex/drug use scores for both visits were 3.1 (0.8).

Reliability

Reliability analysis was based on the first two sessions in both studies. Cronbach’s alphas were all ≥ 0.70 ; that is, indicating “moderate” to “excellent” reliability (Table 2).²⁶ Intraclass coefficients of test-retest stability across the overall mean and the three factors were all ≥ 0.83 ; that is, “excellent” (Table 2).

Construct Validity

As expected, higher overall REI enjoyment score as well as the socialization score and the active hobbies subscores were correlated

Table 1. Demographics and Smoking History of Participants

	Study 1 (<i>n</i> = 162)	Study 2 (<i>n</i> = 278)	Current smokers (<i>n</i> = 269)	Former smokers (<i>n</i> = 171)
Age (<i>M</i> ± <i>SD</i>)	48 ± 12	42 ± 15***	41 ± 14	49 ± 13***
Women (%)	60	45**	48	54
White/Non-Latino (%)	90	86	87	89
Some college or more (%)	81	73*	69	86***
Cigarettes per day (%)				
1–9 cigarettes/day	31	0	7	—
10–19 cigarettes/day	29	49	44	—
20 cigarettes/day	19	30	28	—
>20 cigarettes/day	21	20	20	—

Categorical variables were tested using the Pearson chi-square and continuous variables using the Wilcoxon Rank Sum Test.

p* < .05. *p* < .01. ****p* < .001.

with a greater frequency of rewards, higher PANAS PA score, and lower AES and TEPS anhedonia scores (Table 2) ($r = 0.37$ – 0.53). The same was true for the passive hobby scores and sex/drugs scores but to a lesser degree ($r = 0.15$ – 0.40). The REI was not correlated with EEfRT scores.

Predictive Validity

Contrary to our prediction, overall enjoyment score and factor scores did not differ between current and former smokers (Table 3). Higher overall and factor scores did prospectively predict a lower probability of relapsing during the laboratory study (Table 4). For example, each one unit increase in the overall enjoyment score at Visit 1 decreased the probability of relapse by 27%.

Moderators

Women scored higher than men on the overall enjoyment score and the socializing and passive hobby factor scores, but scored lower on

the sex/drug use scores (Supplementary Appendix Table 2). Older participants scored lower than younger participants on the overall mean score and on all factors except for passive hobbies (which showed a similar trend). Ethnicity/race and education did not moderate scores.

Discussion

Our REI (see Supplementary Appendix for the final version) includes three outcomes: enjoyment from rewards, wanting of rewards, and frequency of rewards. The psychometric analysis in this report focuses on the enjoyment ratings. The list of rewards in the REI appears to be comprehensive (includes 58 rewards) and up-to-date, yet the enjoyment scale of the REI can be completed by most participants within 5 minutes. Internal reliability and test-retest reliability of enjoyment ratings were excellent, concurrent validity was good, but predictive validity was unclear.

Our scale is most similar to the PES,¹⁰ the Pleasant Activities List,¹¹ and the Reinforcement Survey Scale.⁹ Factor analysis of these

Table 2. Internal Reliability ($n = 440$), Test-Retest Reliability ($n = 348$), and Concurrent Validity ($n = 278$)

		Overall mean score	Socializing	Active hobbies	Passive hobbies	Sex/drug use
Internal reliability						
Cronbach's alpha						
Visit 1		0.94	0.88	0.83	0.72	0.71
Visit 2		0.95	0.90	0.84	0.70	0.73
Test-retest reliability						
ICC ^b		0.89	0.89	0.87	0.83	0.88
Concurrent validity ^a						
Visit 1	Frequency ^b	0.52	0.44	0.44	0.40	0.24
	EEfRT	-0.11	-0.14	-0.06	-0.01	-0.01
	AES	-0.51	-0.53	-0.46	-0.30	-0.15
	TEPS	-0.53	-0.44	-0.45	-0.40	-0.25
	PANAS PA	0.53	0.52	0.44	0.35	0.22
Visit 2	EEfRT	-0.03	-0.07	0.03	0.06	-0.02
	AES	-0.38	-0.39	-0.37	-0.19	-0.15
	TEPS	-0.49	-0.44	-0.41	-0.35	-0.19
	PANAS PA	0.53	0.51	0.45	0.33	0.22

AES = Apathy Evaluation Scale, EEfRT = Effort Expenditure for Rewards Task, ICC = Intraclass Correlation Coefficient, PANAS PA = Positive and Negative Affect Scale, Positive Affect score, REI = Rewarding Events Inventory, TEPS = Temporal Experience of Pleasure Scale.

$p < .01$ for all correlations except: $p < .05$ for AES and Sex/drug use and $p > .05$ for all EEfRT correlations.

^aVisit 1 vs. Visit 2.

^bAdministered only at Visit 1.

Table 3. Adjusted Overall Mean REI and Factor Scores for Current ($n = 269$) Versus Former Smokers ($n = 171$)

	Overall mean		Socializing		Active hobbies	
	Current smoker	Former smoker	Current smoker	Former smoker	Current smoker	Former smoker
Visit 1	3.7	3.6	3.8	3.7	3.7	3.6
Visit 2	3.6	3.6	3.7	3.7	3.6	3.6
	Passive hobbies		Sex/drug use			
	Current smoker	Former smoker	Current smoker	Former smoker		
Visit 1	3.6	3.6	3.1	3.1		
Visit 2	3.5	3.7*	3.1	3.1		

Adjusted for sex, race, and education.

* $p = .02$, for current vs. former smoker.

Table 4. Hazard Ratios for Time to Relapse

	Overall score	Socializing	Active hobbies	Passive hobbies	Sex/drugs
Visit 1	0.73*	0.94	0.84	0.83	0.85
Visit 2	0.72**	0.89	0.82*	0.81*	0.81**

* $p \leq .10$. ** $p \leq .05$.

scales suggested socializing, solitary, craft, and sexual factors which is similar to our analysis. Only the PES has had psychometric testing and our results are comparable to their results.¹⁰ Our scale may be preferable to these three scales for several reasons. First, these three scales have 2–4 times the number of rewards as our scale and take about 30–60 minutes to complete. Second, two of the scales were published in 1981–1982, and thus fail to include more recent rewards. Third, these scales ask about past enjoyment, whereas our scale asks about anticipated enjoyment. We focused on anticipated rewards because future behavior and much psychopathology are based on perceived outcomes.

Our study had limitations. First, the REI was not based on any specific theoretical conceptualization of anhedonia. Also, the REI measures only anticipatory anhedonia and not consummatory anhedonia; thus, the scale does not measure actual enjoyment when the reward occurs. This is important because anticipating and consuming rewards appear to be two different phenomena.²⁷ Our use of convenience samples decreased our external validity, and our use of only current and former smokers may mean that our results may not generalize to never-smokers. In addition, our sample had few minorities and few participants with a high school-only education. To conduct factor analysis, we had to combine results from two different studies, which, although increasing the range of possible scores, may have added unwanted variance.

We hope that publishing our scale will prompt researchers to conduct rigorous tests of the REI. Future studies especially need to include more stringent validity tests; for example, whether scores differ in those with depression, schizophrenia, or drug withdrawal. Another important test would be whether the REI predicts outcomes, or whether it changes with clinical improvement. For example, the REI should change with successful implementation of contingency-management³ or behavioral-activation therapies,²⁸ or with certain medications; for example, antidepressants.²⁹ In addition, our decision to focus only on anticipated enjoyment was based on our anecdotal experience and clinical logic. Delineation of the relationships among enjoyment of, wanting for, and frequency of rewards is clearly indicated. Our REI scale includes questions about wanting and frequency as well as enjoyment so that future researchers can examine these relationships.

In summary, we have developed what we believe is a comprehensive, up-to-date, yet brief inventory that can be used to measure self-reported reward sensitivity on a repeated basis. In addition, it is one of the few scales that has been shown to have test-retest and prospective validity. Replication of our results in more generalizable samples and tests of the clinical utility of our scale are necessary prior to its widespread use, and we encourage such tests.

Supplementary Material

Supplementary Appendix can be found online at <http://www.ntr.oxfordjournals.org>

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Declaration of Interests

JRH has received consulting fees from companies that develop or market products for smoking cessation or harm reduction and from nonprofit companies that engage in tobacco control. Other authors have nothing to disclose.

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