

**THE RELATIONSHIP BETWEEN ADDICTION AND REWARD BUNDLING: AN
EXPERIMENT COMPARING SMOKERS AND NON-SMOKERS**

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ABSTRACT

Aims Previous studies indicate that addicts show reduced patience, compared to non-addicts, for more delayed versus more immediate rewards. This may reflect a lower propensity to view such decisions in terms of the larger sequences to which they typically belong (e.g. smoking is a frequently repeated act). Therefore, in a sequence of decisions involving smaller sooner (SS) versus larger later (LL) rewards, it may be possible that suggesting or forcing people with a propensity to addiction to make the decision for the series as a whole would increase patience. People without a propensity to addiction should benefit less from this because they already tend to take that view. **Design** 30 regular smokers (as exemplars of addicted individuals) and 30 non-smokers chose between small short-term and larger long-term monetary rewards over a sequence of four decisions spaced two weeks apart. Subjects were divided into three groups: one who made each decision independently with no suggestion that they be considered as a series ('Free'), a group to whom it was suggested from the start that they consider each decision as part of the series ('Suggested'), and a group who were told that their very first choice in the series would be used for the remaining decisions ('Forced'). All subjects were paid what they had chosen. **Setting** A laboratory room at the University of Cape Town (UCT). **Participants** UCT undergraduate volunteers. **Measurements** The proportion of LL choices in each subgroup was evaluated by chi-squared tests and a probit model. **Findings** Smokers increased their preference for LL rewards when 'bundling' of individual decisions into a sequence was either suggested or forced, and also increased this preference with repeated experience. Non-smokers showed neither pattern. **Conclusions** The propensity of smokers to prefer small short-term rewards over larger delayed rewards

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may be mitigated, over a sequence of decisions of this kind, by encouraging or forcing them to think of the sequence as a whole. If replicated, this finding may form the basis of an intervention that could attenuate the choice patterns characteristic of addiction.

I. INTRODUCTION

The persistence of addictions is often associated with addicts' relatively great valuation of imminent rewards [1], sometimes called myopia. Such apparent overvaluation might reflect effects of addictive agents themselves, either from their interaction with innate susceptibilities or from impairments of judgment they induce [2,3]; but it might also reflect a lower propensity to view decisions to consume addictive agents in terms of the larger sequences to which they typically belong (e.g. smoking is a frequently repeated act) [4].

A common intuition about self-control is that people should look at each choice they make about a particular kind of temptation as a test case for how they expect themselves to choose in similar situations in the future. That is, someone trying to lose weight should look at a piece of chocolate not as an individual reward with a small one-time cost, but as a threat to his or her expectation of eating prudently in the future. The perception of the current example as a test case, or self-signal [5], *bundles* together similar rewards in the foreseeable future, putting the expectation of getting them at risk in the current choice – and by that very fact making the tempting option less attractive. On this hypothesis, tendencies to myopic choice may be reduced by a person's perception that his or her current choices carry information about future ones, bringing to his or her attention such possible bundling principles as “If I avoid chocolate on this present occasion, this allows me to believe that I will avoid chocolate on future occasions.” Several authors have described how such bundling would be predicted to reduce tendencies to choose myopically [4,5,6,7,8], but experimental evidence has been confined to a single report:

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Kirby and Guastello [9] reported that manipulating students' perception of how salient a current choice was for similar future choices affected their preference for LL rewards. Their subjects showed greater preference for LL rewards (money in one experiment, pizza in another) when choosing bundles of five weekly deliveries than when choosing one week at a time, and showed an intermediate degree of preference when the self-signalling aspect of weekly choices was merely suggested to them. We report the use of a similar design to replicate this phenomenon and to compare its occurrence between groups of self-identified regularly smoking and non-smoking students. We chose smoking status as a rough means of dividing a student population according to disposition both to addiction and to impulsiveness in general [10].

The central hypothesis investigated by our study is that people who are more disposed to addictive behavior patterns are more likely to be sensitive to external manipulation in the direction of more future-oriented choice, by binding commitments and/or by the suggestion that their current choices are test cases. An idea underlying this hypothesis, which is supported but not directly tested by the study we report, is that non-addicts are ordinarily more likely than addicts to bundle reward series without external suggestion or pressure. The study is not intended to address questions around putative causal relationships between steep intertemporal discounting and addiction. We indeed distance ourselves from such claims; discounting models may simply be one frequently useful way of representing the basic consumption pattern characteristic of addiction, which in turn has complex causes.

II. METHODS

Subjects were recruited through sign-up sheets circulated in undergraduate economics classes at the University of Cape Town (UCT). Each potential subject indicated whether he or she was a ‘regular smoker’, and was screened using the World Health Organisation’s (WHO) Alcohol, Smoking and Substance Involvement Screening Test (ASSIST) [11]. This allowed us to check the reliability of subjects’ self-identifications of smoking status. In addition, subjects that met the criteria for alcohol or substance abuse were excluded to eliminate potential comorbid confounds. The Problem Gambling Severity Index (PGSI), the scored module of the Canadian Problem Gambling Index (CPGI) [12], was also administered to all potential subjects, and those with gambling problems were excluded.

60 students – 30 smokers and 30 non-smokers - met the criteria for inclusion in our study. One subject was excluded after self-identifying as a regular smoker, because his self-reported status was inconsistent with his WHO ASSIST Smoking score. Table I presents summary statistics for the self-identified regular smokers and non-smokers in the sample. Smokers’ mean score of 26.03 on the WHO ASSIST screen implies that they are at moderate risk for health and other problems associated with their current pattern of substance use. 53 percent of smokers have scores on the tobacco module in excess of 27, which places them in the high risk category and implies they are likely to be dependent. Nine of the non-smokers reported having never tried cigarettes, and only 3 reported having had more than 2 cigarettes over the preceding 3 months. WHO ASSIST results thus confirm that self-judged smoking status in the sample, minus the 1 excluded subject, reliably tracked status as measured by the screen.

[Table I here]

Table I shows a significant difference between smokers and non-smokers in the proportion of Black subjects, with more Blacks among the non-smokers. We therefore control for race in the estimation framework to guard against misattribution of results.

Each group of smokers and non-smokers was randomly sorted into the three experimental conditions described below. Subjects then took part in a temporal discounting binary titration procedure to elicit a stable baseline or pre-experimental preference for a smaller, sooner (SS) reward to be delivered in 1 day over a larger, later (LL) reward to be delivered in 10 days. We used a 1 day front-end delay (FED) to hold the subject's transaction costs constant for SS rewards and LL rewards, following Coller and Williams [13]. This FED also removes the possible influence of emotional arousal provoked by imminent (in the economics literature, "visceral" or "β") reward, which has been claimed to be a distinctive source of temptation [14,15]. The LL reward was fixed at 50 South African Rand (R50, which had the purchasing power of about \$11 US at the time) and the SS reward varied according to the subject's choices. The titration implements a binary search algorithm that halves the difference between a subject's choices. Thus if a subject facing the choice between R25 in 1 day (SS) and R50 in 10 days (LL) chooses the LL reward, then the next choice the subject faces is between R37.50 in 1 day and R50 in 10 days. If instead the subject in the example chose the SS reward, the next choice would be between R12.50 in 1 day and R50 in 10 days. By this procedure one hones in on the subject's indifference point between an SS reward in 1 day and R50 in 10 days. Lest the algorithm continue indefinitely, the titration terminated when it was forced to halve R0.50. Subjects were not told how their choices would be used, so as to avoid

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presenting them with an incentive to misreport their preferences in order to be subsequently offered higher SS rewards.

Once the titration had reached its limit for a subject, that subject was again offered the smallest SS reward he or she had previously preferred to the LL reward, to ensure that the preference was pre-experimentally stable. If the subject selected the LL reward, then the procedure was repeated until the subject selected the same SS reward over the LL reward twice in a row when the titration had reached its limiting value of R0.50. This selection established the subject's *baseline* preference.

Past studies have shown that smokers tend to choose smaller SS rewards relative to LL reward magnitudes than non-smokers [16]. In our sample the difference in preference for SS rewards as between smokers and non-smokers showed the standard direction but did not reach significance by a non-parametric Mann-Whitney test (Table I: $z = 1.63$; $p = 0.10$).

The experimenter noted the subject's preference amount and then posed one of three condition-specific questions, depending on the condition into which the subject had been randomly placed. *SS reward* was subject-specific and was determined by each subject's baseline preference amount. Phrases in brackets were only used in follow-up phone calls.

FREE CONDITION:

"[As you know] I will be calling you every two weeks for six to ten weeks. Every second week I will be asking you to choose between *SS reward* in one day and R50 in ten days. Which would you like me to give you this week: *SS reward* in one day or R50 in ten days?"

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SUGGESTED CONDITION:

“[As you know] I’ll be calling you every two weeks for six to ten weeks. Each week I will be asking you to choose between *SS reward* in one day and R50 in ten days. Each time you are offered this choice you will be in the same situation that you are now, facing a choice between *SS reward* in one day and R50 in ten days. Therefore, the choice you make now is the best indication of how you will choose every time. What somebody chooses one week is often what they go on choosing in later weeks, but you’ll be completely free to choose between these two options every two weeks. Which would you like me to give you this week: *SS reward* in one day or R50 in ten days?”

FORCED CONDITION:

"You will now make a choice for a set of rewards. If you choose *SS reward* in one day then you will receive *SS reward* in one day and *SS reward* every two weeks after that for six to ten weeks. If you choose R50 in ten days then you will receive R50 in ten days and every two weeks after that for six to ten weeks. Which would you prefer: *SS reward* in one day and every two weeks after that or R50 in ten days and every two weeks after that?"

All subjects were told they would make further choices or receive further prizes for the indefinite ‘six to ten weeks’ in order that all repeated choices in the Free and Suggested conditions were made in possible expectation of a similar future choice.

The three conditions allowed us to test hypotheses about the propensity of individuals to increase their preference for LL rewards when we varied the salience of the subjects’ current choices for their expectation of future rewards. The Free

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condition provided a comparison group without manipulations: individuals were simply told that we would contact them again to offer them the same choice. The Suggested condition primed subjects to think about their current choice as a predictor of future choices and thus framed an individual choice as an indicator of the reward they might expect in the future as well. The Forced condition determined all the future rewards by the subject's current choice, forcing him or her to choose the rewards as a series.

SS rewards used were the smallest SS values reliably chosen (baseline preferred) over the LL reward in the binary titration session. From here on subjects actually received the money they chose, deposited directly in their bank accounts. After subjects in the Free and Suggested conditions made their initial choices in the presence of the experimenter they were contacted by telephone three more times and offered the same choice in intervals of two weeks. The two week interval was used to reduce the possible impact on preferences of accumulation of money over the course of the experiment. The data were gathered in four *waves*, at weeks 0, 2, 4, and 6. There was no attrition, so the panel of 60 individuals was balanced across the waves.

To test for any potential experimental confounds we investigated whether demographic variables and baseline experimental values differed significantly across the three experimental conditions. Results are presented in Table II.

[Table II here]

The only significant differences that emerged were for income between the Free and Suggested conditions ($z = 2.59$; $p = 0.01$) and between the Suggested and Forced conditions ($z = -2.39$; $p = 0.02$) and for age between the Suggested and Forced

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conditions ($z = -2.02$; $p = 0.04$). We control for these factors in our statistical models, and find that they do not influence the experimental results of interest.

III RESULTS

Under the experimental conditions some subjects in all groups made more patient choices than they had at baseline, where preference for LL rewards was zero by design. However, only smokers increased their patience as a function of condition. Figure 1 displays the fraction of LL choices made during Wave 1 for smokers and non-smokers in the three experimental conditions. Among smokers, there is a significant increase in the fraction of subjects selecting LL between the Free and Forced conditions ($\chi^2 = 9.98$; $p = 0.00$) and between the Suggested and Forced conditions ($\chi^2 = 7.01$; $p = 0.01$). Among non-smokers there are no significant differences in the fraction selecting LL in Wave 1 between any of the experimental conditions (Free vs Suggested: $\chi^2 = 0.22$, $p = 0.64$; Free vs Forced: $\chi^2 = 0.83$, $p = 0.36$; Suggested vs Forced: $\chi^2 = 0.20$, $p = 0.65$). These results imply that, in Wave 1, smokers' choice of LL was affected by the experimental condition whereas non-smokers' choices were not.

[Figure I here]

Directly comparing smokers and non-smokers across the experimental conditions at Wave 1, we find that, in the Forced condition, a significantly higher fraction of smokers selected LL than did non-smokers ($\chi^2 = 6.11$; $p = 0.01$). That is, smokers, when able to bindingly pre-commit to later choices, abandoned their baseline preferences for SS rewards at a markedly higher rate than non-smokers.

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To clarify the effect of experimental condition and to test for the possibility of learning across waves in the experiment we present binary choice estimation models for smokers and non-smokers. We estimated, but do not report here, a model which pooled the observations for these two groups. However, if there are systematic differences between smokers and non-smokers then the model should be estimated separately on the two subsamples. To investigate this issue we used a Chow test [17], which requires that we interact a dummy variable for smoking status with each variable in the statistical specification and then test the joint significance of all the smoking intercept and slope coefficients. The test provided a chi-squared statistic, with 12 degrees of freedom, of 3.54 ($p = 0.00$). We can therefore reject the null hypothesis that there is no statistically significant difference in the slope and intercept coefficients for smokers and non-smokers. Hence, we estimate the model separately for the two groups. This procedure emphasizes a point made previously, that our results speak to the differential effects of pro-bundling interventions in addicts and non-addicts, and not to putative causal or other relationships between discounting per se and addiction.

We used a random effects probit model because of the dichotomous nature of our dependent variable, which follows the Bernoulli distribution, and to explicitly incorporate the longitudinal structure of the data. We do not use an ANOVA model, because this incorporates an assumption, false in this instance, that the dependent variable is normally distributed. These models also allow us to control for, or partial out, the differences reported earlier in income and age across experimental conditions and in race between smokers and non-smokers.

[Table III here]

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Table III shows the results of our modeling, estimated on the smoker and non-smoker subsamples. In the model for smokers, the coefficient for participation in the Forced condition tends toward infinity because it is a perfect predictor of the response probability (i.e. all smokers in the Forced condition selected LL). We note that there is likewise a significant increase in the probability of selecting LL in the Suggested condition relative to the Free condition, our omitted category.

The results also show that the likelihood of selecting LL is significantly higher ($p < 0.05$) in Waves 2, 3 and 4 relative to the omitted category, Wave 1. This result confirms the pre-modeling observation of marginally significant pairwise comparisons in the Suggested condition, in smokers only, showing increased preference for LL rewards between Waves 1 and 2 and between Waves 1 and 3 ($\chi^2 = 3.14$; $p = 0.08$ for each comparison). This is depicted graphically in Figures II and III below, where the upward trend in the fraction of smokers selecting LL across waves is apparent.

[Figure II and Figure III here]

We also used the model to control for demographic differences between subjects, in order to ensure that the results of interest are not significant merely because of correlations with omitted demographic characteristics. In the model for smokers, being Black lowers the probability of selecting LL. This result highlights the importance of controlling for race in our model because the other variables would be biased in its absence. Being older increases the likelihood of selecting LL and a higher baseline preferred SS lowers the probability of selecting LL. In the model for non-smokers, we find that only two variables influenced their choices in the experiment: having a higher income raises the probability of selecting LL whereas a

higher baseline preferred SS has the opposite effect. By including these variables in our model, we partial out their effects and find that they are not driving the results.

In sum, the model indicates differential effects of experimental condition and repeated experience on smokers and non-smokers. Smokers are more likely to select LL in the Suggested and Forced conditions than they are in the Free condition. Furthermore, the probability that smokers select LL rises across repeated trials in the experiment. Non-smokers, on the other hand, are not influenced by the experimental conditions nor do they adjust their behavior significantly over time.

IV. DISCUSSION AND CONCLUSIONS

Acknowledging the limitation of the small numbers in our study our data suggest two important patterns. First, when the salience of a current choice to similar future choices is either suggested or offered as a binding commitment to subjects, smokers but not non-smokers make more future-oriented choices than they do in the absence of such external manipulation. This suggests that smokers may have been less likely than non-smokers to have been framing series of similar rewards as bundles on their own, as an intuitive self-management skill they brought to the experiment. This hypothesis is strengthened by the second pattern we observed, that smokers but not non-smokers became increasingly likely to choose LL rewards as they gained experience with the choice problem. This does not imply that non-smokers were more impatient than smokers. The choices presented to each subject were calculated from his or her particular baseline preference, and although the difference in mean baseline preferences between the two groups did not reach significance ($p = 0.10$; see Table I), it was consistent with previous observations of lower patience in smokers [16]. The

point, rather, is that manipulations of salience did not move non-smokers to *increase* their patience.

From a theoretical standpoint, it is important to note that conventional utility theory predicts neither inconsistent preferences for SS rewards over time nor a reduction in this inconsistency through reward bundling. The discovery [18] and replication [19,20,21] of a fundamental tendency to devalue the future less steeply at longer delays (“hyperbolic discounting”) provides a rationale for both. Some researchers have proposed a lesser modification of the conventional discount function that can account for inconsistent choices caused by emotional arousal (“hyperboloid discounting”) [15,22,23], but that function does not predict the increase in patience from reward bundling observed elsewhere [9,24] and in the present experiment. The present experiment also confirms that merely suggesting the “test case” viewpoint can increase patience, presumably by increasing reward bundling.

Our data do not address the issue of whether smokers’ responsiveness to the suggestion of salience was related to their drug use pattern or addiction per se, or to some underlying variables that predispose them to both addictive consumption and reliance on external prompts for bundling. However, the observation that this pattern is absent in non-smokers suggests that even addicts whose addictive consumption does not affect judgment by way of intoxication (i.e. smokers) may differ from non-addicts in their tendency to refer choices involving delays to larger categories of choice. The observation that this tendency is manipulable opens a promising avenue for studying self-control in addicted or drug-abusing populations.

It is also potentially relevant to therapeutic intervention. Cognitive-behavioral therapy is a common treatment approach to addictions. This raises questions about

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possible specific aspects of cognitively mediated perceptual re-framing at which therapists might usefully aim. Although the idea that increased self-control comes from referring individual choices to larger categories goes back to Aristotle, willpower remains an empirically under-specified construct. Our study focuses on one of its possible bases in choice framing, use of which may differ between addicts and non-addicts. When a current choice creates an expectation of similar choices in the future, by external structure or by the kind of suggestion that could be employed in the context of cognitive-behavioral therapy, addicts' choices become more patient.

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TABLE I
SUMMARY STATISTICS AND SMOKER - NON-SMOKER COMPARISONS

Variable	Mean (Standard Deviation)		Significant Difference?	
	Smokers	Non-smokers	z-statistic or χ^2	p value
<u>Demographics</u>				
ASSIST tobacco score	26.03 (6.44)	3.03 (2.48)	$z = -6.69$	0.00
Income	2658.33 (2047.54)	2458.33 (2891.55)	$z = -1.40$	0.16
English first language	0.83 (0.38)	0.83 (0.38)	$\chi^2 = 0.00$	1.00
Age	20.97 (1.52)	21.23 (3.18)	$z = -0.31$	0.75
Male	0.53 (0.51)	0.53 (0.51)	$\chi^2 = 0.00$	1.00
White	0.47 (0.51)	0.37 (0.49)	$\chi^2 = 0.61$	0.43
Black	0.27 (0.45)	0.57 (0.50)	$\chi^2 = 5.55$	0.02
<u>Baseline values</u>				
Baseline preferred SS	29.13 (12.53)	33.78 (15.14)	$z = 1.63$	0.10
Proportion selected LL	0.57 (0.50)	0.60 (0.50)	$\chi^2 = 0.02$	0.79

Notes: Summary statistics computed from a sample of 60 subjects

Only wave 1 data is presented

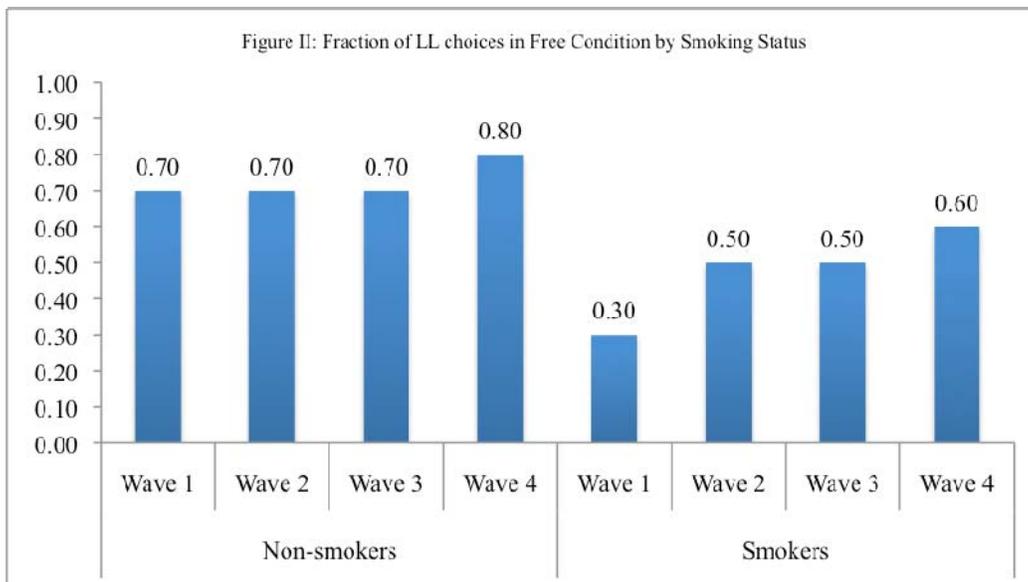
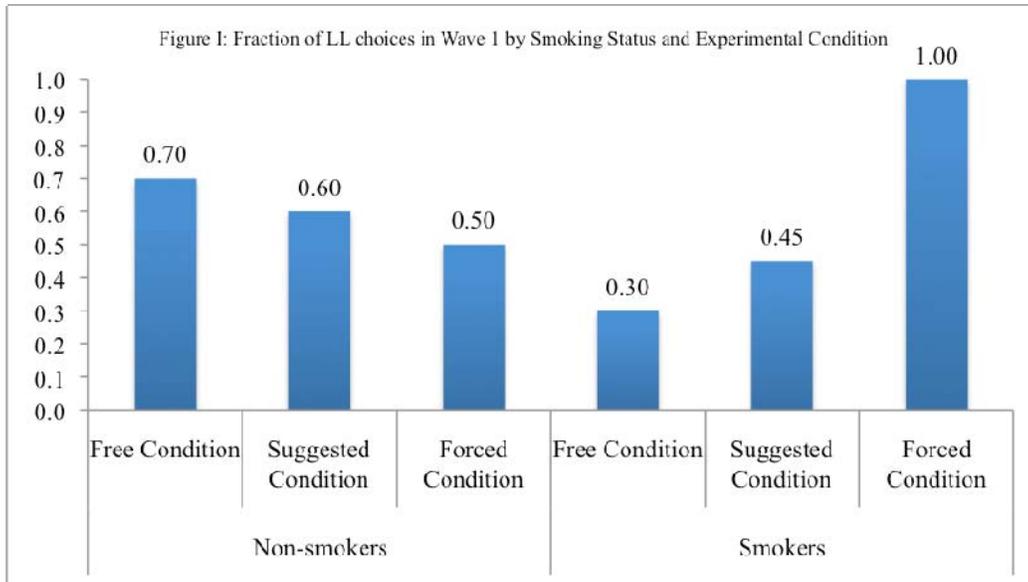
TABLE II
SUMMARY STATISTICS AND EXPERIMENTAL CONDITION COMPARISONS

Variable	Mean (Standard Deviation)			Comparisons		
	Free Condition	Suggested Condition	Forced Condition	Free vs Suggested	Free vs Forced	Suggested vs Forced
<u>Demographics</u>						
ASSIST tobacco score	15.25 (13.30)	14.33 (11.77)	14.00 (13.27)	$z = -0.29$ (p = 0.77)	$z = -0.33$ (p = 0.74)	$z = -0.15$ (p = 0.88)
Income	1777 (1168)	3536 (3116)	2300 (2484)	$z = 2.59$ (p = 0.01)	$z = 0.14$ (p = 0.89)	$z = -2.39$ (p = 0.02)
English first language	0.85 (0.37)	0.76 (0.44)	0.89 (0.32)	$\chi^2 = 0.51$ (p = 0.48)	$\chi^2 = 0.17$ (p = 0.68)	$\chi^2 = 1.22$ (p = 0.27)
Age	20.90 (1.77)	21.86 (3.62)	20.47 (1.02)	$z = 1.04$ (p = 0.30)	$z = -0.51$ (p = 0.61)	$z = -2.02$ (p = 0.04)
Male	0.60 (0.50)	0.52 (0.51)	0.47 (0.51)	$\chi^2 = 0.24$ (p = 0.62)	$\chi^2 = 0.63$ (p = 0.43)	$\chi^2 = 0.10$ (p = 0.75)
White	0.35 (0.49)	0.57 (0.51)	0.32 (0.48)	$\chi^2 = 2.02$ (p = 0.16)	$\chi^2 = 0.05$ (p = 0.82)	$\chi^2 = 2.63$ (p = 0.11)
Black	0.45 (0.51)	0.29 (0.46)	0.53 (0.51)	$\chi^2 = 1.19$ (p = 0.28)	$\chi^2 = 0.23$ (p = 0.63)	$\chi^2 = 2.41$ (p = 0.12)
<u>Baseline values</u>						
Baseline preferred SS	30.35 (13.25)	32.16 (13.99)	31.83 (15.33)	$z = 0.31$ (p = 0.75)	$z = 0.51$ (p = 0.61)	$z = -0.24$ (p = 0.81)
Proportion selected LL	0.50 (0.51)	0.52 (0.51)	0.74 (0.45)	$\chi^2 = 0.02$ (p = 0.88)	$\chi^2 = 2.31$ (p = 0.13)	$\chi^2 = 1.93$ (p = 0.17)

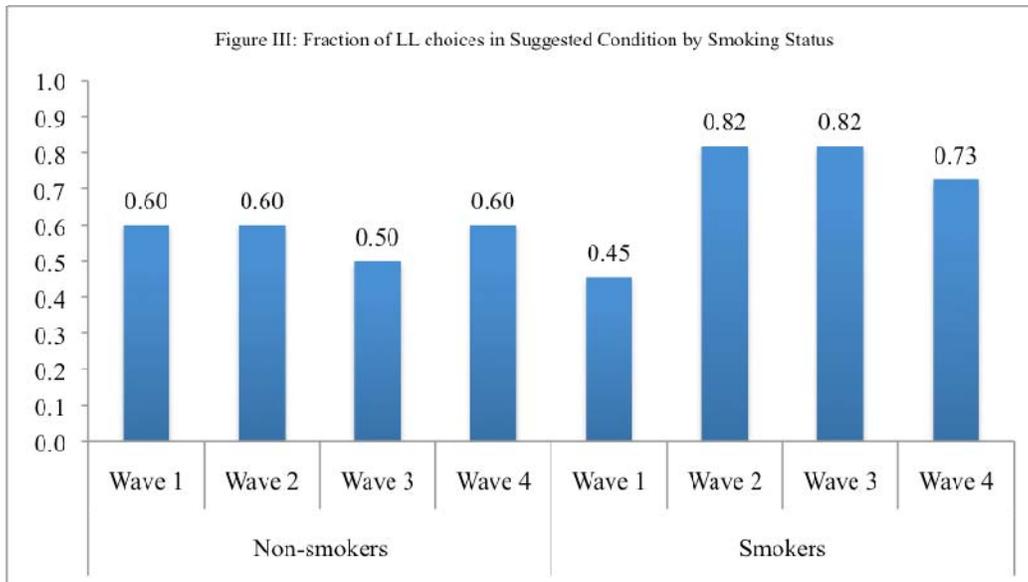
Notes: Summary statistics computed from a sample of 60 subjects

Only wave 1 data is presented

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TABLE III
BINARY CHOICE ESTIMATES FOR SMOKERS AND NON-SMOKERS

Variable	Smokers	Non-Smokers
	Coefficient Estimates	
Suggested Condition	0.65* (0.35)	-2.73 (2.18)
Forced Condition	∞ ***	-0.39 (1.31)
Black	-1.50*** (0.53)	-1.36 (1.66)
Male	0.44 (0.38)	-1.51 (1.20)
English first language	0.63 (0.55)	-0.41 (1.68)
Age	0.24** (0.11)	-0.23 (0.18)
Income	0.30 (0.30)	2.72* (1.41)
Baseline preferred SS	-0.05*** (0.018)	-0.11** (0.047)
Wave 2	1.03** (0.47)	0.33 (0.57)
Wave 3	1.07** (0.47)	0.04 (0.57)
Wave 4	1.09** (0.48)	0.66 (0.58)
Constant	-7.06** (3.55)	-8.06 (7.04)
Observations	120	116
Log Likelihood	-37,73	-40,6
	Marginal Effects	
Suggested Condition	0.17*	-0.40
Forced Condition	0.49***	-0.05
Black	-0.29***	-0.21
Male	0.08	-0.23
English first language	0.12	-0.07
Age	0.04**	-0.04
Income	0.05	0.45*
Baseline preferred SS	-0.01***	-0.02**
Wave 2	0.19**	0.06
Wave 3	0.20**	0.01
Wave 4	0.20**	0.11

Notes:

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

∞ Forced condition is a perfect predictor and its coefficient tends toward infinity