Master's Thesis in International Economics

Stockholm School of Economics

Self-Control Problems and Obesity

- An Experimental Study

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Abstract:

Several detrimental health behaviors can be viewed as problems of self-control, composed of an immediate reward and delayed adverse consequences. Drug abusers, pathological gamblers and many obese people engage in activities providing instant pleasure, while long-term health and social functioning are compromised. Drug abusers have been shown to display self-control problems regarding both their drug of choice and money, indicating a possibility of a general discounting mechanism. This proposition has further been strengthened by the identification of a pharmacological compound simultaneously affecting drug dependence, overeating and nicotine use. This thesis investigates whether obese people with acknowledged self-control problems for food also are impulsive regarding money. This is done by use of an experiment with real monetary rewards, administered to obese patients voluntarily enrolled at a specialist clinic, and matched controls. In contrast to findings from similar experiments in drug abusers, the results provide no support for the proposition that obese people have greater self-control problems regarding money. Hence the findings do not lend support to a theory of a commodity-independent, general discount rate.

Tutor: Magnus Johannesson

Presentation: June 12, 2006

Location: Room 336

Time: 10.15-12.00

Discussants: Sofi Bergkvist and Klara Halkjaer

I would like to thank my tutor Magnus Johannesson for his support and comments on the study design, experiment implementation and manuscript drafts. I would also like to thank Stephan Rössner, Karolinska Institute, for allowing me to conduct the study at the Obesity Unit, Karolinska University Hospital, and for comments on medicine- and obesity-related content in the thesis. Finally, I would like to express my sincere gratitude to the patients and personnel who volunteered to participate.

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1. Introduction

Standard economic theory rests on the assumption of rational, utility maximizing consumers who are able to make inter-temporal decisions. Rationality in inter-temporal decision-making entails treating each moment of delay equally and discount according to an exponential function. Although this is a useful assumption for many applications, there is increasing evidence that although individuals may behave rationally when comparing options that will occur in the more distant future, they may act differently when it is possible to receive an immediate reward[1]. Hence many act impatiently today, but plan to act patiently tomorrow. For those who follow such a pattern, who act impulsively and display impaired self-control, the patience-governed decision-making may never materialize for certain behaviours, since the future will always be replaced by another today including temptations that cannot be resisted. For many alcoholics, drug abusers and obese people, this is a recognized problem, which is confirmed by the existence of markets for commitment technologies facilitating self-control[2 3].

Self-control has been defined as the choice of a large delayed reward while foregoing a smaller immediate alternative[4]. The definition of impulsivity, i.e. lack of self-control, has also been extended to encompass all choices that result in small immediate rewards but have delayed aversive consequences[5]. Such a definition mirrors many detrimental health behaviours, which are hard to explain by standard economic theory. One such example is substance abuse, which entails an immediate reward in the form of intoxication, while the delayed adverse consequences may be massive, including deteriorating health, family disruption, loss of employment, estrangement from friends, and premature death. Other examples in addition to drug abuse are pathological gambling, alcoholism, cigarette smoking and overeating.

Heroin and cocaine abusers, as well as pathological gamblers, have been found to be impulsive not only regarding their drug or habit of choice, but also discount monetary rewards more steeply than matched controls[6-10]. This has been interpreted as support for the notion of a general mechanism for self-control, which is not commodity-specific. If individuals have such a general discounting system, then alcoholics and overeaters with self-control problems would also discount monetary rewards more steeply than matched non-alcoholic or non-obese controls. The findings from heroinists, cocaine abusers and pathological gamblers have, however, not been replicated in alcoholics[7] and not been investigated in any obese population. Therefore the aim of this study was to test the hypothesis that obese subjects with self-control problems regarding food, also exhibit a higher degree of discounting for monetary rewards.

2. Background

Although the standard exponential discounting function dominates modelling of inter-temporal decision-making in economics, several observations have led researchers and lay-people to question its validity under some circumstances. This is especially true for certain detrimental health behaviours[6-10], where preference reversals are commonly seen and markets for commitment technologies have developed. For decisions involving immediate rewards, alternative discounting functions have been proposed and shown to display better fit to empirical data[1 11]. Furthermore, with the emergence and development of behavioural economics and neuro-economics, new angles to approach and explain departures from the standard exponential discounting model have been employed[12]. Neuro-imaging techniques as well as centrally acting pharmacological compounds have provided clues regarding the biological basis for such behaviors[3 12 13], which facilitates constructing and testing economic hypotheses from a new perspective.

This section is divided into theoretical and biological background. The theoretical background describes preference reversals, commitment technologies and hyperbolic discounting theory. It also provides an overview of previous experiments conducted on populations engaging in detrimental health behaviours with elements of self-control problems. The biological background describes the neural basis for self-control, exemplified by evidence from patients suffering severe brain trauma, neuro-imaging studies and neuro-pharmacology. The section is concluded by a remark regarding the possible practical and theoretical importance of investigating self-control problems and time-inconsistent preferences.

2.1 Theoretical background

The existence of preference reversals and demand for commitment technologies constitute strong evidence of time-inconsistent preferences. These two phenomena will be described before introducing the theory on hyperbolic discounting and measurement of self-control/impulsivity.

2.1.1 Preference reversals

Preference reversals constitute a violation of the predictions made by the standard exponential discounting model. Drug users, alcoholics, pathologic gamblers and obese people are commonly observed to enrol voluntarily in rehabilitation or intervention programs. Despite this voluntary action, many report abusing drugs, drinking alcohol, gambling or overeating while in the program. With time-consistent preferences, such aberrations would not be observed. It has also been noted that drug users may have no problems in refraining from drugs in an environment where drugs are not immediately available[14]. However, when drugs become immediately available, preference reversals frequently occurs and they relapse to drug use. Similar observations have been made in overeaters who cannot resist calorie-dense temptations when confronted with them, sparking research into the development of drugs facilitating impulse control[3 15 16]. Given an exponential discounting function, the rational drug user would always prefer drug use above abstinence, while the non-drug user would prefer the opposite. The choice of drug use, as opposed to non-drug use, should be made independent of where the choices are made along the time axis.

2.1.2 Commitment technologies

While standard economic theory does not acknowledge that problems of self-control exist, it is hard to ignore the fact that markets have evolved for pure commitment technologies. Time-consistent decision-makers would never need commitment technologies such as disulfiram, orlistat or bariatric surgery (described below), since their preferences in the future are in agreement with their preferences in the present.

Disulfiram (Antabus®) is used in voluntary alcohol aversion therapy because of its inhibitory effect on the enzyme aldehyde dehydrogenase. While the compound produces no marked effect when given alone, it causes a severe reaction, including vomiting, headaches, hyperventilation, panic and distress, upon alcohol ingestion. A similar "commitment compound," orlistat (Xenical®), is used voluntarily by obese patients, although orlistat does not punish impulsiveness with vomiting, but diarrhoea and intermittent anal leakage if a low-fat diet is not followed[17]. A further example of an extreme commitment technology for the obese population is bariatric surgery, which is effected by restricting the luminal volume of the gut either by sutures or by direct banding. Post-operatively, patients are anatomically forced to eat small portions of food, otherwise they vomit. Despite the fact that the surgical procedure is associated with approximately 0.5% absolute mortality risk[18], extreme subsequent changes in daily life, increased risk of malnutrition and surgical complications, the number of procedures has increased 7-fold during the last decade, and demand still seems to be in excess of supply[2].

2.1.3 Hyperbolic discounting

The emergence of markets for commitment technologies which effectively raise the stakes for future impulsive decision-making is strong evidence for the existence of self-control problems. This existence may partly explain the common observation of time-inconsistent choices in real life, and the poor fit of the standard exponential discounting function for certain behaviours, such as addiction, pathological gambling, and overeating[11].

The standard exponential discounting function is a simple model of inter-temporal preferences, capturing the fact that people are impatient, but assumes that the preferences are time-consistent:

$$U_t(u_t, u_{t+1}, \ldots, u_T) = \sum_{\tau=t}^{T} \delta^{\tau} u_{\tau}$$

where $\delta \in (0,1]$ is the discount factor $\left(\frac{1}{1+r}\right)$

The time-consistency assumption implies that a subject's relative preference is indifferent to when she is asked. However, people tend to be present-biased, not time-consistent, giving relatively higher weight to earlier rewards as the earlier moments gets closer[19]. Already in the 1930's, Paul Samuelson noted that the exponential discounting function can predict preference reversals if the immediate reward is discounted to a higher degree than the delayed reward[20]. The phenomenon of time-inconsistent preferences has been termed hyperbolic discounting, and is sometimes referred to as the beta-delta (*β-δ*) preference[12]. A simple two-parameter (*β* and *δ*) model has been developed to capture present biased or time-inconsistent preferences[21]. In this model larger weight is given to rewards obtained closer in time. A simplified quasi-hyperbolic model has also been developed and popularized by Laibson[1]. In the quasi-hyperbolic model, the *β*-parameter represents the special value placed on *immediate* rewards relative to rewards received at *any other* point in time. According to this model, a person's inter-temporal preferences at time *t* are given by the following equation:

$$U^t(u_t, \ldots, u_T) \equiv u_t + \beta \sum_{\tau=t+1}^{T} \delta^{\tau-t} u_\tau,$$

where $0 < \beta, \delta \leq 1$ and u_t is the instantaneous utility in period τ

The long-run time-consistent discounting is represented by the parameter *δ*, treating a given delay equivalently regardless of when it occurs, while the *β*-parameter represents the bias for the present.

With a β-parameter of 1, synonymous with no present bias, the equation reduces to the traditional exponential discounting function. However, when $\beta < 1$, more weight is given to period τ in τ, than at any time prior to that specific period. The β-parameter hence represents the special time-inconsistent preference for immediate gratification, where $\beta < 1$ implies preferences biased towards the present. The β-parameter is often interpreted as a measure of self-control problems, since it reflects the propensity for immediate gratification, driving behavior which is disapproved of at any other point in time; the smaller the value of β, the greater the self-control problems.

2.1.4 Naïve vs. sophisticated subjects

The quasi-hyperbolic modelling of preferences assumes that every subject consists of *T* "selves", indexed by the respective periods when the consumption decision is made[1]. Therefore it is of interest to determine what a subject believes about the preferences of her future selves. It may be that the subject is unaware of her self-control problems/time-inconsistencies, and hence believes that the future selves will have the same preferences as the present one. Alternatively, she may be fully or partly aware of her present bias. These two types of subjects have been termed naïve and sophisticated, respectively. The demand for commitment technologies such as disulfiram, orlistat, and bariatric surgery is evidence of at least some degree of sophistication in many subjects, since a naïve subject would never identify a need for such technologies.

2.1.5 Previous experimental studies on detrimental health behaviours

Experimental studies investigating hyperbolic discounting and self-control problems have mainly focused on substance abusers (**Table 1**), pathologic gamblers and pathologically gambling substance abusers (**Table 2**). Substance abusers have been consistently found to discount monetary rewards in a steeper fashion than matched controls, as have gamblers. Furthermore, gamblers who concurrently use drugs tend to have greater discounting rates than non-abusing gamblers. In addition, the degree of discounting has been found to be state-dependent as well, with abstinent drug abusers displaying greater impulsivity regarding monetary rewards than when non-abstinent. The only study including alcoholics could not find any difference between this group of subjects and matched controls, while the cocaine and heroin users included differed significantly in their preferences compared to controls.

An almost universal feature in the listed studies (Table 1 and 2) was the use of hypothetical rewards, with only one study[7] employing real rewards. Most studies also used control subjects matched on age, gender and education (and/or income), while two examined heroinists only without a control group.

The design of the employed instrument to measure the degree of discounting, or degree of self-control problems, was also fairly consistent across studies with questionnaires or interviews. These were based on questions where the subjects were asked to choose between a certain payoff $X immediately and a higher payoff $X+$Y to be obtained with a certain delay.

No study could be identified in the literature investigating obese individuals voluntarily enrolled in weight-loss treatment. However, similarities between obesity and drug addiction have been described in the literature, based on findings from neurofunctional imaging (positron emission tomography; PET)[13]. Wang et al concluded in a concept review that "*overeating in obese individuals shares similarities with the loss of control and compulsive drug taking behaviour observed in drug-addicted subjects*." In both drug-addicted and obese subjects, the researchers identified reductions in density of the same kind of dopamine receptors (striatal d_2-receptors). They postulated that the decreased density of these receptors predisposed subjects to search for reinforcers, i.e. food for the obese subjects and the drug of choice for the drug addicts[13]. These reinforcers would in turn temporarily compensate for the decreased sensitivity of the d_2-receptor regulated reward circuits. If this similarity in sensitivity to reward stimuli is real, the greater self-control problems for monetary rewards seen in addicts may also be present in obese individuals, given that money as a reinforcer converges on the same reward node.

Table 1. Overview of studies on hyperbolic discounting in substance abusers (sorted by year of publication in descending order).

Author & Year	**N**	**Matching criteria**	**Commodities**	**Magnitude effect**	**States**	**Rewards**	**Findings**
Kirby & Petry[7] 2004	148 Heroin (n=27) Cocaine (n=41) Alcohol (n=33) Controls (n=44)	Age, race, gender and education[a]	Money	Small ($25-35) Medium ($50-60) Large ($75-85)	Active Abstinent	1/6 chance to win a real monetary reward $30-$80	Cocaine and heroin abusers > controls Alcoholics = controls Abstinent heroinists > non-abstinent heroinists
Giordano, Bickel, Loewenstein, Jacobs, Marsch, Badger[14] 2002	13 Heroin (n=13)	-	Heroin Money	Small ($1 000) Medium ($3 000) Large ($10 000)	Deprived Non-deprived (cross-over)	Hypothetical rewards $10-$10 000 Heroin (bags)	Deprivation increased the degree of discounting of both money and heroin
Madden, Bickel, Jacobs[11] 1999	Heroin (n=18) 3 discarded from analysis	-	Heroin Money	-	-	Hypothetical rewards $1-$1000 Heroin (bags)	Heroin discounted to a greater degree than monetary rewards
Madden, Petry, Badger, Bickel[8] 1997	56 Heroin (n=18) Controls (n=38)	Age, gender, education, IQ	Heroin Money	-	-	Hypothetical rewards $1-$1000 Heroin (bags)	Heroin abusers > controls Heroin abusers discounted heroin to a greater extent than money

[a] Loose matching to abusers as a whole.

Table 2. Overview of studies on hyperbolic discounting in pathologic gamblers with and without substance abuse problems (sorted by year of publication in descending order).

Author & Year	**N**	**Matching criteria**	**Commodities**	**Magnitude Effect**	**Rewards**	**Findings**
Dixon, Marley, Jacobs[6] 2003	40 Gamblers (n=20) Controls (n=20)	Age, gender, income, education	Money	-	Hypothetical rewards $1-$1000	Gamblers > controls
Petry[22] 2001	86 Gamblers (n=60; 21 with and 39 without substance use disorders) Controls (n=26)	Age, race, gender, education	Money	-	Hypothetical rewards $1-$1000	Abusing gamblers > non-abusing gamblers > controls
Petry & Casarella[10] 1999	81 Heroin&gamblers (n=29) Heroin (n=34) Controls (n=18)	Age, race, gender and education[a]	Money	Low ($100) High ($1000)	Hypothetical rewards $1-$1000	Abusing gamblers > non-abusing gamblers > controls

[a] Loose matching to abusers as a whole

2.4 Biological background

The neural basis for self-control in human decision-making has received increasing attention with the introduction of both neuro-imaging techniques and new centrally acting pharmacological compounds[12 23-25]. Although there is a long history of case-reports on patients suffering brain trauma and thereafter developing and displaying behaviours characterized by impulsivity and low levels of self-control, technological and pharmacological breakthroughs are now making more direct assessments of the functional basis for the disturbances possible to make.

Some researchers argue that a single decision-making system generates the temporal inconsistencies observed in the field and in the laboratory[24], while others believe that it is caused by an interaction of two decision-making systems[12 26]. Tentative evidence for the latter has existed for more than a hundred years from case-reports of individuals exposed to head trauma who subsequent to the injury display impulsive behaviours. More recent evidence from both neuro-imaging studies provides support for two distinct, but interacting, systems where one is governing patient, rational decision-making, while the other is activated when immediate rewards are obtainable[12].

2.4.1 Physical trauma and self-control

The most famous piece of evidence from trauma-induced impulsivity originates from the railroad construction foreman Phineas Gage, who in 1848 miraculously survived a severe head trauma, but woke up as an impulsive, short-sighted and rude individual, after a 3 cm thick and 109 cm long steel-rod pierced his frontal lobe[27]. The injuries that he contracted, including both left and right prefrontal cortices, resulted in defects in rational decision-making and processing of emotion[28]. The steel-rod entered through the left eye-socket and exited through the frontal bone, resulting in major injuries to the prefrontal lobe. Although his memory, learning and intelligence appeared intact, his respect for social conventions and sense of responsibility were lost after the injury. Furthermore, he could not be trusted to honour his commitments. According to his physician, *"the equilibrium or balance, so to speak, between his intellectual faculty and animal propensities"* had been destroyed[28]. The "animal propensities" could be interpreted as impulsiveness or lack of self-control (the β-parameter) and the intellectual faculty as the ability to appreciate the rewards of self-control (the δ-parameter). With the massive prefrontal damage, it appeared like the δ-parameter had been compromised.

The defects in rational decision-making and processing of emotion associated with such injuries have further been confirmed by Gage's modern day counterparts. Brain tumours and ischaemic events interfering with prefrontal areas have been found to result in behaviours mainly driven by immediate awards[29]. In addition, there are large discrepancies in time discounting between animals and humans. This may be explained by the fact that the most distinguishing feature of the human brain compared with other animals is the size of the prefrontal cortices, which are responsible for cognition and hence more closely associated with the δ-parameter than the β-parameter.

2.4.2 Neuro-imaging and self-control

By use of neuro-imaging techniques, further light has recently been shed on the neurological foundation for the β-/δ-preference and quasi-hyperbolic discounting specifically regarding monetary payoffs[12]. In a recent neuro-economic publication, McClure et al have shown that monetary decisions involving immediate rewards preferentially activate parts of the limbic system, while inter-temporal decisions activate regions of the prefrontal and posterior parietal cortex[12]. This indicates that there probably are two separate systems at work when inter-temporal decision-making occurs. The β-parameter seems to be mainly governed by limbic structures, while the δ-parameter is governed by prefrontal cortical areas and associated structures supporting higher cognitive functions. This is congruent with the observations of trauma-, tumour-, and ischaemia-induced behaviour, as in the case of Phineas Gage.

2.4.3 Pharmacological influences on self-control and impulsive behaviours

The presented evidence indicates that impatient behaviour seems to be driven by the limbic system, which often is implicated in addiction. Heroin addicts have been shown to temporally discount not only heroin but also money more steeply than matched controls[8 22], which could imply that alterations of the limbic signalling pathways possibly affect behaviour in a general fashion. If that is the case, an individual may have a common β-parameter for a number of commodities.

Limbic structures have not only been implicated in heroin addiction, but also for other detrimental health behaviours such as smoking, pathologic gambling and overeating[23]. Recently, a new pharmacologic compound, rimonabant, has been tested for treatment of drug addiction, smoking and obesity[3 30 31]. The compound is an endocannabinoid receptor (ECR) antagonist, influencing the reward system of the brain, which is situated in the limbic structures. It seems to result in improved self-control, less relapse events and fewer bouts of uncontrolled eating, and it increases cigarette smoking quit rates compared to placebo[3]. In quasi-hyperbolic discounting terminology, the compound seems to raise the β-parameter, diminishing the passion for the present. Given the seemingly general effects of ECR-antagonists, it is likely that it acts at a central level in the reward hierarchy. By blocking the ECR:s, several hedonic behaviours, providing instant gratification and delayed adverse consequences, are affected. However, it is unclear whether the different hedonic behaviours share a common underlying pathology/abnormality or whether each behaviour can be decoupled from the rest. The ECR-antagonists may act proximally, and affect what could be thought of as the main or higher-order power switch, while the sub-systems regulating different forms of hedonic behaviours may be possible to modify in separation by distally acting compounds.

Similar to the seemingly general effects of ECR-antagonists, dopaminergic signalling pathways are implicated in addiction, food intake, pathological gambling and hypersexuality. Drugs of abuse tend to converge on the mesolimbocortical system to produce reward, specifically by enhancing dopamine release or prevent its re-uptake in the nucleus accumbens[32]. It is well-established that dopaminergic transmission affects food intake; psychotic patients generally gain weight on neuroleptics[33], which have high affinity for dopaminergic receptors, and rats unable to produce dopamine die of starvation[34]. In rare cases, patients suffering from parkinsonism treated with dopaminergic compounds have also been found to develop pathological gambling behaviour, which can be reversed by discontinuation of therapy[35 36]. This has been attributed to disproportionate stimulation of dopamine d_3 receptors, which are primarily localized in the limbic system.

2.5 Practical and theoretical implications

The importance of exploring hypotheses regarding presence of self-control problems and time-inconsistent preferences can be judged from both a policy-making perspective and from a treatment perspective. Many policy decisions involve trade-offs between the present and the future, and if discount rates are not constant, then individuals may reverse their preferences over identical outcomes depending on when they perform their evaluation. Therefore it may be wise to investigate the prevalence, extent and distribution of self-control problems for certain policies aimed at, for example, curbing detrimental health behaviours. Furthermore, when moving from the policy to the treatment level, the degree of self-control problems are also of importance, since the use of delayed reinforcers may have little or no effect for highly impulsive individuals.

From a theoretical standpoint, it is of interest to shed further light on the underlying mechanism for self-control. There is still diverging evidence regarding whether there is a single system, a single β, for all types of commodity discounting, or whether self-control systems are commodity-specific.

Enhancing the understanding of the underlying mechanisms may further facilitate and improve the design of policy and treatment strategies.

3. Methods

In order to test a hypothesis of greater impulsivity among certain obese people not only for food, but also for monetary rewards, an experiment on obese and non-obese subjects was conducted. It was assumed that presence of obesity and voluntary enrolment in a weight-loss programme constituted evidence for impulsivity regarding food, or conversely, presence of self-control problems regarding this specific reward item.

Previous studies have been able to distinguish between different degrees of impulsivity in drug addicts and control subjects, matched on age, ethnicity, gender, and education, by use of questionnaires involving inter-temporal monetary choices[8 10 22 37]. However, a limitation of previous studies contrasting drug addicts, alcoholics or pathological gamblers with control subjects is that they have almost exclusively used hypothetical rewards. A study by McClure et al used internet vouchers as *"cash equivalents"* which were handed out after the experimental sessions[12]. While it can be argued how immediate and cash equivalent such a reward is, due to the transaction costs involved and the restrictions on use, that specific study did not contrast different subgroups displaying detrimental health behaviours, but investigated within-subject differences regarding brain activity associated with immediate or delayed reward decisions in college students. Kirby & Petry offered their subjects (alcohol, cocaine and heroin abusers) a one in six chance of receiving a real monetary reward, and this appears to be the only study on detrimental health behaviours and self-control involving real rewards[7]. In the present study, real monetary rewards provided in cash immediately after the experiment, were used instead, and the purpose was to contrast obese and non-obese groups in their degree of impulsiveness/self-control for money.

3.1 Study participants

Sixty subjects meeting the criteria from the World Health Organization (WHO) for obesity (BMI ≥ 30 kg/m²)[38] were recruited for the study from the Obesity Unit, Karolinska University Hospital. Significant primary obesity aetiology was ruled out in these patients by a medical doctor, ensuring non-interference from pituitary tumours, leptin deficiency or similar known hormonal abnormalities causing obesity. Sixty control subjects (BMI < 30 kg/m²), loosely matched on age, gender and education level, were recruited from hospital personnel. Data on height, weight, age, gender and education level were collected from all subjects. Education level was dichotomized into less than college (=low) and college or more (=high).

Informed consent was ascertained from each subject before the experimental session was started, and subjects were informed that they could withdraw their consent at any time during the session.

3.2 Procedure

The obese participants were approached before or after screening and information meetings, before initiating treatment, and asked if they were willing to participate in a study conducted by a student from the Stockholm School of Economics. Subjects already in treatment were not considered for participation because of the explicit focus of the behavioural therapy on impulse control. The size of the groups approached varied between 5 and 25 subjects. Hospital personnel were approached before or after meetings at the hospital. Study group sizes ranged between 3 and 20. Subjects were provided written information and instructions before starting the experiment (**Appendix A**). Participants were then given a paper-based questionnaire requiring approximately 5 minutes to complete. Briefly, the subjects were queried about their preference regarding a fixed reward of SEK 65 immediately, and a delayed reward of SEK 65, 67, 70, 75, 80, 95 or 130. The full questionnaire is provided in **Appendix B**.

To encourage correct responding, subjects were also informed orally that one of their choices was to be chosen at random and result in actual monetary compensation. A bowl with lottery tickets and the package of money were displayed to increase the credibility of the promise.

3.3 Statistical methods

Statistical analyses were conducted using STATA 9.0 (StataCorp, College Station, Texas, USA). Demographic and anthropometric variables are presented as mean ± standard deviation, complemented with subgroup-specific ranges. Differences between continuous and categorical variables were assessed by independent t-tests and chi-square tests, respectively.

In order to investigate the effect of obesity status on self-control independent of age, gender and education, an interval regression model was fitted. Interval regression models lie between discrete choice and censored regression models. The method is similar to ordered probit models, with the exception that the exact cut-points of the intervals are known, not only the relative ordering. This has the implication that the likelihood function is simpler, using the appropriate difference in cumulative distribution functions for each observation. Also, since the parameters are completely identified by knowledge of the cut-points for the intervals, the variance of the error term is identified. The interval regression command fits a model of y = [lower limit, upper limit] on a number of independent variables, where y for each observation is either interval data [a, b], left-censored data [-∞, b] or right-censored data [a, ∞]. Such data could also be modelled by use of an OLS regression on the midpoints of the intervals. However, such an approach is clearly inferior, since it would not reflect the uncertainty concerning the nature of the exact values within each interval, nor deal adequately with the left- and right-censored observations in the tails.

In the current model, the dependent variable, reflecting degree of self-control, was specified as the interval where subjects switched from immediate reward to delayed reward (*y = [immediate reward, delayed reward]*). The outcome intervals from the questionnaire were used: [-∞,65], [65,67], [67,70], [70,75], [75,80], [80,95], [95,130], and [130, ∞], where attainment of a higher interval indicates a lower degree of self-control. Subjects who never switched from immediate to delayed reward were right-censored [130, ∞], and subjects who preferred to wait in all seven scenarios were left-censored [-∞ 65]. Obesity status (non-obese reference), gender (female reference), age, and education level (high reference) were entered as independent variables in successive order. To adjust for potential bias introduced by the fact that not all subjects conducted the experiment at the same time of the month, a time variable for the number of days from the salary pay-out day was also introduced in the model. The full model is presented in **Equation 1**.

Equation 1.

$$y = \alpha + \beta_1 Obesity + \beta_2 Gender + \beta_3 Age + \beta_4 Education + \beta_5 Days\_from\_payday + \varepsilon$$

The resulting coefficients can be interpreted in the same way as the coefficients in an OLS-regression. Thereby the dummy variables provide the difference in the threshold level, in monetary units, of impulsivity/self-control between the chosen categories, when holding all other covariates constant. Similarly, the coefficients for the continuous variables provide a point estimate for the difference in the threshold value when increasing the variable in question by one unit, while holding all other covariates constant.

Measures of fit, such as the adjusted R^2, pseudo R^2, Bayes' information criterion (BIC) or Akaike's information criterion (AIC), are not provided for interval regressions. A rough estimate of the model fit could be obtained by fitting an OLS-regression to the midpoint of the interval where subjects change from taking the immediate reward to wait for the larger delayed reward. This approach would suffer from the same limitations already described. Therefore no rough estimate of the degree of model fit was calculated.

Heteroscedasticity robust standard errors were used in the regressions and the significance level was set at p=0.05.

3.4 Hypothesis

The starting point of this thesis is the notion that obese individuals, voluntarily enrolled in weight-loss programmes, have self-control problems which may not be specific to food but also apply to money. In order to formalize this assertion, a hypothesis, based on the obesity status of the study participants, was formed.

H_0: No differences in self-control/impulsivity for monetary rewards exist between obese and non-obese subjects

H_1: Differences in self-control/impulsivity exist between obese and non-obese subjects

This hypothesis was tested by use of the interval regression model described above, allowing adjustments for potential confounders. A significant difference between obese and non-obese subjects in the threshold value where subjects choose the delayed reward instead of the immediate would would be interpreted as support for the alternative hypothesis H_1.

The analysis rests on the assumption that the included obese subjects have self-control problems regarding food. This cannot be ascertained with complete certainty, although measures were taken in the design of the study to increase the probability by:

1. Recruiting obese subjects from a voluntary enrolment weight-loss treatment program
2. Excluding subjects with primary obesity aetiology (e.g. pituitary tumours or leptin deficiency)

By only including voluntarily enrolled participants with non-primary obesity aetiology, the included subjects have indirectly acknowledged their self-control problems regarding food.

3.5 Sample size considerations

Previous studies on drug abusers, alcoholics and pathological gamblers have used subgroup sample sizes ranging from 18 to 41 subjects in the addict groups, and 18 to 44 in the control groups[7 10]. The ratio of addicts/controls have varied from below one[10] to greater than two[8]. In none of the studies a greater subgroup sample size was used than in this study. Provided that the differences in self-control are of similar magnitude, and dispersion, for the obese as for drug addicts and pathological gamblers, power should hence not be an issue.

This study included a total of 120 subjects, with a subgroup ratio of 1:1. This corresponds to about double the subgroup sample size used in most previous studies, which implicates that smaller differences are possible to detect. Using a sample size calculation for an independent t-test, which is what the interval regression reduces to when only using the categorical obesity variable as independent variable, the power to detect population differences between SEK 3 and 15 is displayed in **Figure 1** for varying assumptions of standard deviations for these differences. The calculation is performed for a two-sided hypothesis with a significance level of 0.05. Provided that the standard deviation of the differences is not greater than SEK 10, the power will be greater than 0.8 to detect differences greater than SEK 5. With the greater dispersion of SEK 15, the same power will be achieved if the difference in population means is greater than SEK 8.

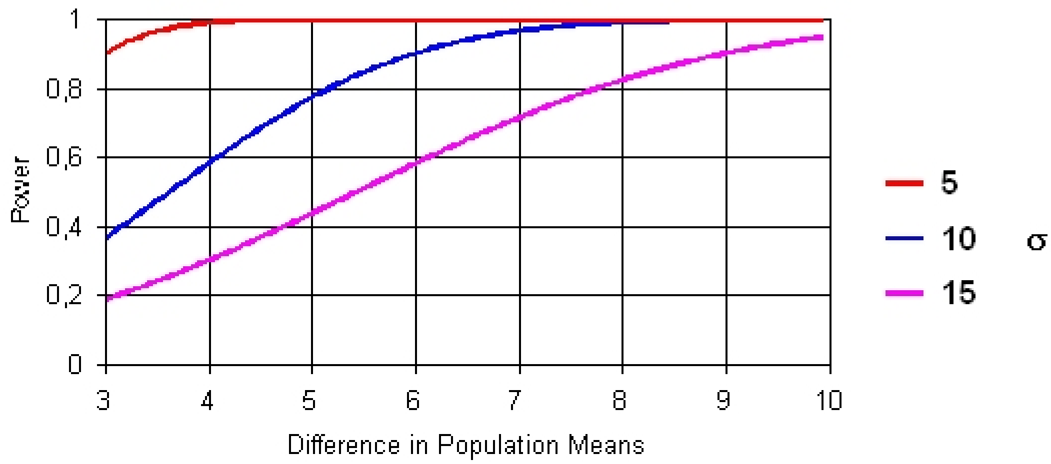

Figure 1. Resulting power for various differences between population means and standard deviations.

4. Results

In this section the experimental findings of the thesis are outlined. The presentation of the subject characteristics is followed by a description of the raw experimental outcomes in frequency tables. Thereafter the results from the interval regression analyses are outlined, investigating the association between obesity and self-control regarding monetary rewards, after adjustments for potential confounders.

4.1 Subject characteristics

The sample of experimental subjects comprised a wide range of ages and adiposity levels (**Table 3**). There was a slight gender imbalance, with 60.0% females in the total sample, but balance was seen across the experimental groups; in the non-obese group, 61.7% were females compared to 58.3% in the obese group (p=0.85). No significant differences in age (p=0.87), height (p=0.07) or education level (p=0.20) were observed between the obese and non-obese groups, while the differences in weight and BMI were highly significant (p<0.0001). Few subjects had less than a high school education (10.0%) while 47.5% had at least a college degree.

Table 3. Subject characteristics of the obese group and the control group.

	Obese (n=60)	**Controls (n=60)**	**Total (n=120)**
Age (years)[a]	43.2 ± 11.4 (18-64)	42.9 ± 12.3 (23-64)	43.0 ± 11.8 (18-64)
Height (m)[b]	1.74 ± 0.09 (1.48-1.96)	1.71 ± 0.08 (1.55-1.93)	1.72 ± 0.09 (1.48-1.96)
Weight (kg)[c]	115.9 ± 21.3 (75-192)	69.8 ± 12.7 (48-104)	92.8 ± 29.0 (48-192)
BMI (kg/m^2)[c]	38.4 ± 6.0 (30.1-53.0)	23.8 ± 1.9 (18.4-29.5)	31.1 ± 8.7 (18.4-53.0)
Gender (male, %)[d]	41.7%	38.3%	40.0%
Education (%)[e] - Less than high school - High school - College or more	 15% 45% 40%	 5.0% 40% 55%	 10.0% 42.5% 47.5%

[a] Difference between groups non-significant (p=0.87)
[b] Difference between groups non-significant (p=0.07)
[c] Difference between groups significant (p<0.0001)
[d] Difference between groups non-significant (p=0.71)
[e] Difference between groups non-significant (p=0.20)

4.2 Experimental outcomes

As predicted, there was a positive association between acting patiently and higher differential between immediate and delayed reward (**Table 4**). Two thirds had switched to the delayed reward when the differential was SEK 10, three fourths at SEK 15, and nine tenths when the differential was SEK 65. However, close to half of the sample chose to wait two weeks to receive SEK 65 instead of receiving it immediately, while 10% did not regard a 200% interest in two weeks to be incentive enough to wait for the money. This corresponds to a β-parameter of less than 0.5. Translating the other provided answers into terms of β-values, about half of the sample displayed at least a slight bias for the present (Table 4).

No significant differences or consistent trends in relative frequencies were seen between the obese and non-obese group at any of the questions (p=0.20-1.0; Table 4). The relation between the degree of obesity, represented as a continuous variable by BMI, and the upper and lower limits of the interval where the shift from immediate to delayed reward was made, further underscores this finding in a crude analysis (**Figure 2**). However, significant differences were found between genders, with females consistently acting less impulsively (**Table 5**). Similarly, a lower education was associated with less impulsivity (**Table 6**).

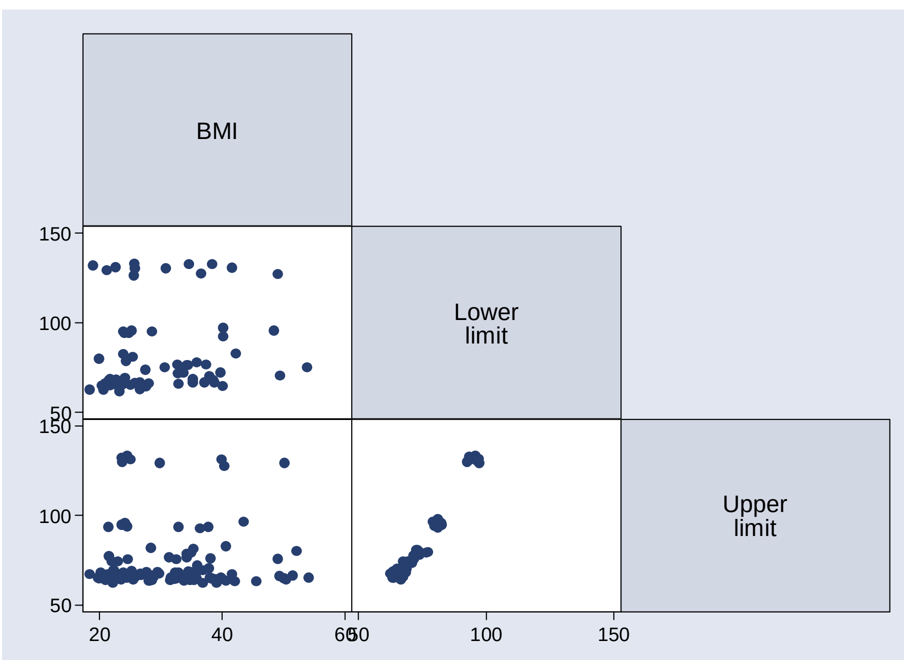

Figure 2. Scatter matrix of BMI against the upper and lower limits of the interval where the subjects chose the delayed instead of the immediate reward.

Table 4. Preferences for choices between monetary rewards today vs. two weeks (n=120) by obesity status. Percentages represent the fraction of subjects choosing the immediate reward.

	Monetary reward (SEK) received today vs. in two weeks						
	65 vs. 65 $\beta \leq 1.0$	**65 vs. 67** $\beta \leq 0.97$	**65 vs. 70** $\beta \leq 0.93$	**65 vs. 75** $\beta \leq 0.87$	**65 vs. 80** $\beta \leq 0.81$	**65 vs. 95** $\beta \leq 0.68$	**65 vs. 130** $\beta \leq 0.50$
Total (n=120)	55.8%	42.5%	36.7%	29.2%	23.3%	16.7%	10.0%
Non-obese (n=60)	61.7%	38.3%	33.3%	26.7%	25.0%	18.3%	10.0%
Obese (n=60)	50.0%	46.7%	40.0%	31.7%	21.7%	15.0%	10.0%
Difference	11.7%	-8.4%	-6.7%	-5.0%	3.3%	3.3%	0.0%
p-value	0.20	0.36	0.49	0.55	0.67	0.62	1.0

Table 5. Preferences for choices between monetary rewards today vs. two weeks (n=120) by gender. Percentages represent the fraction of subjects choosing the immediate reward.

	Monetary reward (SEK) received today vs. in two weeks						
	65 vs. 65 $\beta \leq 1.0$	**65 vs. 67** $\beta \leq 0.68$	**65 vs. 70** $\beta \leq 0.93$	**65 vs. 75** $\beta \leq 0.87$	**65 vs. 80** $\beta \leq 0.81$	**65 vs. 95** $\beta \leq 0.68$	**65 vs. 130** $\beta \leq 0.50$
Females (n=72)	51.4%	34.7%	30.6%	22.2%	16.7%	11.1%	9.7%
Males (n=48)	62.5%	54.2%	45.8%	39.6%	33.3%	25.0%	10.4%
Difference	-11.1%	-19.5%	-15.2%	-17.4%	-16.6%	-13.9%	-0.7%
p-value	0.23	0.035	0.09	0.040	0.034	0.046	0.90

Table 6. Preferences for choices between monetary rewards today vs. two weeks (n=120) by education level (low/high; less than college degree/college degree or more). Percentages represent the fraction of subjects choosing the immediate reward.

	Monetary reward (SEK) received today vs. in two weeks						
	65 vs. 65 $\beta \leq 1.0$	**65 vs. 67** $\beta \leq 0.68$	**65 vs. 70** $\beta \leq 0.93$	**65 vs. 75** $\beta \leq 0.87$	**65 vs. 80** $\beta \leq 0.81$	**65 vs. 95** $\beta \leq 0.68$	**65 vs. 130** $\beta \leq 0.50$
High (n=57)	66.7%	52.6%	47.4%	35.1%	31.6%	21.1%	12.3%
Low (n=63)	46.0%	33.3%	27.0%	23.8%	15.9%	12.7%	7.9%
Difference	20.7%	19.3%	20.4%	11.3%	15.7%	8.4%	4.4%
p-value	0.023	0.033	0.021	0.175	0.042	0.22	0.43

4.3 Interval regression results

In order to investigate the gender, age and education independent relationships between degree of self-control and obesity status, interval regression models were fitted. The interval within which the monetary threshold where subjects chose the delayed reward instead of the immediate was used as outcome variable and served as proxy for self-control/impulsiveness.

The obese group was found to be less impulsive, as judged by the point estimates, both in a crude analysis and after adjustment for gender and educational level (**Table 7**). However, the magnitude was modest, ranging from SEK 3.5 to 5.8 and the estimates were associated with great imprecision; in none of the models was the point estimate significant. The effect of gender was estimated with greater precision, although it did not reach statistical significance either. The point estimate showed that the threshold was approximately SEK 12 higher for males than females, indicating greater impulsivity in males, after adjustment for obesity status and educational level. Educational level was the only variable reaching statistical significance (p=0.048) and the sign indicated that low education level was associated with lower levels of impulsiveness. After adding time to pay-day as an additional covariate, the associations with all previously entered variables were slightly attenuated, except for the precision of the estimate for education which increased further (p=0.042). The addition of time to pay-day also resulted in a change of sign in the coefficient for obesity status, while the magnitude remained small. Finally, adding age as a final covariate did not alter any of the estimates markedly.

Table 7. Results from interval regression models investigating the relationship between obesity status and impulsiveness, adjusting for potential confounding by gender, education level and age[a,b].

	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**
Intercept	67.8	63.0	70.1	58.9	45.3
Obesity status	-5.0 (-20.8 to 10.7) P=0.53	-5.8 (-21.5 to 9.9) P=0.47	-3.5 (-19.2 to 12.2) P=0.66	1.2 (-15.8 to 18.2) P=0.89	1.6 (-15.3 to 27.5) P=0.85
Gender	-	13.0 (-2.7 to 28.8) P=0.11	12.4 (-3.6 to 28.4) P=0.13	12.2 (-3.5 to 28.0) P=0.13	11.4 (-4.8 to 27.5) P=0.17
Educational Level	-	**-**	-15.3 (-31.4 to 0.7) P=0.06	-16.4 (-32.7 to -0.13) P=0.048)	-16.8 (-33.1 to -0.6) P=0.043
Time	-	-	-	0.7 (-0.4 to 1.8) P=0.21	0.8 (-0.3 to 1.9) P=0.17
Age	-	-	-	-	0.3 (-0.4 to 1.0)
Prob chi^2	0.53	0.25	0.026	0.051	0.062

[a]Observation summary: 0 uncensored observations, 53 left-censored observations, 12 right censored observations, 55 interval observations.

[b]Reference groups: Non-obese, female, high education.

5. Discussion

This study investigated differences in self-control regarding monetary rewards between obese and non-obese subjects. No evidence could be found for the hypothesis that obese people with self-control problems regarding food are afflicted by greater self-control problems for monetary rewards or have a steeper discounting function than non-obese. There was, however, a trend towards greater impulsiveness in males than in females, with females consistently making less impulsive choices. This gender difference in relative frequencies did not reach statistical significance in multivariate analyses. Education level was found to be significantly and positively correlated with impulsivity, and the point estimate for the difference was of rather large magnitude. Furthermore, almost half the sample unexpectedly chose to wait two weeks for SEK 65, instead of receiving it immediately.

The absence of a significant difference in self-control between obese and non-obese control subjects contrasts with the findings from heroin and cocaine abusers, who have previously been found to discount money more steeply than demographically matched non-abusers[7 8]. This has also been replicated in pathological gamblers, with and without drug problems[6 9 10], but not in alcoholics[7]. All of these studies were using hypothetical rewards, except for one, which gave subjects a one in six chance to obtain the money in one of their choices[7]. The result from the present study is, on the other hand, congruent with the fact that certain centrally acting pharmacological compounds, e.g. sibutramine, can significantly and seemingly selectively affect impulse control regarding food[15]. Furthermore, while polydrug use is commonly seen[7], as is polydrug use and pathological gambling[10 22], there are few if any reports on polydrug use and concurrent overeating. Hence it may be the case that any potential overlap in pathological basis is greater for drug abuse and gambling behaviours than with overeating. It is, however, well-documented that cannabis increases appetite[39] and amphetamines are anorexigenic, which indicate some common neural circuitry, as does a plethora of evidence on the effects of interference with dopaminergic signalling[23].

Another explanation for the conflicting findings may be that drugs such as cocaine and heroin are much more expensive than food items as well as alcohol. Therefore the link between illicit drugs and money may be stronger than the link with food or alcohol. While drug abusers spend a large proportion of their dispensable income on drugs, over-consumption of food or alcohol does not affect the household budget to the same extent. Such an argument is strengthened by the fact that many of the studies find drug abusers to discount drugs more heavily than money[8 11 14], which could indicate that either separate discounting mechanisms are at work or that there are transaction costs involved in converting the money into drugs. Both contradict the authors' postulated hypothesis of a general discounting mechanism.

The trend towards higher impulsivity for monetary rewards in males than in females has previously been observed in heroinists as well[7]. Also, males tend to be afflicted to a higher degree by overweight and obesity than females both in Sweden and in several other countries in the world[38 40]. The finding regarding education level in the present study, however, is in stark contrast to expectations and to findings regarding obesity and education level[41]. Education level was expected to be associated with self-control, since investments in education can be interpreted as an inter-temporal decision resulting in delayed rewards. By this reasoning, the relationship between impulsivity and education would be expected to be significant and inverse also for pure monetary rewards. The data from the present study point in the other direction, when stratified into high (college degree or more) and low (less than a college degree) level. The subgroup with low education was consistently less impulsive, according to the relative frequencies, and the difference remained after adjustments for age, obesity status and gender. Also, the difference was both of large magnitude and statistically significant. One could suspect that this potential anomaly might be explained by a possible bias that could arise from the fact that the data collection was extended in time, and that the degree of discounting may be influenced by the time of month when the decisions were made. For impulsive individuals, it is likely that the end of the month, before pay-day, could be classified as an "unsatiated" or "hot" state with greater self-control problems, while the period shortly after pay-day would be a "satiated" or "cold" state associated with less self-control problems. Abstinent heroinists have been shown to discount both money and heroin steeper in their hot, unsatiated, abstinent state compared to peers in a non-abstinent state[7 14]. This could potentially bias the results if subjects with low education level happened to be selectively queried closely after pay-day, and subjects with high education either were insensitive to this effect or selectively queried closely before pay-day. In order to adjust for such confounding, a time variable was added to the interval regression. This addition slightly attenuated the association with gender, but only strengthened the education effect. Another possible explanation is that the small magnitude of the rewards may bias the results. Low education is generally synonymous with low income, implicating that the two subgroups may have different magnitude sensitivity. The subjects with higher education may be insensitive to the increments, which may be large in relative terms but are rather small in absolute terms. However, being insensitive to the increments would probably imply insensitivity to when the money is paid out as well. If so, there would be no incentive for subjects with higher education to choose money today. The only explanation, which cannot be easily rejected, is the potential for overmatching and over-adjustment.

The fact that almost half the sample preferred to wait for two weeks instead of having the money directly is also puzzling. Such choices could be expected to occur in people who answer the questions at random and oscillate back and forth in their choices between delayed and immediate rewards. However, in this experiment no such inconsistencies were encountered with subjects switching back from delayed to immediate rewards, which otherwise could indicate that they did not understand the questions. In addition, it is a hard task to argue that the questions at hand were complicated and could cause confusion. Since this answer was not anticipated, no systematic approach was in place to further explore why these subjects answered the way they did. Even if such an approach was in place, it would be required that the subjects were conscious of their decision-basis and honest, requirements which may not easy to fulfil. Some were queried after the experiment, in conjunction with the immediate pay-out/non pay-out decision. One explanation given by some was that they would rather have the money at a later date, because having them immediately would lead to immediate spending on unnecessary goods. How this would change with delivery in two weeks is unclear, but the explanation hints about acknowledged self-control problems and sophistication. Another explanation was that they had no acute need of money and would appreciate a gift in the mail two weeks later. In any case, the distribution of the preference for the delayed reward of SEK 65 was similar across obesity status, education level and gender. Therefore it is unlikely to bias the results, although it may have resulted in some dilution.

The main strength of this experimental study was the novelty regarding the choice of investigated population by use of a design previously shown to be sensitive enough for detection of self-control problems in substance abusers and pathological gamblers. A small but important difference in design compared to most, but not all[7], previous studies was the use of real monetary rewards instead of hypothetical. This design feature is likely to increase the honesty in replies; given that a person has a self-control problem regarding money, immediate real money would be expected to elicit the impulsive behaviour. In contrast, a hypothetical choice is likely to be conceived as having the same immediate practical consequences as a plan to start a new life in the future – i.e. none. An additional strength was the recruitment of obese subjects with non-primary obesity aetiology. Recruitment of subjects from a college or university, the main recruitment pool in experimental economics, would risk including subjects with primary obesity which could confound the results. More importantly, the subjects in this study were voluntarily enrolled in a weight-loss programme, implying indirectly acknowledged self-control problems. The obese population at colleges and universities is more likely to be heterogeneous with at least some being "rationally" obese, optimally choosing to engage in a lifestyle resulting in weight gain despite full information about the beneficial effects of physical activity and healthy eating, as well as the long-term health consequences of obesity. Finally, the sample size was larger than in previous studies, although it was not large enough to estimate the coefficients with desired precision.

The study was also afflicted with a number of limitations. Firstly, although patients were granted anonymity and informed that the experiment was not part of the hospital treatment programme, potentially sophisticated patients may have felt a pressure to answer in a way that would signal self-control, not impulsivity, since that is what their future treatment is designed for. However, the use of real monetary rewards should at least partly mitigate such an effect. Also, the same limitation would be present in the studies on voluntarily enrolled drug addicts, in which significant self-control differences have been found compared to matched controls. The problem would also be expected to be greater when employing hypothetical rewards, as most of the drug addict studies did. Hence this limitation is unlikely to explain the different findings. Secondly, due to financial constraints the use of real money precluded the offers of large rewards to investigate potential magnitude effects. The only study previously using real money gave participants somewhat greater rewards, but the subjects had only a one in six chance of receiving anything at all[7]. That study investigated magnitude effects and found less self-control problems with greater rewards on average, although the difference between groups was similar across varying magnitudes. Since both the magnitude and dispersion of the difference appeared to be constant, the statistical power of the present study would be unaffected by the use of smaller rewards. A problem would materialize only if there is a floor effect, where subjects do not care about amounts below a certain threshold. Thirdly, the estimates in this study were imprecise with wide 95% confidence intervals implying low power. The great dispersion contrasts with findings from the studies on drug addicts and pathological gamblers, which all have employed smaller subgroup sample sizes than used in this study. Despite this, they detected significant differences. The present study is the largest to date, judged by the subgroup sample size; with 120 subjects in total, and a subgroup ratio of 1:1, significant differences would have been found if the effects in the obese population were as great as in the drug addict and pathological gambler populations. Finally, the assumption that the obese subjects were afflicted by self-control problems regarding food, while the non-obese were not, could only be indirectly assessed with current obesity and a wish to receive specialist help as a proxy. Obesity is a condition of multi-faceted aetiology, including an interaction of genetic, environmental and psychosocial mechanisms[38]. Reducing it to a question of self-control is therefore a major simplification. Two arguments can be laid out as justifications for this simplification. The first is that obesity ensues only after a prolonged period of positive energy balance and the laws of thermodynamics cannot be bypassed. In the end, obese subjects consult medical specialists in order to be provided help with attaining a negative energy balance. This help consists of provision of behavioural therapy and often the addition of commitment technologies, pharmacological or surgical, facilitating self-control. A rational decision-maker with time-consistent preferences would not need such help to achieve a negative energy balance to reach her desired weight status and would never demand commitment technologies. The second argument is the fact that the studies on substance abusers rely on similar proxies, presence of drug abuse and voluntary enrolment in treatment programmes. It may also be hard to argue that the reasons for drug abuse are much less complex than reasons for being obese. Therefore it is unlikely that the assumption of self-control problems for food is less valid than the one for drugs in previous studies. Hence it is unlikely that this would explain the conflicting findings.

6. Conclusion

In conclusion, no evidence could be found for greater self-control problems regarding monetary rewards in obese subjects, similar to previous findings for alcoholics. This implies that the discounting system of the human brain may consist of several commodity-specific β:s, not one general as the authors of the studies on drug abusers and pathologic gamblers have suggested. However, absence of evidence of a difference is not synonymous with evidence of absence. The present study was afflicted by several limitations, although none of them was sufficient to explain the contrasting findings in studies on drug addicts. Given the greater statistical power in this study it is fairly safe to conclude that any potential difference in self-control regarding money between obese and non-obese subjects is of smaller magnitude than for substance abusers.

A possible explanation for the conflicting finding is that illicit drugs are much more expensive than food or alcohol. Therefore the addicts may conceive the monetary rewards as heroin, with a slight transaction cost attached to it. Obese people and alcoholics, on the other hand, are likely to have a greater decoupling between their addictive good of choice and money. However, since some common circuitry undoubtedly exists for self-control regarding different commodities, as evidenced by novel pharmacological compounds and brain trauma, further research with more sophisticated techniques is warranted. Hereby it may be possible to develop cheap screening tools for individuals at risk of developing detrimental health behaviours, and obtain a better decision-basis for policy making aimed at these populations.

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8. Appendix

A. Experiment instructions

"The present experiment is conducted as a part of a thesis project at the Stockholm School of Economics. *[Only for patients: The project is not associated with the treatment programme at Karolinska University Hospital]*. Your participation is voluntary and you may withdraw your consent to participate at any time during the experiment.

The experiment consists of seven questions where you are asked to choose between receiving SEK 65 today or a higher amount to be received in two weeks.

One of the seven choices that you make will be drawn at random and you will receive the amount of money chosen in that specific question. If you have chosen money today, you will receive that amount of money immediately. If you have chosen money in two weeks, the money will be mailed to you. The letter with the money will be mailed one day before two weeks have passed by in order to reach you after exactly two weeks.

Each question is on a separate page. After answering a question you are not allowed to go back and revise previous answers. Therefore it is recommended that you think carefully before answering.

In order to determine which of your answers that will be chosen for actual payment, one of you will draw a lottery ticket from a bowl with seven tickets, numbered from one to seven (one for each question), after the experiment.

All collected information will be treated as confidential and anonymized prior to analysis and presentation."

B. Questionnaire

Question 1: Which of the following would you prefer?

a) SEK 65 today
b) SEK 65 in two weeks

Question 2: Which of the following would you prefer?

a) SEK 65 today
b) SEK 67 in two weeks

Question 3: Which of the following would you prefer?

a) SEK 65 today
b) SEK 70 in two weeks

Question 4: Which of the following would you prefer?

a) SEK 65 today
b) SEK 75 in two weeks

Question 5: Which of the following would you prefer?

a) SEK 65 today
b) SEK 80 in two weeks

Question 6: Which of the following would you prefer?

a) SEK 65 today
b) SEK 95 in two weeks

Question 7: Which of the following would you prefer?

a) SEK 65 today
b) SEK 130 in two weeks