A Measurement of Decreasing Impatience by DI-index in Money and Health Domain

Yi Li

July, 2015

Abstract

This paper uses the DI index introduced by Rohde (2014) to measure the impatient condition and quantify deviations from constant discounting for health and money. Our measurements, which can easily be obtained from only two indifferences, make no assumptions about utility and also be computed for people with increasing or constant impatience. In an experiment, the group shows no deviation from constant discounting as a result of Wilcoxon test, which means increasing impatience is almost as prevalent as decreasing and constant impatience. But in individual level, a substantial minority was increasingly impatient. By comparing the deviation between monetary DI index and health DI index, we know that the intertemporal preferences are context dependent and findings for money outcomes cannot be simply transferred to health. The generalized hyperbolic discounting model is rejected by the average experiment data in health condition but accepted in money condition. The Quasi-hyperbolic model is rejected in both conditions. The curve for CADI model is discussed, and the CADI model is rejected. The CRDI model is also rejected by the same logic.

Key words: decreasing impatience, time preference, health and money

Introduction

Facing a same choices list at different time points, people would make different decisions, which means time inconsistent. A fascinating movie is perfect entertainment in a weekend, but it better to be delayed before an exam. Healing a chronic disease should be the sooner the better, but it is no longer that emergent when an extremely urgent work needs to be done. Time inconsistent leads to future consequence. Not only personal benefit would be influenced, the whole society also spends a lot on the consequence. Both individual and policy makers can take advantage of reducing the cost of inconsistent behavior and making long term plans.

One property of pure time preference can cause time-inconsistencies is decreasing impatience. Decreasing impatience means that a delay between two outcomes is weighted less in the further future. Many evidence for decreasing impatience have been found in economic studies (Frederick, Loewenstein, and O'Donoghue 2002). The degree of Partt-Arrow convexity of the logarithm of the discount function from Prelec(2004), tradeoff method from Attema et al. (2010), hyperbolic factor from Rohde (2010) are previous models to measure decreasing impatience. But these models always have some limitations (discussed in section 2). Rohde (2014) introduced a new decreasing impatient measuring index, which can be computed for all individuals easily and would be used in this paper.

In heal states, the health outcome for time inconsistency cannot be delivered in the single point in time. Although the same (constant) discounting of money and health is often assumed by researchers and a single official discount rate to evaluate all public investments is tried to be set by government office, it is not clear that money and health should have similar or related discounting. In this paper, this concise model from Rohde (2014) is used to test time inconsistency in both money and health conditions to clear the uncertainty.

In this paper, the section 2 introduces general theory background and related definition.

Section 3 present background and measurement about decreasing impatience. The hyperbolic factor and isoTTO plane are mentioned to explain the logic of DI index. Section 4 is a precise experiment design. The DI index was used to measure the impatience attitude in both money and health domain. Section 5 is data analysis and section 6 is conclusion. Finial section is discussion.

Literature review

2.1 Theory development in time inconsistent

Before Samuelson introduced the discounted utility in 1937, the intertemporal choice is explained as a product of conflicting psychological motives. At first, Rae (1834) established the intertemporal choice as a distinct topic. He believed that intertemporal choice behavior is determined by either promoted or limited the effective desire of accumulation. Then, Böhm-Bawerk(1889) argued that humans suffer from a systematic tendency to underestimate future wants. Instead of explaining intertemporal choice as motives uniquely associated with time, Bawerk illustrated them as an allocation of consumption among time periods. A decade later, with plotting the intertemporal consumption decision on a two good indifferences diagram, Fisher (1930) clarified that a person's observed rate of time preference depends on both time preference and diminishing marginal utility. The crucial motives mentioned above for understanding intertemporal choices include psychological determinants, but things changed when Samuelson introduced the discounted utility model. In the simplified DU model, all the psychological concerns were compressed into a single discount rate. In the DU model, new alternatives were integrated with existing plans, the distribution of utility across time makes no difference, and consumption across time is also independent. However, the exponential discount in DU model was not supported by both intuition and experimental data. From empirically observed data, discount rate are not constant over time, but are decreasing (Thaler (1981); Benzion (1989); Chapman (1996); Pender (1996); Redelmeire (1993)). Meanwhile, discount rates vary across different types of

intertemporal choices, even for a given delay. Discount rate for gains are larger than for losses (Thaler (1981); Benzion (1989); Loewenstein (1987); MacKeigan et al.(1993); Redelmeier and Heller (1993), small amounts are more than larger amounts (Haendel (1983); Benzion et al.(1989); Green, Fristoe and Myerson (1994); Green, Fry and Myerson (1994); Kirby (1997); Kirby, Petry and Bickel (1999)), and explicit sequences of multiple outcomes are discounted differently than outcomes considered singly (Loewenstein and Prelec (1993)). Later, in response to these DU model's anomalies, further studies developed pointing at constant discounting and different effects. Violation of constant impatience was often reported, with decreasing impatience occurring more frequently than increasing impatience.

2.2 Decreasing impatient models

Prelec (2004) proposed a measurement for decreasing impatience: the degree of Partt-Arrow convexity of the logarithm of the discount function. But it is hard to get real data with his theory, as the discount function needs to be measured first which required assumptions about or a measurement about the utility function, and often assuming a specific parametric form of the discount function. Attema et al. (2010) introduced the time tradeoff sequences for analyzing time inconsistency. The tradeoff sequence method can be used into reality easily with no assumptions about utility or intertemporal separability and it is informationally equivalent to Prelec's measure. But the time tradeoff sequences method is still complicated. If subjects make an error, the error will be propagated in the trade-off method as the answer of one question will be used as input for the next question. Rohde (2010) developed a hyperbolic factor as another measure of time inconsistency, which can only be computed with limited degree of decreasing impatience or increasing impatience. Later, Rohde (2014) introduced a new decreasing impatient measuring index, which can be computed for all individuals and would be used in this paper, overcomes the problem of hyperbolic factor.

2. 3 Studies for health

In this paper, we follow the idea (from critical review Frederick, Loewenstein, and

O'Donoghue 2002) that the time discounting should be distinguished from time preference. The *time preference* refers to the preference for immediate utility over delayed utility. The term *time discounting* is used broadly to include any reason for not caring about a future consequence, including factors that diminish the expected utility generated by a future consequence.

Time inconsistency is important in health economics, for both individual with long-term health care and public policy makers with future health outcome. Not in an explicitly intertemporal market and cannot be transferred across time or individuals, health is a unique commodity (see the review, Attema (2012)). In health domain, there are many findings of decreasing impatience (Redelmeier and Heller, 1993; Chapman, 1996b; Bleichrodt and Johannesson, 2001; Lazaro Alquezar et al, 2001; van der Pol and Cairns, 2002; Khwaja et al, 2007; van der Pol and Cairns, 2011), although some indirect evidence of increasing impatience also appeared (Martinet al (2000), Attema and Brouwer (2011) and Attema et al (2012)). To accommodate the observed violations to constant discounting impatience, Loewenstein and Prelec (1992) introduced the generalized hyperbolic discounting function. Hyperbolic discounting models have become popular in the health domain because of violations of stationarity in a health context. A gain-loss asymmetry was observed by MacKeigan et al (1993) and other researchers. MacKeigan et al (1993) found that for the health gain, devaluation due to delay was consistent across duration. For the health loss, devaluation depended on duration; the long-duration loss was devalued with delay while the fleeting loss was inflated.

2.4 Relationship between health and money

Some studies have compared the discounting of monetary and health outcomes, but results are varies and shown by the following table.

Author	Conclusion	Comparison

Moore and Viscusi (1990)	Estimated real discount rate equals approximately 2%, consistent with financial market rates for the period.	Similar discount rates for money and health.
Cropper et al (1994)	the general public appears to agree with the diseounting of future lives saved, and, furthermore, that its diseount rate for iife-saving is, on average, equal to its discount rate for money	
Cairns (1992)	The estimated rates were significantly lower for future health as compared to future wealth states	Higher discount rates for money than for health.
Chapman and Elstein 1995	Decision makers use different discount rates for health-related decisions and money-related decisions.	Low correlation between discounting for health and discounting for money.
Chapman 1996	The temporal discount rate differed for the 2 domains. Domain independence, defined as the low correlation between health and money discount rates relative to the consistency within each domain, was not due to different utility functions for health and money.	
Vuchinich and Simpson, 1998;	Heavy social drinkers in Study 1 and problem drinkers in Study 2 both showed greater temporal discounting than light social drinkers; this difference was stronger in Study 2.	For addictive behavior there seems to be a substantial relation with time preference.
Bickel et al, 1999;	Cigarette smoking, like other forms of drug dependence, is characterized by rapid loss of subjective value for delayed outcomes, particularly for the drug of dependence	

Kirby et al, 1999;	Heroin addicts have higher discount rates for delayed rewards than non-drug-using controls.	
Madden et al, 1999;	The degree of discounting is affected by reward type and specifically that delaying the delivery of heroin greatly reduces the subjective value of heroin in buprenorphine-maintained opioid dependent individuals.	
Bretteville- Jensen, 1999;	Active injectors of heroin and amphetamine have a higher discount rate than a group reporting that they have never used the substances	
Baker et al, 2003	Current smokers' delay discount rates for monetary outcomes, however, were higher than never-before smokers across all magnitudes and both signs	

Table 1 Theory about discounting of monetary and health outcomes

In sum, some underlying mechanism is valid for both monetary and health outcomes. While several other contextual factors, like sign effect (Khwaja et al (2007). Hardisty and Weber (2009)), sequence effect (Chapman, 1996, 2000; Read and Powell, 2002) and magnitude effect (Chapman and Elstein, 1995; Chapman, 1998; Bickel and Johnson, 2003), are also influential in determining the observed intertemporal behavior.

Background

3.1 Definitions

This paper considers preferences $\prec$ over *timed outcomes* $(t : x) \in T \times X$ as outcome x at time t. Outcomes are health states or money amounts in the experiment. Time point t=0 is the present. Strict preference is denoted by $\succ$, indifference by ~, and

reversed preferences by $\preccurlyeq$ (weak reversed preference) and $\prec$ (strict reversed preference). Throughout the paper, we assume that the decision maker evaluates timed outcomes using *discounted utility*:

$$\mathrm{DU}(\mathrm{x},\mathrm{t}) = \sum\nolimits_{t} \Psi(\mathrm{t})\mathrm{U}(\mathrm{x})$$

In the discounted utility, ψ it the discount function (decreasing and positive) and U is a real valued utility function. Decreasing Ψ means that the decision maker is impatient or say he prefers receive good outcome sooner to a same outcome later. We scale Ψ such that Ψ (0) =1 and the utility of money such that U(0) = 0. For health we will select a specific health state (chronic back pain) that we assign the value 0.

Throughout this paper we also assume monotonicity and impatience. *Monotonicity* holds if $x \succcurlyeq y$ implies $(t : x) \succcurlyeq (t : y)$ for all $t \in T$, and $x \succ y$ implies $(t : x) \succ (t : y)$ for all $t \in T$. *Impatience* holds if for all $s < t$ we have that $x \succ 0$ implies $(s : x) \succ (t : x)$ and $x \prec 0$ implies $(s : x) \prec (t : x)$. Impatience means that an individual dislikes delays of pleasant outcomes and likes delays of unpleasant ones(Rohde, (2014)).

Constant impatience says that preference between timed outcomes do not change when a common constant delay happens: for all $y \succ x \succ 0$, all $s < t$, and all $\sigma > 0$ with s, t, $s+\sigma$, $t+\sigma \in T$ we have that $(s : x) \sim (t : y)$ implies $(s+\sigma : x) \sim (t+\sigma : y)$; Decreasing impatience holds if a common delay is added, people are more willing to wait for the better outcome: for all $s < t$ and $\sigma > 0$ with s, t, $s+\sigma$, $t+\sigma \in T$, $y \succ x \succ 0$ and $(s : x) \sim (t : y)$ imply $(s+\sigma : x) \prec (t+\sigma : y)$; Increasing impatience is the opposite of decreasing impatience and means that people less willing to wait for a larger outcome when a common delay is added: for all $s<t$ and $\sigma>0$ with s, t, $s+\sigma$,$t+\sigma \in T$, $y \succ x \succ 0$ and $(s : x) \sim (t : y)$ imply $(s+\sigma : x) \succ (t+\sigma : y)$.

Various alternative models have been proposed to accommodate the deviations from constant discounting. One of the most popular of these models is *Quasi-hyperbolic discounting model* (Laibson 1997, Phelps and Pollak 1968):

$$\psi(t)=\begin{cases}\beta\delta^{t}, t>0\\ 1, t=0\end{cases}$$, with $0<\beta, \delta<1$.

In this model, the parameter β captures the present bias which leads to decreasing impatience in the first period and constant impatience in other periods.

Hyperbolic discounting model was proposed by Loewenstein and Prelec (1992). In this more general model, decreasing impatience is not restricted to the first period but also occurs in later periods:

$$\psi(t)=(1+ht)^{-\frac{r}{h}}, h\geq 0, r>0.$$

The parameter h is a measure of decreasing impatience. For h=0, the hyperbolic discounting is equivalent to constant discounting. The larger h is, the more the decision maker deviated from constant discounting.

Bleichrodt, Rohde, and Wakker (2009) introduced CRDI and CADI as two models for non-hyperbolic time inconsistency. From their paper, any degree of decreasing or increasing impatience can be accommodated by discount functions with constant absolute (CADI) or constant relative (CRDI) decreasing impatience.

CADI: $$D(t)=\begin{cases}ke^{re^{-ct}} & \text{for } c>0\\ ke^{-rt} & \text{for } c=0\\ ke^{-re^{-ct}} & \text{for } c<0\end{cases}$$

CRDI: $$D(t)=\begin{cases}ke^{rt^{1-d}} & \text{for } d>1\\ kt^{-r} & \text{for } d=1\\ ke^{-rt^{1-d}} & \text{for } d<1\end{cases}$$

In the two models, the parameter k is a scaling factor without empirical meaning in the sense that it does not affect preferences. The parameter r is the power of the discount function, which determines the degree of discounting. The exist constants c in CADI and d/t in CRDI are the degree of decreasing impatience (explained later in this session). These models can handle any degree of decreasing impatience and also

increasing impatience.

Decreasing and increasing impatience can induce time-inconsistent behavior. As it is mentioned above, many studies have found decreasing impatience. But *degrees* of decreasing impatience and their correlations with behavior in daily life is little known about. Prelec (2004) was the first to analyze comparative decreasing impatience. But for his definition, a chained procedure which causes problematic incentive compatibility in experiment is required. It is also too complicated to be implemented in field experiment and large general population surveys. Definition of comparative decreasing impatience from Rohde (2014) is a good alternative. Preferences $\succcurlyeq^*$ satisfy *more decreasing impatience* than $\succcurlyeq$ if for all x, y with $x \prec y$ and all $s<t$, $\sigma > 0$ the indifferences $(s : x) \sim (t : y)$, $(s : x) \sim^* (t^* : y)$, $(s+\sigma : x) \sim (t+\tau : y)$, and $(s+\sigma : x) \sim^* (t^*+\tau^* : y)$ imply that $(\tau^* - \sigma)/(t^* - s) \geq (\tau - \sigma)/(t - s)$. This definition measures the increase of the time difference ($\tau - \sigma$) between outcome *x* and outcome *y* relative to the initial time difference ($t - s$), which has useful theoretical properties. Although does not guarantee the existence of the required indifferences, this definition of decreasing impatience as it does not require a chained elicitation, which lead to a more elegance and practical meaning.

3.2 Index of decreasing impatient

Prelec (2004) showed the degree of convexity of the logarithm of the discount function as an appropriate measure of decreasing impatience. The following equation is his measurement:

$$P(t) = -\frac{[\ln\delta(t)]''}{[\ln\delta(t)]'}$$

This measure is hard to obtain from data in practice as the discount function first needs to be measured. Assumptions about utility function are required to measure discount function. Later, Attema et al. (2010) developed the trade-off method, a non-parametric method to measure the discount function. No first requirement about a full measurement of the utility function is the biggest advantage of the trade-off method, but it is still

complicated. As it is mentioned above, if subjects make an error, the error will be propagated in the trade-off method as the answer of one question will be used as input for the next question. Based on the similar idea, Rohde (2014) introduced the decreasing impatience index to measure decreasing impatience with directly application of the definition of comparative decreasing impatience. This method approximated Prelec's measure P(t) and does not require any parametric assumptions about discounted utility models.

The index can be computed just from two indifferences. For $x, y \neq 0, s < t, \sigma > 0$ with

$$(s : x) \sim (t : y)$$
$$(s + \sigma : x) \sim (t + \tau : y)$$

The decreasing impatience (DI) index is defined as:

$$DI = \frac{\tau - \sigma}{\sigma(t - s)}$$

This index was obtained from the hyperbolic factor from Rohde (2010), an alternative measure of decreasing impatience. It is given by

$$H = \frac{\tau - \sigma}{t\sigma - s\tau}$$

The hyperbolic factor works pretty well with hyperbolic discounting, being equal to the parameter α of the generalized hyperbolic discount function $\delta(t) = (1 + \alpha t)^{-\beta/\alpha}$. The hyperbolic factor captures but only captured the moderate degree of the decreasing impatience as strongly decreasing impatience is ruled out by imposing regularity amounts. An upper bound on the degree of decreasing impatience as held by imposing regularity amounts. *Regularity* holds for most popular discounted utility model, i.e. for two indifference pairs we have $t\sigma > s\tau$. But for strongly decreasing impatience, we have $t\sigma < s\tau$ (Rohde (2010)). In the paper for DI index, Rohde also proved that DI index is an approximation of Prelec's (2004) measurement decreasing impatience P(t) if discounted utility holds while the hyperbolic factor is not.

Compared to the approach of estimating the parameters of hyperbolic discount models which can only capture restricted degrees of decreasing impatience, the DI index can represent constant discount, increasing discount and decreasing discount just by DI index of zero, positive or negative, respectively.

Consider a real person A, who has strictly decreasing impatience and satisfies $(s : x) \sim (t : y)$ and $(s + \sigma : x) \sim (t + \tau : y)$ for $x, y \succ 0$, $s < t$, and $\sigma > 0$. If y is a better outcome compared with x, then τ must be larger than σ. As a strictly decreasing impatience person, she would be willing to wait for longer time for the better outcome. The difference between changed times $\tau - \sigma$ captures the degree of decreasing impatience. A larger difference $\tau - \sigma$ corresponds to a larger degree of time inconsistency (Prelec 2004).

The logic of DI-index scales this difference by σ and (t-s) would be explained by the *timetradeoffs*. Suggest we have two indifferences $(s : x) \sim (t : y)$ and $(s + \sigma : x) \sim (t + \tau : y)$. From the first indifference pair, the tradeoff between outcome x and y can be counteracted by the tradeoff between time s and t. Similarly, in the second inference pair, the tradeoff between outcome x and y can be counteracted by the tradeoff between time $s+ \sigma$ and $t+ \tau$. In this way, we say timetradeoff between s and t is equivalent to the timetradeoff between $s + \sigma$ and $t + \tau$ whenever we can find outcomes x and y to construct such two indifference pairs. The timetradeoffs (TTO) can be shown in a T*T plane which is called timetradeoffs plane (TTO plane). Every point in a TTO plane represents one TTO. Equivalent TTO points can be connected to form an iso-timetradeoffs (isoTTO) curves in the TTO plane. In this way, on one isoTTO curve, all points are equivalent TTO. Mazur (2001) have used iso-timetradeoff curves and timetradeoff planes to graphically represent discounting behavior as the psychology study.

Consider the following figure, on a TTO plane, two pairs of indifference were drawn. When the outcomes are ignored, the time points pairs are (s, t), $(s + \sigma, t + \tau)$.

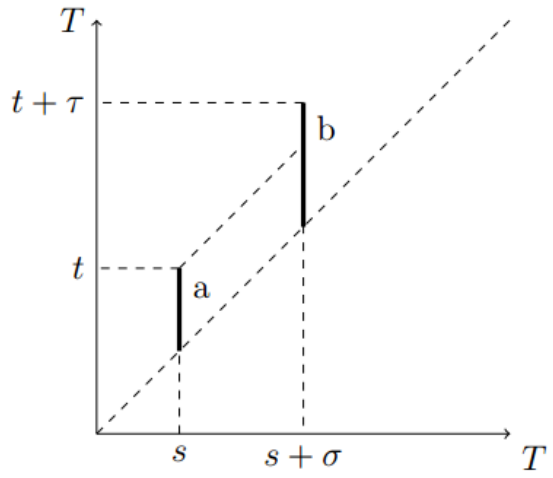


Figure 1. iso TTO for DI index

In the plane, a= t-s and b= (t + τ) - (s + σ). The DI index tries to measure the relative differences in the vertical distance between these two pairs to the horizontal distance, which means (b-a)/a/σ. When the pervious equations are put inside, the DI index measures the (b-a)/a/σ = $DI = \frac{\tau - \sigma}{\sigma(t - s)}$

In the TTO plane, although isoTTO curves not need to be linear, the 45 °line holds for constant impatience. Furthermore, the more decreasingly impatient, the steeper the iso-TTO curve is for points above the 45 °line and the flatter it is for points below the 45 ° line.

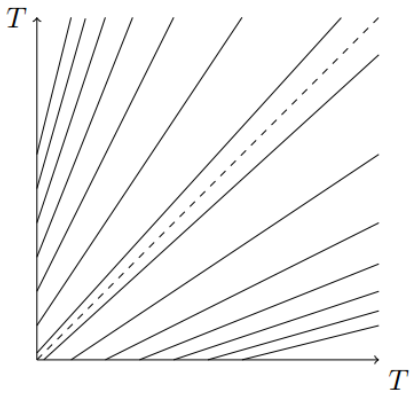


Figure 2 isoTTO for generalized hyperbolic discounting

The figure above is the iso-timetradeoff curves for generalized hyperbolic discounting, the ratio for a curve is fixed and the latter the time point is, the farther the curve from 45 °line.

In the paper, the following theorems about the relationship between utility models and DI index are proved by Rohde (2014):

Theorem 6 *Under monotonicity and impatience the following statements are equivalent:*

(i) Constant discounted utility holds.

(ii) For all $x, y \succsim 0$, $s < t$, *and* $\sigma > 0$ *with* $(s : x) \sim (t : y)$ *and* $s + \sigma, t + \sigma \in T$ *we have* $DI(\sigma, s, x, y) = 0$.

Theorem 7 *Under monotonicity and impatience the following statements are equivalent for all* β, δ *with* $0 < \beta < 1$ *and* $0 < \delta < 1$:

(i) Quasi-hyperbolic discounted utility holds with $\delta(t) = \beta\delta^t$ *for* $t > 0$.

(ii) The following two conditions hold:

1. *For all* $x, y, \bar{x}, \bar{y} \succsim 0$, $t > s > 0$, *and* $\sigma > 0$ *with* $(s : x) \sim (t : y)$ & $(s + \sigma : x) \sim (t + \tau : y)$ *and* $(s : \bar{x}) \sim (t : \bar{y})$ *we have* $DI(\sigma, s, x, y) = DI(\sigma, s, \bar{x}, \bar{y}) = 0$
2. *For all* $x, y, \bar{x}, \bar{y} \succsim 0$, $t > 0$, *and* $\sigma > 0$ *with* $(0 : x) \sim (t : y)$ & $(\sigma : x) \sim (t+\tau : y)$ *and* $(0 : \bar{x}) \sim (t : \bar{y})$ *we have* $DI(\sigma, 0, x, y) = DI(\sigma, 0, \bar{x}, \bar{y}) = \frac{\ln(\beta)/\ln(\delta)}{\sigma t}$.

Theorem 9 *Under monotonicity and impatience the following statements are equivalent:*

(i) CADI discounted utility holds.

(ii) For all $t > s$, $\sigma > 0$, and all κ with $(s : x) \sim (t : y)$ & $(s + \sigma : x) \sim (t + \tau : y)$ and $(s + \kappa : \bar{x}) \sim (t + \kappa : \bar{y})$ we have $(s + \kappa + \sigma : \bar{x}) \sim (t + \kappa + \tau : \bar{y})$ i.e.

$$DI(\sigma, s + \kappa, \bar{x}, \bar{y}) = DI(\sigma, s, x, y).$$

Experiment design

4.1 Background

The steps in Rohde's paper to get a DI index would be followed in this paper.

1. Fix two outcomes *x* and *y* and verify that $y \succ x \succ 0$ or $0 \succ x \succ y$;
2. Fix time *s*;
3. Find time *t* such that $(s : x) \sim (t : y)$;
4. Fix $\sigma > 0$ such that $s + \sigma \in T$;
5. Find τ such that $(s + \sigma : x) \sim (t + \tau : y)$.

By following these steps, the procedure is not chained and for both indifferences. Subjects are asked to reveal a point of indifference in the time dimension, which is easy to be understood. Meanwhile, in order to compute *n* independent values of the DI-index, one does not need *2n* but only *n + 1* indifferences.

4.2 Subjects

For the experiment 61 subjects was recruited to finish the experiment online. A website link was sent to everyone in text message and the participants finished it by mobile phone or computer. The experiment consisted of three parts: Part 1 was an experiment on monetary preference choice, Part 2 is a similar preference choice experiment but in health domain. In Part 3 we ask for demographic information and self-reported behavioral consciousness. No fee was paid for participating. Each part started with

instructions. Subjects were told that the experimental questions had no right or wrong answers that we were only interested in their preferences.

4.3 Task

In the first part, subjects were asked to choose between receiving €400 at a specified point in time or €500 at a later point in time. They were asked to fill out choice lists to determine t_0, t_4, t_8 in the following three indifferences:

€400 in 0 weeks ~ €500 in t_0 weeks

€400 in 4 weeks ~ €500 in t_4 weeks

€400 in 8 weeks ~ €500 in t_8 weeks

The range of t_0, t_4, t_8 are 0 to 100, 4 to 100, 8 to 100 respectively. In the first indifferences, the subject would face a question asking for choosing an approximate range for t_0, the optional ranges would be 4 to 10, 11 to 20, 21 to 31, ..., 91-100. After choosing this range, the subject would be leaded to the second question to make a more precise choice. In the second question, optional choices would be all the time points in the range the subject choose previously. For example, if he choose the range 21 to 30 before, then he would face the choices 21, 22, 23, … , 30 and decide an exact time choose from the 9 options. For the other two indifferences, choice questions were designed with the same logic, the only difference is the optional range for final answer changes with different starting time point. In this way, the subject determines a preference choice for every pair of indifferences by answering two questions and we don't need worry about the subject switch more than once when they face a long choice list. Although the range for final choice is as large as nearly 100, the two questions help the subject first to get a fuzzy choice then a precise one. We want to make the treatment amount large enough for subjects to care. Considering most participants are students, there is no doubt that €400 and the difference between €400 and €500 are large for these time-horizons.

In the second part, subjects faced questions in health domain. They were told to imagine that they suffered from chronic back pain. Chronic back pain was described as:

You have moderate problems in walking about.

You have moderate problems performing your usual activities (e.g., work, study, housework, family or leisure activities).

You have moderate pain or discomfort.[1]

Subjects were told that there are two treatments, Treatment A and Treatment B can heal the chronic back pain.

Both Treatment A and Treatment B removes the pain, but Treatment B also improves walking and the performance of usual activities. The effects of the treatments start immediately at the beginning of the treatment and last for exactly one week. After this week, chronic back pain happens again. These questions are common in the measurement of time preferences for health (e.g. Hardisty and Weber 2009, Van der Pol and Cairns 2011) except that usually subjects consider only one change in health (e.g. Treatment A) and the duration of this change is varied. To test causal effect, two treatments with the same effect duration would be used to avoid imposing restrictions on the utility for time duration.

Treatment A	**Treatment B**
During one week: You have **moderate** problems in walking about. You have **moderate** problems performing your usual activities. (e.g. work, study, housework, family or leisure activities) You have **no** pain or discomfort.	*During one week*: You have **slight** problems in walking about. You have **no** problems performing your usual activities. (e.g. work, study, housework, family or leisure activities) You have **no** pain or discomfort.

Table 2 Treatments in health condition

In this part, subjects were asked to make decision about the time points in the following

[1] Original descriptions were taken from EQ-5D-5L value set., have be used by Bleichrodt et al. (2014) before http://www.euroqol.org/fileadmin/user_upload/Documenten/PDF/Products/Sample_UK__English__EQ-5D-5L_Paper_Self_complete_v1.0__ID_24700_.pdf

indifferences:

Treatment A in 0 weeks ~ Treatment B in t_0 weeks

Treatment A in 4 weeks ~Treatment B in t_4 weeks

Treatment A in 8 weeks ~ Treatment B in t_8 weeks

It is similar with the first part that the range for the time points for treatment B is also from the time point for treatment A to 100. For each indifference, two questions were given to the subject, one asking for a fuzzy choice for preferable range from 10 ranges(smallest range to 10, 11 to 20,.., 91 to 100) and then the other asking for a more precise time point based on the previous question.

Parts	**Sequence**	**s**	**x**	**y**
Money	M_{04}	Immediately	€400	€500
	M_{48}	4 weeks	€400	€500
	M_{08}	8 weeks	€400	€500
Health	H_{04}	Immediately	Treatment A	Treatment B
	H_{48}	4 weeks	Treatment A	Treatment B
	H_{08}	8 weeks	Treatment A	Treatment B

Table 3 Stimuli for experiment

In the final part we asked for some demographic questions as well as some self-reported behavioral questions and self-awareness questions. The demographic questions ask for age and gender. The behavioral questions ask for the number of hours per week the subjects do sports, number of days per week they drink alcohol, the number of glasses drank on such days. The questions were borrowed from Rohde (2014). Self-awareness questions were constructed to reflect awareness of a discrepancy between actual and optimal behavior as perceived by the subjects, thereby reflecting awareness of self-control problems. Questions were asked on a 7-point scale from strongly disagree (1) to strongly agree (7). The self-awareness question list is an adapted version of a question by Strathman et al. (1994) and have been used by Rohde (2014).

I wish I would do sports more often than I do currently.

I should do sports more often than I do currently.

I wish I would drink less than I do currently.

I should drink less than I do currently.

The variables resulting from these questions are labeled as sportswish, sportshould, drinkwish, drinkshould, respectively.

Data analysis

5.1 General analysis

In the analysis 8 subject were dropped as they violated impatience by having $t_0 > t_4$ or $t_4 > t_8$. 10 individuals choose 0 for t_0 (always choose €400 immediately or get treatment A immediately), this cause the DI index started at the time point zero does not meaningful. But their choice in other conditions is still making sense so they were not dropped. Then 52 subjects were remained for analyzing. Table 2 shows the summary statistic of the subjects.

variable	**mean**
gender	48.07% female
age	27.33
sporthour	3.13 hours/week
sportwish	5.37*
sportshould	5.27*
drinkday	0.77 days/week
drinkamount	1.52 cups/day
drinkwish	2.88*
/drinkshould	2.85*

Table 4 General information of demographic and behavioral variables of Experiment

*the response to the variable deviates significantly ($p < 0.01$) from 4 according to a

Wilcoxon signed rank test.

In the following parts, MDIs are the DI indexes calculated in monetary questions and HDIs are the ones from health questions. The first number for superscript is the first fixed time point s in equation and the second number is $s + \sigma$ in equation. For example, MDI04 is the decreasing impatience index calculated by subject's choice from monetary questions in which the settled time points as s=0 and $s + \sigma$=4.

Deviation from constant impatience

Table 4 and 5 gives the number of subjects exhibiting decreasing, constant and increasing impatience.

	MDI_{04}	MDI_{48}	MDI_{08}
Decreasing impatience (DI>0)	17	19	21
Constant impatience (DI=0)	9	9	10
Increasing impatience (DI<0)	20	15	15

Table 5 Deviations from constant discounting for money

	HDI_{04}	HDI_{48}	HDI_{08}
Decreasing impatience (DI>0)	12(13)	11	13(14)
Constant impatience (DI=0)	16	20	18
Increasing impatience (DI<0)	15	9	12

Table 6 Deviations from constant discounting for health

The numbers between brackets are if we include the subjects for whom we cannot compute a DI index, but can conclude that his/her impatient condition. From Rohde's

paper, a larger possible range would make very patient individual switch and get DI index finally. But in this experiment, the possible range is as large as nearly two years (100 weeks), so only one totally patient individual (his choice list for health problem is (0,100,100)) appears in the experiment. Different from the idea from Rohde's paper, the totally patient would have an extremely large DI index and lead to deviation from constant impatient. As the DI index model is not generalized to totally patient individuals, in the following analysis, he would be ignored. The other individuals who have DI index cannot be computed are totally impatient individuals, this kind of people should have a DI index does not exist. In monetary condition, the money amount in the experiment is €400 to €500, which is a pretty large amount of money in developing countries. The outcome would influence the patient attitude, making people do not willing to wait at all. So a possible improvement of this experiment is change the money amount to a same purchasing power when the participants come from different countries.

In all conditions, Wilcoxon signed-rank test shows us there is no deviation from constant discounting for our sample (p=0.74, 0.28, 0.26, 0.75, 0.47, 0.67).However, from the dataset, more than half of our subjects deviate from constant discounting. In both condition, there are nearly the same amount of deviation for decreasing impatience and increasing impatience.

Table 7 Frequency of preferable time points from experiment

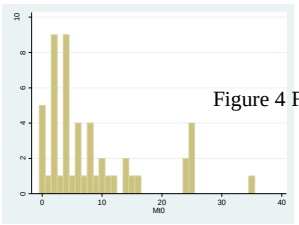
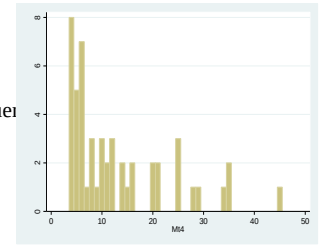


Figure 3 Frequency of Mt0

Figure 4 Freque



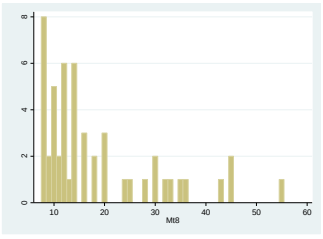


Figure 5 Frequency of Mt8

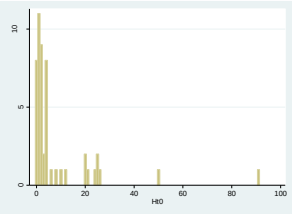


Figure 6 Frequency of Ht0

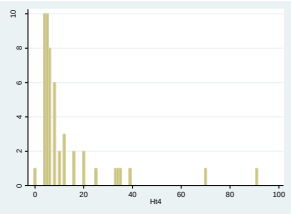


Figure 7 Frequency of Ht4

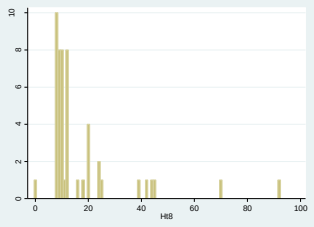


Figure 8 Frequency of Ht8

Robustness of DI index.

Spearman rank correlation between any two DI indexes (MDI_{04} with MDI_{08}, MDI_{04} with MDI_{48}, MDI_{08} with MDI_{48}, HDI_{04} with HDI_{08}, HDI_{08} with HDI_{48}) we get p= 0.34, 0.12, 0.72, 0.99, 0.70. So we cannot reject that any pair are independent. But for HDI_{04} with HDI_{48}, we get a p=0.08, which means the HDI_{04} and HDI_{48} are independent with a 10% significant level.

Correlation between demographic information and behavior

Then we use different test to find out that there is no correlation between any DI and gender (by Man-Witney U test, p= 0.71, 0.97, 0.92, 0.79, 0.25, 0.16). Although there is no correlation between any money DI and ages (p= 0.79, 0.51. 0.25, by Spearman test), in health questions, HDI_{04}, HDI_{48}, HDI_{08} are all correlated with age at 10% level significance (p= 0.078, 0.094, 0.073, the Spearman rank correlation). Kruskal-Wallis test show that the ethnicity is related with none of the DIs at 5% level.

We analyze the Spearman rank correlation between each behavioral and one of the DIs. P value of 0.029 is gotten for the Spearman rank correlation between MDI_{08} with daily drinking amount. But none of the correlation between self-control/willingness and DIs in health condition is significance in 10% significance level. For each of these variables we also run an OLS of the variable on one of the DI-indices, age and gender.

In the regression of drink amount, MDI_{08} (p=0.02), MDI_{48} (p=0.089), MDI_{08} (p=0.007) are significant at 5% level. The coefficients are always positive, which means the more alcohol people drink per day when he drinks, the more decreasingly impatient he is in monetary problems, And HDI_{08} is significant at 1% level for regression for sporthour with a p=0.001. In the regression of the variable drinkday, drinkamount, HDI_{08} is significant at 5% level (p=0.032, 0.018). The more hours the person do sport per week, the less decreasingly impatient he is in long term health problems with a coefficient as -2.186712. Similarly, either the more day the person drink per weeks or the less alcohol people drink per day when he drinks, the less decreasingly impatient he is in relatively long term health problems.

Correlation between self-control/self-willingness in both conditions.

When testing the correlation between self-control/self-willingness in both condition, only sportswish has a significant correlation with MDI_{08}, none of the other self-control/self-willingness variable has a 5% significant correlation with anyone of the DIs. We also run an OLS of each of these variables on one of the DI-indices, age and gender. For sportwish, MDI_{08} is significance a 5% level (p=0.026). With a coefficient as -3.295056, the more willing the person wants to do sport, the less decreasingly impatient he is in long term monetary condition.

Correlation between DIs

For correlation between DIs, the correlation value between MDI_{04} and MDI_{08} is 0.75 with a p=0 and the correlation value between MDI_{04} and MDI_{08} is 0.53 with a p=0. The correlation value between HDI_{04} and HDI_{08} is 0.60 also with a p=0. The correlation ratio between MDI_{48} and MDI_{08} is 0.53 with a p=0.0001.

The regression between DIs in each condition is:

$$MDI_{08}=0.48MDI_{04}+0.43MDI_{48}+0.01;$$

$$HDI_{08}=0.48HDI_{04}+1.40HDI_{48}-0.01$$

All the independent variables are significant at 5% significance level with p=0. It make sense that the decreasing index for starting period and later period would contribute on the total period. All the ratios are positive, as in one shorter period the individual becomes more decreasing impatience, the more decreasing impatience it would be in the total period, in both money and health condition. But different from other independent variables just have moderate influence on dependent variables, the DI index for health in 4 to 8 weeks has a relative strong influence on the DI index for 0 to 8 weeks. When the HDI_{48} increase 1, the HDI_{08} would increase 1.4. For the health problem, the more decreasing(increasing) impatience the person is in a latter half period, the more decreasing(increasing) impatience the person will be in the whole period which means the later attitude is more crucial to the full period attitude. When the person is constant impatience for both 0-4 weeks and 4-8 weeks, from the regression, his impatience for 0-8 weeks is also nearly constant impatience(the constant in the models are ±0.01), which is following the common sense.

5.2 Discussion with two conditions.

Correlation between health and money

	MDI04>0	MDI04=0	MDI04<0
HDI04>0	**8**	2	2
HDI04=0	5	**4**	5
HDI04<0	4	1	**10**

Table 8 Distribution between MDI04 and HDI04

	MDI48>0	MDI48=0	MDI48<0
HDI48>0	**7**	1	3

HDI48=0	8	**5**	5
HDI48<0	2	1	**5**

Table 9 Distribution between MDI48 and HDI48

	MDI08>0	MDI08=0	MDI08<0
HDI08>0	**9**	1	3
HDI08=0	8	**6**	2
HDI08<0	3	1	**8**

Table 10 Distribution between MDI08 and HDI08

In our sample, there is a special individual who choose the time series as (0,100,100) which lead HDI_{04} as high as 25. It would be dropped now and discussed later. And the correlation between MDI and HDI for others for different time periods, none of the correlation is significance at 5% significance level. In different time period, nearly 50% in each period there are people have the same impatience condition (22/41, 17/37, 23/41), which suggest that the intertemporal preferences are context dependent and that findings for money outcomes cannot be simply transferred to health.

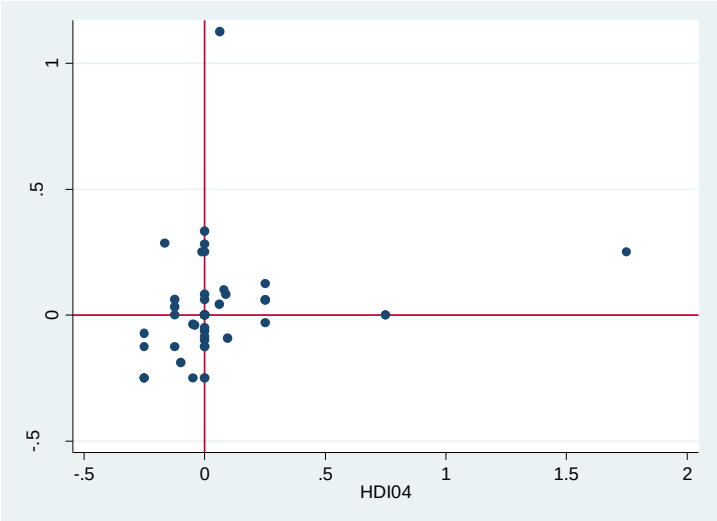


Figure 9 Distribution between MDI04 and HDI04

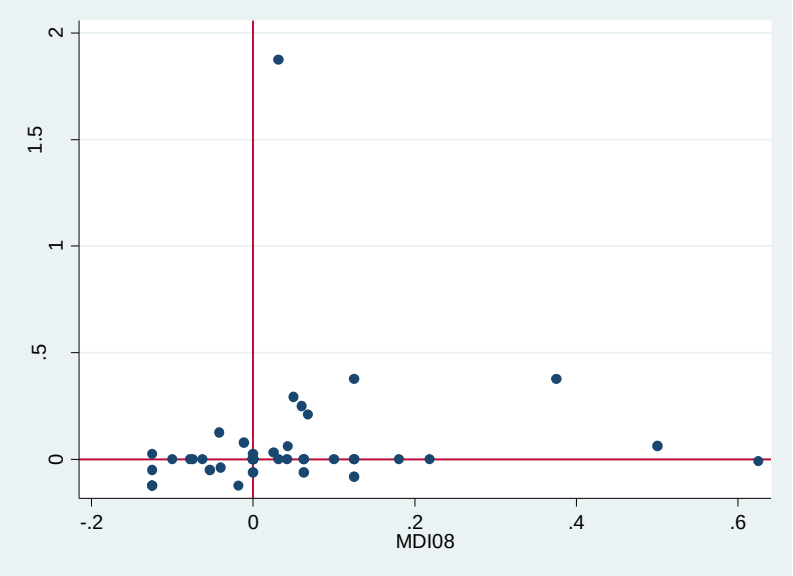


Figure 10 Distribution between MDI08 and HDI08

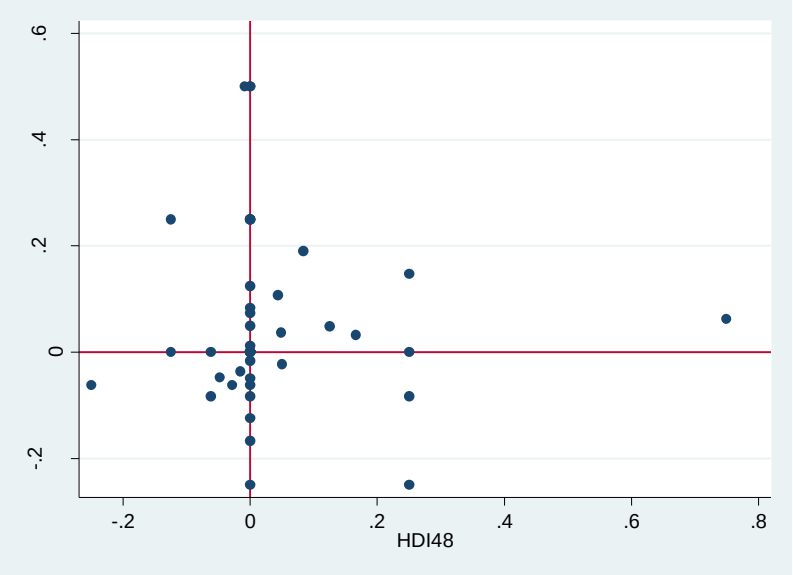


Figure 11 Distribution between MDI48 and HDI48

From Spearman test for MDIs and HDIs, the correlation between MDI_{04} and HDI_{04} (p=0) or HDI_{08} (p=0.011), the correlation between MDI_{08} and HDI_{04} (p=0.0006) or HDI_{08} (p=0.0049) are significant as 5% significant level.

5.3 Popular models testing.

T	Average Mt	Average Ht

0	8.24	8.1
4	13.04	12.82
8	18.20	17.16

Table 11 Average of Mt and Ht in three time points

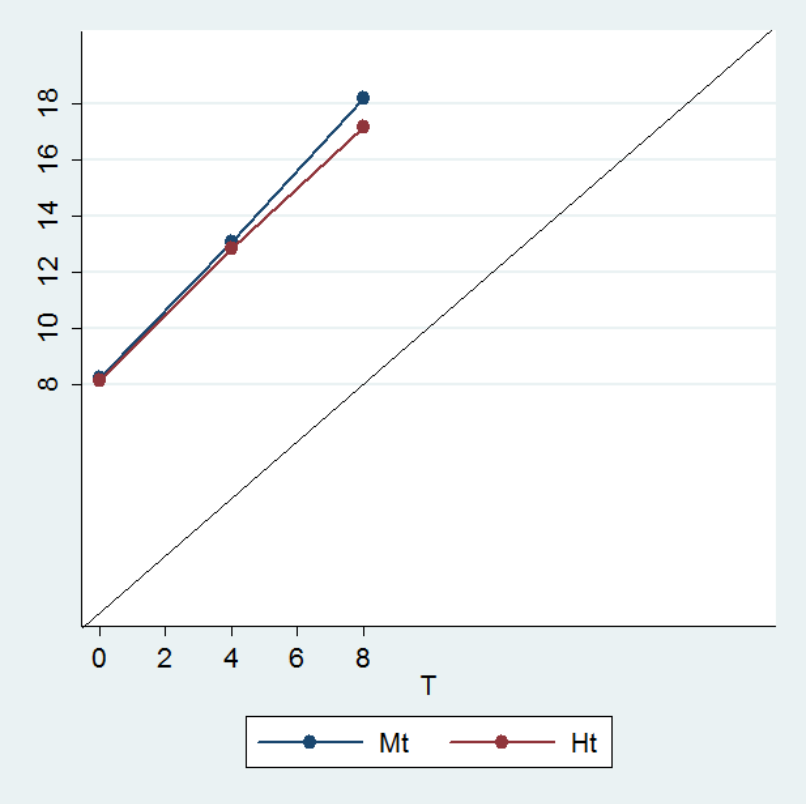


Figure 12 Line of average Mts and Hts

The DI indexes calculated by average Mts and Hts are following:

MDI04	MDI48	MDI08
0.024	0.032	0.013
HDI04	HDI48	HDI08
0.022	0.001	0.008

Theorems were proved by Rohde (2014) to talks about the index is related to models. But her theorems are not easy to be used in real experiment, as so many restricts need to be meet at the same time. In this paper, the approximate estimation would be given

by comparing the group average iso-timetradeoffs (isoTTO) curves with the standardized curve of the model in the TTO plane

Rohde gave the isoTTO curves of constant discounted model and generalized hyperbolic discounting. In that paper, the curves for Quasi-hyperbolic discounted utility, CRDI and CADI were not expressed for brevity even the proving was given. The missing graphs and the result from this experiment will be discussed later in this session.

From the discussion of Quasi-hyperbolic discounted utility, we know that the DI index for the indifference pair with s=0, the DI indexes should be non-zero. For indifference pair with s>0, the DI indexes should be zero. In all conditions, Wilcoxon signed-rank test shows us there is no deviation from constant discounting for our sample In this way, the Quasi-hyperbolic model is rejected from experiment data in both money and health condition.

The iso-timetradeoff curves for generalized hyperbolic discounting was introduced in section 2. For generalized hyperbolic discounting, the ratio for a curve is fixed and the latter the time point is, the farther the curve going from 45 °line. But in our model, in health condition, the latter the time point is, the nearer the curve from 45 °line which means the generalized hyperbolic discounting model is also rejected. In money condition, the ratio of the curve increase which means the generalized hyperbolic discounting model is supported.

Now the iso-timetradeoff curve for CADI model is going to be discussed. The decreasing impatience condition is taken for instance. A curve one can be drawn from the two indifferences:

For all $t > s$, $\sigma > 0$, and all κ with $(s : x) \sim (t : y)$ & $(s + \sigma : x) \sim (t + \tau : y)$

From the theorem 9 in the paper, Rohde proved that adding a constant to s does not change the degree of decreasing impatience for CADI model. Another pair of

indifference can be gotten by adding a constant to time points in both indifference.

$(s + \kappa : \bar{x}) \sim (t + \kappa : \bar{y})$ we have $(s + \kappa + \sigma : \bar{x}) \sim (t + \kappa + \tau : \bar{y})$

The isoTTO curve would move to another starting point and end point but the new curve (curve two) is parallel to the previous one. As $t > s$, $\sigma > 0$, the curve two would always be above 45 °line if the curve one is above the 45 °. If k can be set as any rational number and infinite pairs of indifferences are gotten, the starting points for all isoTTO curves consist of a starting line paralleling to 45 °and the ending points for all isoTTO curves consist of a ending line, also paralleling to 45 °. So, by the experiment data, the CADI model is rejected. The CRDI model is also rejected by the same logic.

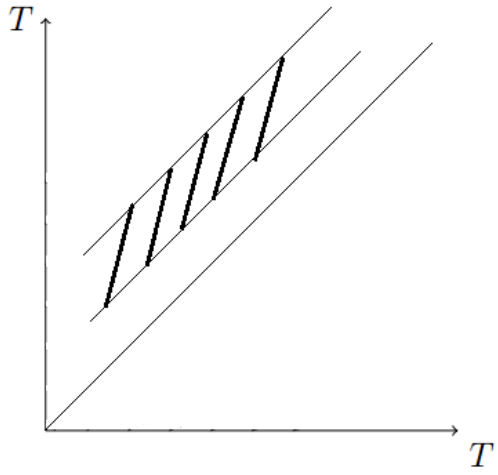


Figure 13 isoTTO for CADI

5.4 About $t_0=0$

There are individuals who showed totally impatience during the experiment. Most of them always prefer the nearest but lower outcome, no matter in monetary condition or in health condition. One of those individual express her view as “I don’t know whether I would be alive tomorrow, so I would like to get everything I can now.” Even though personally I don’t agree with this kind of sense of worth, her argument is still reasonable, especially for those who are suffering terrible disease and poverty. One problem in our experiment is as these people always choose 0 in the first round, their DIs would not be able to be computed. In this way they cannot be used during

the data analysis. Totally 9 subjects were ignored in either condition or both.

5.5 Interesting individuals

There was a lot of individual heterogeneity in the measured decreasing impatience index.

No.	**16**	**43**	**60**
sporthour	1.00	4.00	2.00
drink day	0	0	0
drinkamount	7	0	0
age	23	24	39
gender	1	1	0
sportswish	6	7	7
sportshould	7	1	7
drinkwish	4	1	7
drinkshould	4	1	7
Mt_0	0	100	0
Mt_4	4	100	5
Mt_8	8	0	9
MDI_{04}	Not able to compute*	Ignored**	Not able to compute*
MDI_{48}	Not able to compute*	Ignored**	0
MDI_{08}	Not able to compute*	Ignored**	Not able to compute*
Ht_0	2	12	1
Ht_4	6	16	100
Ht_8	10	24	100
HDI_{04}	0	0	Ignored
HDI_{48}	0	0.083333333	Ignored
HDI_{08}	0	0.041666667	Ignored

Table 12 list of interesting individuals

*This data cannot be computed by the DI index as the denominator equal to zero.

**We ignore this person's answer in this domain as we suppose $Mt_0<Mt_4<Mt_8$

No. 16

About money problems, he show the completely impatience by just be will to get the fast money even though the amount is lower. But for health problems he is a constant impatience person. No.16 is a 23 years old boy, with pretty little sport every day. He almost does not drink, but if he drinks, he drinks a lot. It can be deduced that No.16 is a young man with a health body but not good financial condition. He doesn't do either good or bad things to his body but he knows he should do better. He is a kind of normal young man with a living style neither positive nor negative, healthy but lack of money.

No. 43

No. 43 has a regular reaction for health problems, a little bit decreasing impatience in later or long term period and constant impatience in the nearest period. But for monetary problems, his choice is pretty interesting. He chose the maximum time point to get the larger amount of money in two shorter periods, but for the long term, he shows the greatest impatience. As he chose the maximum time point twice, it is not sure that how long he exactly will be willing to wait. No 43 is a 24 years old man with normal sports every week and doesn't drink at all. He is confident by himself by extreme disagree attitude to selfshould questions but wish to do sports more. It seems he is a young man with strongly confidence and self-control but ambiguous view of money.

No. 60

In the monetary question, No.60 shows normal reaction as totally impatient at first and constant impatience in later period. But in health condition, No.60 showed great decreasing impatience in the nearer period by choosing the maximum possible value 100 for Ht_4. No.60 also chooses 100 for Ht_8, but if even larger value is available, she might choose a time point later than 100 weeks. From the behavior variable, she is

recognized as a 39 years old female with low sport and no drink. For all wish and should questions she choose “totally disagree”, even though her sport condition is lower than average condition. It seems she is a pretty confident person, not caring about others opinion about self-improvement. She is not patience about getting money and short term health problem but is greatly patience or say just not care about long term health problem.

Conclusion

Although the DI indexes calculated by average Mts and Hts are not equal to zero, in both monetary condition and health condition, there is no significant deviation from constant impatience based on our experiment. The results show that increasing impatience is almost as prevalent as decreasing and constant impatience. In this way, models like CADI and CRDI which includes both decreasing and increasing impatient would be better for future research than the ones only contain decreasing impatient.

About individual level, in monetary condition, most people deviate the constant impatience, and the amounts for decreasing impatience and increasing impatience are half to half. In health condition, all indexes are correlated with age. Any one for money DI indexes and daily drinking amount are correlated. The full term DI for health index is correlated with sportwish, drinkday and drinkamount. The full term DI for monetary index is correlated with sportwish.

For the long term MDI, the contribution of first half and later half are nearly half to half. But for long term HDI, the latter half impatience would contribute much more than the first half. In monetary condition, the impatience attitudes for first period and later period (DI_{04}, DI_{48}) contribute the same to the impatience attitudes for whole period (DI_{08}). However, in health domain, if the impatience attitude would be considered in a longer period divided into two periods, the later period attitude would contribute more than the first period.

Meanwhile, in different time period, just nearly 50% in each period there are people have the same impatience condition (22/41, 17/37, 23/41) in monetary and health condition, which suggest that the intertemporal preferences are context dependent and that findings for money outcomes cannot be simply transferred to health.

The generalized hyperbolic discounting model is rejected by the average experiment data in health condition but accepted in money condition. The Quasi-hyperbolic model is rejected in both conditions. The curve for CADI model is discussed, and the CADI model is rejected. The CRDI model is also rejected by the same logic.

There are people are totally impatient in experiment data. The number of this kind of people is not small as imagined, while their argument about their attitude is reasonable, especially for unhealthy and poor people. They are dropped from the data analysis but it is still necessary to improve the DI index model.

Discussion

Compared with the experiment from Rohde's paper, in this experiment, the possible range is as large as nearly two years (100 weeks), so only one individual is total patient. However, the experiment design still can be improved if the limitation of resources can be solved. Firstly, for half subjects, the sequence of money condition and health condition, the sequence of parts in the same condition can be switched to reduce framing bias (Tversky and Kahneman (1981)). Secondly, the experiment was held through online test, asking people to imagine they would be given the money or have chronic back pain. The result would have more real sense if the experiment could be held in the real world by imitating real environment and giving people real incentives. Thirdly, about the distribution of the ethnicities, in this experiment, nearly 80% subjects are Asian. The experiment design using euros as money induces may not work that well as €400 means different purchasing power among Asian and European. Time-

inconsistent behavior can also be induced to change by the valuations of outcomes (Gerber and Rohde (2010)). The possible solution is randomize the participants by recruiting people publicly in a relatively small area (in a same city or country). Finally, some participants show totally impatient attitude in the experiments making their DI index does not exist. Now for the DI index model, both total impatient and total patient people are not generalized. In the future, improvement about adding the two extreme types of people into the model would be an interesting research topic.

From previous study, people with more steeply declining impatience tend to develop more unhealthy behavior and ill-health conditions(Kang & Ikeda (2013)), such as BMI(obesity condition) is associated positively with the degrees of impatience (Courtemanche, Heutel, McAlvanah (2011); Shinsuke, Fumio (2010)) ; the impatience are positively associated with smoking probability (Ida (2015)). From this paper, people's impatience degree is correlated with self-reported daily drinking amount, weekly sport hour and sport wish. In this way, policy maker can take advantage of this kind of interaction, such as monitoring people's unhealthy behavior to approximate the changes of impatient degree and estimating the impatient degree for health caring system building.

Reference

Abdellaoui, M., Attema, A. E., Bleichrodt, H. (2010). Intertemporal tradeoffs for gains and losses: An experimental measurement of discounted utility. Economic Journal, 120, 845-866.

Attema, Arthur E., Han Bleichrodt, Kirsten I.M. Rohde, and Peter P. Wakker (2010), "Time-Tradeoff Sequences for Analyzing Discounting and Time Inconsistency," Management Science, 56, 2015–2030.

Attema, A. E. (2012). Developments in time preference and their implications for medical decision making. Journal of the Operational Research Society, 63, 1388-1399.

Attema, A. E., Bleichrodt, H., Wakker, P. P. (2012). A direct method for measuring discounting and QALYs more easily and reliably. Medical Decision Making, 32.

Baker F, Johnson MW and Bickel WK (2003). Delay discounting in current and never-before cigarette smokers: Similarities and differences across commodity, sign, and magnitude. Journal of Abnormal Psychology 112: 382–392.

Bickel WK, Odum AL and Madden GJ (1999). Impulsivity and cigarette smoking: Delay discounting in current, never, and ex-smokers. Psychopharmacology 146: 447–454.

Bleichrodt,Gao,Rohde. A Measurement of Decreasing Impatience for Health and money, working paper.

Bleichrodt, Han, Kirsten I.M. Rohde, and Peter P. Wakker (2009), "Non-Hyperbolic Time Inconsistency," Games and Economic Behavior, 66, 27–38.

Bretteville-Jensen AL (1999). Addiction and discounting. Journal of Health Economics 18: 393–407.

Cairns J (1992). Health, wealth and time preference. Project Appraisal 7: 31–40.

Chapman GB (1996). Expectations and preferences for sequences of health and money. Organization Behavior and Human Decision Processes 67: 59–75.

Chapman GB and Elstein AS (1995). Valuing the future: Temporal discounting of health and money. Medical Decision Making 15:373–386

Courtemanche, Charles J., Heutel, Garth and McAlvanah, Patrick (2015): Impatience, incentives, and obesity. The Economic Journal, Volume 125, Issue 582, pages 1–31.

Cropper M, Aydede SK and Portney P (1994). Preferences for live saving programs: How the public discounts time and age. Journal of Risk and Uncertainty 8: 243–265.

Frederick, Shane, George Loewenstein, and Ted O'Donoghue (2002), "Time Discounting and Time Preference: a Critical Review," Journal of Economic Literature, 40, 351–401.

Gerber, Anke, and Kirsten I.M. Rohde (2010), "Risk and Preference Reversals in Intertemporal Choice," Journal of Economic Behavior & Organization, 76, 654–668.

Ida, Takanori (2012): Impatience and immediacy: a quasi-hyperbolic discounting approach to smoking behavior. Discussion papers from Graduate School of Economics Project Center, Kyoto University.

Ikeda, Shinsuke and Ohtake, Fumio (2010): Time Discounting and Body Mass Index: Toward Economics of Obesity and Underweight, Journal of Health Economics 29, page 268-284.

Kang, Myong-Il and Ikeda, Shinsuke (2013): Time Discounting, Present Biases, and Health-Related Behavior. ISER Discussion Paper No. 885.

Kirby KN, Petry NM and Bickel WK (1999). Heroin addicts have higher discount rates for delayed rewards than non-drugusing controls. Journal of Experimental Psychology—General 128: 78–87.

Laibson, David (1997), "Golden eggs and hyperbolic discounting," Quarterly Journal of Economics, 112, 443–477.

Loewenstein, G. F. & Prelec, D. (1993). Preferences for sequences of outcomes. Psychological Review, 100, 91.

Loewenstein, G. F. (1987). Anticipation and the valuation of delayed consumption. Economic Journal, 97, 666‐684.

Loewenstein, George, and Drazen Prelec (1992), "Anomalies in intertemporal choice: evidence and an interpretation," Quarterly Journal of Economics, 107, 573–597.

Madden GJ, Bickel WK and Jacobs EA (1999). Discounting of delayed rewards in opioid-dependent outpatients: Exponential or hyperbolic discounting functions? Experimental and Clinical Psychopharmacology 7: 284–293.

Mazur, James E. (2001), "Hyperbolic Value Addition and General Models of Animal Choice," Psychological Review, 108, 96–112.

Moore MJ and Viscusi WK (1990). Discounting environmental health risks: New evidence and policy implications. Journal of Environmental Economics and Management 18: S51–S62.

Prelec, Drazen (2004), "Decreasing Impatience: A Criterion for Non-stationary Time Preference and 'Hyperbolic' Discounting," Scandinavian Journal of Economics, 106, 511–532.

Rohde, Kirsten I.M. (2010), "The Hyperbolic Factor: a Measure of Time Inconsistency, Journal of Risk and Uncertainty, 41, 125-140.

Rohde, K. I. M. (2014). An index to measure decreasing impatience, working paper

Samuelson, Paul A. (1937), "A note on measurement of utility," The Review of Economic Studies, 4, 155–161.

Strathman, Alan, Faith Gleicher, David S. Boninger, and C. Scott Edwards (1994), "The consideration of future consequences: Weighing immediate and distant outcomes of behavior," Journal of Personality and Social Psychology, 66, 742–752.

Tversky, A. & D. Kahneman. 1981. "The Framing of Decisions and the Psychology of Choice." Science 211: 453-458.

Uri Gneezy and Aldo Rustichini (2000): Pay Enough or Don't Pay At All, in: Quarterly Journal of Economics, 791-810.

Vuchinich RE and Simpson CA (1998). Hyperbolic temporal discounting in social drinkers and problem drinkers. Experimental Clinical & Psychopharmacology 6: 292–305.

Appendix: Experimental instructions.[2]

Welcome to this experiment!

There are 2 parts of the experiment. The whole experiment will take about 15 minutes. Please read the following instructions carefully and finish the whole experiment alone. There are no "right" or "wrong" answers; we are only interested in your personal opinion.

Part 1:

Instructions:

In this part of the experiment, imagine that there are two options.
Option A gives you €400.
Option B gives you €500.
You are asked to make several choices between option A and B. Usually, you receive Option B at a later point in time than Option A.

There will be two types of screens.
In the first type you face a single choice. Figure 1 gives an example.

option A	A	B	option B
Get €400 immediately			Get €500 in 4 weeks

In the example, you are asked to choose between option A (get €400 immediately) and option B (get €500 in 4 weeks). You will be asked to indicate your choice by clicking "A" or "B". Once you are satisfied with your choice, you can go to the next question.

This part consists of 3 lists of 13 options each. In every list, you are asked to make one choice for each row. For every row option A remains the same, while the time of payment varies in Option B.
In the first row, you will choose option B, because it offers more money and both options pay at the same time. As you move down the list, option B becomes less attractive because you have to wait longer to be paid. In some row, you will probably

[2] The webpage of the experiment is http://kwiksurveys.com/s/UuitJm1G

choose option A. If so, you will also choose option A in all rows below that one, because in these, option B is less attractive. Similarly, if you choose option B in a given row, you will also choose option B in all rows above that one, because in these, option B is more attractive.

You can change your choices as often as you like. Once you are satisfied with your choices, click the "next" button. Then you can no longer change your choices.

PLEASE SWITCH ONLY ONCE IN ONE TABLE

Now you will get two training questions to become familiar with the questions asked in this part of the experiment.

Part 2:

Instructions:

Back pain is a common health problem across all age groups.
In this part of the experiment please imagine that you have chronic back pain.
This means that:

You have moderate problems in walking about.

You have moderate problems performing your usual activities. (e.g. work, study, housework, family or leisure activities)

You have moderate pain or discomfort.

There is no treatment available that can completely cure you, but there are two treatments
that give you a temporary relief of your symptoms.
Treatment A completely takes away the pain during one week. It does not improve your
walking and usual activity problems.
Treatment B also completely takes away the pain during one week. In addition, it allows you to walk with only slight problems and to perform your usual activities with no problems.

The effects of the treatments start immediately at the beginning of the treatment and last for
exactly one week. After this you return to your usual health state with chronic back pain.
You will be asked to make several choices between Treatment A and Treatment B. The questions differ in the starting time of the treatments. Usually Treatment B starts at a later date than Treatment A.

Treatment A	Treatment B
During one week:	*During one week*:

You have **moderate** problems in walking about. You have **moderate** problems performing your usual activities. (e.g. work, study, housework, family or leisure activities) You have **no** pain or discomfort.	You have **slight** problems in walking about. You have **no** problems performing your usual activities. (e.g. work, study, housework, family or leisure activities) You have **no** pain or discomfort.

Here you are asked to make several choices, one for each row. For every row option A remains the same, while the starting time of Option B varies.
In the first row, you will choose option B, because it offers a larger improvement in health and both treatments start at the same time. As you move down the list, option B becomes less attractive because you have to wait longer before it starts. In some row, you will probably choose option A. If so, you will also choose option A in all rows below that one, because in these, option B is less attractive. Similarly, if you choose option B in a given row, you will also choose option B in all rows above that one, because in these, option B is more attractive.
The computer takes this into account and automatically selects option A for all rows below the one where you choose option A and option B for all rows above the one where you choose option B.
There are no right or wrong answers, we are only interested in your choices. You can change your choices as often as you like. Once you are satisfied with your choices, click the "confirm" button. Then you can no longer change your choices.

Part2 of the experiments starts as following.

PLEASE SWITCH ONLY ONCE IN ONE TABLE
Finally, we would like to ask you some questions about yourself.

How many hours per week, on average, do you do sports? _____ hour(s)

How many days per week, on average, do you drink alcohol? _____days

On the day(s) that you drink alcohol, how many glasses do you drink on average? _____glasses

What is your age? _____

What is your gender (circle what applies to you)? Male / Female

What is your nationality? _____

Please read the following statements carefully and indicate to what extent they apply to you.

I wish I would do sports more often than I do currently.

Strongly agree to strongly disagree 7 levels

I should do sports more often than I do currently.

Strongly agree to strongly disagree 7 levels

I wish I would drink less often than I do currently.

Strongly agree to strongly disagree 7 levels

I should drink less often than I do currently.

Strongly agree to strongly disagree 7 levels

Thank you very much for participating in today's experiment!