On Time Inconsistencies: Is the DI-index a game-changer for identifying self-control problems?

Abstract:

Self-control problems are frequently studied in economic literature. A new method to measure changes in impatience, the theoretical driver of self-control problems, is called the Decreasing Impatience (DI)-index and is developed by Rohde (2019). This thesis examines the relationship between the DI-indices for monetary gains and losses, and leisure time gains and losses with the Brief Self-Control Scale and observed self-control problems. Two digital surveys were conducted among Erasmus University students ($n = 140$). There are four main findings: (1) The most prevalent condition is constant impatience; (2) The DI-indices for money and time do not differ significantly; (3) Most DI-indices are not significantly related or counter-intuitively related to self-control problems nor the Brief Self-Control Scale; (4) The DI-index for time losses and the Brief Self-Control Scale yielded both viable results. A replication of the DI-index for time losses is recommended to see if the results are robust. The Brief Self-Control Scale of Tangney et al. (2004) is currently better suited to identify self-control problems.

Keywords: DI-index, Time Inconsistency, Brief Self-Control Scale

Justin G.P. Lever (424999)
Erasmus School of Economics (ESE)
Master thesis Behavioral Economics

Supervisor: Prof. Dr. K.I.M. Rohde
Second Assessor: MSc. X. Yu

Date Final Version: 13 November 2020

Acknowledgment

I should like to thank a few people for their support and encouragement throughout the Behavioral Economics master and this thesis. First of all, I would like to thank my supervisor Professor Kirsten Rohde for her constructive support and advice. Her general knowledge and interest in the topic helped me to advance the paper to its current form. Also, I would like to thank Xiao Yu for her time as the second assessor. Next, the advice given by dr. Stefan Lipman was a great help at the beginning of this thesis project. Also, I express my gratitude to the Behavioral Economics cohort of 2019/2020 and other colleagues for the vibrant year. The help and proofreading of Gaoyi Fang and Louis Kos were greatly appreciated. Lastly, my special thanks are extended to my family for their mental support as well as their economic or psychological insights for this thesis.

Table of Contents

1. Introduction

Inconsistency in decision-making is a part of life. There is nothing uncommon or strange if one suddenly decides to prefer pasta over rice after a walk in an Italian neighborhood. However, the gap between planning and doing can become so enormous that one regrets the chosen options. The examples from everyday life are numerous. The majority does not save enough, gains too much fat, and exercises too little. This lack of saving, dieting, or sporting does not come from objective standards, but from inconsistent behavior. A striking example is offered by a paper of DellaVigna and Malmendier (2004) about gym memberships. The average member with a flat monthly scheme pays $70 per month while only going 4 times per month, which is around $17 per visit. To contrast this $17, a day pass would cost $10. One can imagine that the average gym visitor dislikes going to the gym, especially now, but that he wants to go in general more often to the gym. One explanation as to why he did buy this expensive sports pass is that the gym visitor sincerely believes that he will change his behavior in the future so that he will go 10 times per month. Contrary to his initial beliefs, he, and many others, still go 4 times per month after a few weeks have passed. In this case, the real cause of the problem is his conviction that the future will be different. This phenomenon is reflected by a *change* in impatience, rather than his *level* of impatience. The latter term is also known as the internal constant discount rate.

Most research on intertemporal choice has focused on explaining choice behavior in laboratory settings by examining individual discount rates. These discount rates are in turn related to field behavior. For instance, a higher discount rate for children and adolescents is a significant predictor for future health and saving decisions (Sutter et al., 2013). However, discount models suffer from two drawbacks. The discount models have to be estimated together with a utility function, which requires assumptions about the utility curvature. Assuming a linear utility curve would yield significantly different discount rates than a non-linear function. Also, there is a variety of discount models. The discount rate can be constant, increasing, or decreasing, and not all models are mathematically flexible. For instance, some of those can only account for a constant level of impatience or a moderate change, whereas there was no easy way to elicit all changes of impatience.

A new method was introduced by Rohde (2019) that constructs the decreasing impatience (DI)-index. The DI-index reflects all *changes* in impatience rather than the *levels* of impatience. The DI-index can accommodate all possible increases or decreases in impatience without assuming the utility curvature. Decreasing impatience ought to be the theoretical driver of inconsistent behavior, such as the example on the gym visits. The DI-index has been applied in the financial domain (Rohde 2019; Shiba & Shimizu 2019), and in the health domain (Attema & Lipman, 2018; Lipman & Attema, 2020). Remarkably, Rohde (2019), and Attema and Lipman (2018) found little evidence that self-reported self-control problems were correlated with the DI-index.

This lack of evidence is surprising, and this thesis will further examine the relation between self-control problems and the DI-index in three different ways. Considering that previous studies on the DI-index were conducted with monetary or health outcomes, another outcome, like time, may yield different results. Since there exists an empirical difference between changes in impatience for health and money (Bleichrodt, Gao & Rohde, 2016), then an empirical difference between time and money is also possible. Therefore, this thesis will investigate the relation between the DI-indices for time and money for both gains and losses. Furthermore, the relation between these DI-indices and the widely used Brief Self-Control Scale of Tangney, Baumeister, and Boone (2004) is unknown. The latter has proven to be a "viable option for assessing the trait self-control (Lidner, Nagy & Retelsdorf, 2015, p. 465)." Lastly, self-control problems are assessed through two surveys. Inconsistent behavior can be measured by comparing the planned hours of exercising or sporting, or glasses of alcohol with actual behavior two weeks later. Therefore, the research question of this thesis will be as follows: *To what extent do the DI-indices of monetary and time-domain differ? And to what extent do both indices explain self-control problems?*

Two digital surveys were conducted with two weeks difference. In this first survey, the DI-indices for time and money, and the Brief Self-Control score were elicited. Also, alcoholic, sport, and study behavior are recorded. The second survey asked again for this concrete behavior to compare it to previous expectations. This thesis found that constant impatience was the prevalent condition for all DI-indices except the DI-index for losing leisure time. Similarly, these DI-indices were not related to or were counter-intuitively correlated with any observed self-control problems or the Brief Self-Control Scale. The only promising result is the DI-index for leisure time losses, which was correlated with alcohol consumption and living at one's parents' house. A similar study can be replicated to see if the results for the DI-index for time losses are robust. The Brief Self-Control Scale was related to most self-control problems and is, therefore, the most suitable candidate to identify self-control problems for practitioners.

This paper will continue as follows. The literature will be reviewed in section 2. In section 2.1., an introduction will be given on making choices without time. Section 2.2. and 2.3. will discuss the literature on discount functions and the relation of discount functions to actual behavior, respectively. The theoretical framework of the DI(P)-index is explained in section 2.4 and studies that use the DI(P)-index will be reviewed in section 2.5. Potential behavioral economic reasons why the DI-index might not correlate with observed behavior is discussed in section 2.6. Section 2.7. examines two different disciplines, summarized by the skeptical and the psychological approach, to criticize or complement the behavioral economic approach. Section 3 is dedicated to the hypotheses. The experiment setup and methodology are discussed in section 4. The results are analyzed in section 5 and discussed in section 6.1. Furthermore, the limitations, practical implications, and further research are discussed in section 6.2., 6.3., and 6.4. respectively. The paper ends with a conclusion in section 7. Appendix A and B encompass all other figures and tables, and a transcript of the survey, respectively.

2. Literature review

2.1. Making Choices Without Time

Before investigating intertemporal choices, we will look at the fundamentals of making choices when time is not involved. These choices in the field of behavioral economics are usually decisions under risk or uncertainty. These decisions are best characterized by lotteries, coin flips, or marbles in a vase, in which two factors play a role: the (dis)utility of the reward or punishment and the probability that this will occur. The (cumulative) prospect theory developed by Tversky and Kahneman (1992) is a descriptive method for decisions under risk, which will provide exciting insights later in this thesis. Tversky and Kahneman show that people are loss averse which can be loosely interpreted that people hate losing more than they love winning. To make it concrete, the utility of receiving 10 euros is lower than the disutility of losing 10 euros. The total utility is negative if the two events are added in a segregate manner. Thus, the utility function is asymmetrical for gains and losses. Formally, this is described by

$$(1)\ U(x) = \begin{cases} x^{\alpha},\ x \geq 0 \\ -\lambda(-x)^{\beta}, x < 0' \end{cases}$$

where $U(x)$ is the utility function depending on good or activity x, λ is the degree of loss aversion if α and β are equal. α and β have a value between zero and one (implying concavity for gains and convexity for losses). Thus, the utility of x has a different slope on reference point $x = 0$. This reference point is subjective and is not always equal to zero. It can be manipulated through framing and is then assumed to be the same for all participants.

The difference in utility between gains and losses for these decisions might play a role in decisions including time. Before examining if this asymmetry plays a role, an introduction on discount functions is given in the next section.

2.2. Framework on Discount Functions

The classical literature on utility preferences and intertemporal choice starts with a paper by Samuelson (1937). The idea is straightforward: future gains are less worth now. In a perfect microeconomic environment, an individual would maximize his utility, which is discounted at a particular rate. The discounted utility DU is defined by

$$(2)\ DU(x,t) = U(x)e^{-\pi t},$$

where the instantaneous utility U is a good or activity x, which is discounted with rate π per time period t (Samuelson, 1937, p. 156). Samuelson does not specifically discuss a changing discount rate, which is popularized with an innovative paper written by Strotz (1955). Strotz recognized that the time-distance between the future and the present-day affects the discount function. The discount rate depends on how far an event in the future will take place. The further an event is away, the lower the discount rate is. As a consequence, people will not stick to their original plan, even if their plans are optimally based on future expectations that will become true (Strotz, 1955, p. 165). He provides an

example from antiquity of Ulysses to strengthen his line of argument. Ulysses demanded his crew to tie him to the ship's mast and not listen to him under all circumstances. That was moments before they sailed past magical creatures, the Siren, which would lure Ulysses to stop. If Ulysses were to stop, they would take his life. The main takeaway is that even if a situation goes as planned, like sailing past the Siren, the discounted utility of the action, like stopping for Sirens, becomes different at the moment than it was in the planning phase.

Samuelson, Strotz, and many other scholars proposed discount functions that describe this relationship between the future and "now". This research field is better known as the intertemporal choice field. The formulas describing a discounted utility function will have the following form

(3) $DU(x,t) = D(t)\ U(x)$.

Here, $U(x)$ is again a utility function and $D(t)$ is the discount function, which are combined a discounted utility function DU. The utility function $U(x)$ can take in principle any form that is increasing. The utility function is often assumed to be linear in the empirical literature. However, there also are studies that require no assumptions about a utility function and only estimate the discount function (Abdellaoui, Attema & Bleichrodt, 2010; Attema et al., 2016).

The utility function needs to be accompanied by a discount function. All discount functions have two properties in common. The first is that if time is zero, representing the present, the discount function will take the value of 1 ($D(0) = 1$). Secondly, if x is weakly preferred over y, it means that x is preferred over y if both are offered at the same time. Formally, it means that $(x,t) \succcurlyeq (\mathrm{y},\mathrm{t})$ equals $DU(x,t) \succcurlyeq DU(y,t)$. The literature on discount functions can be divided into two flavors: one and two-parameter models. A selection of models with the corresponding formulas and changes in impatience is presented in Table 1. For readers unfamiliar with changes in impatience, a detailed explanation will follow in section 2.4.1.

Table 1: Discount functions

One-parameter functions

Model	Discount function	Change in impatience
Constant discounting	$D(t) = \frac{1}{(1+r)^t}$	Constant over time
Proportional discounting	$D(t) = \frac{1}{(1+kt)}$	Decreasing
Power discounting	$D(t) = \frac{1}{(1+t)^\alpha}$	Decreasing

Two-parameter functions

Model	Discount function	Change in impatience
Quasi-hyperbolic discounting	$D(t) = \frac{\beta}{(1+r)^t}$	Decreasing with $t = 0$
Generalized hyperbolic discounting	$D(t) = \frac{1}{(1+\alpha t)^{\beta/\alpha}}$	Decreasing
Constant Absolute Decreasing Impatience (CADI)	$D(t) \begin{cases} ke^{re^{-ct}} & if\ c > 0 \\ ke^{-rt} & if\ c = 0 \\ ke^{-re^{-ct}} & if\ c < 0 \end{cases}$	Increasing or decreasing
Constant Relative Decreasing Impatience (CRDI)	$D(t) \begin{cases} ke^{rt^{1-d}} & if\ d > 0 \\ ke^{-r} & if\ d = 0 \\ ke^{-rt^{1-d}} & if\ d < 0 \end{cases}$	Increasing or decreasing

There are three popular one-parameter models described in the literature. The constant discounting goes back to Samuelson (1937), the proportional discounting is formulated by Mazur (1987), and the power discounting originates from a paper of Harvey (1995). The advantage of these models is that they are easy to calculate with one parameter. The disadvantage of constant discounting is that it cannot describe any change in impatience. Also, the disadvantage of proportional and power discounting is that these models cannot accommodate high decreases or any increases in impatience.

Two frequently used models are the quasi-hyperbolic discount functions developed by Phelps and Polak (1968) and promoted again by Laibson (1997), and the generalized hyperbolic discount function by Loewenstein and Prelec (1992). The quasi-hyperbolic function mathematically captures the present bias, which means that the function is discontinuously impatient if the present is involved. This function has constant impatience if only options in the future are considered. A disadvantage of both models is that the mathematical flexibility is limited. Sharply decreasing or any increasing impatience cannot be calculated with these models. Other methods are the constant absolute decreasing impatience (CADI) and constant relative decreasing impatience (CRDI) models developed by Bleichrodt, Rohde and Wakker (2009). Both models can account for all changes in impatience. The CADI and CRDI are from the same family of functions as constant sensitivity (Ebert & Prelec, 2007) or unit variance (Bleichrodt et al., 2013). This thesis will calculate all the one-parameter models because two-parameter models do often not converge with limited data points (Attema et al., 2018, p. 126). However, quasi-hyperbolic discounting will be added in the analysis due to the popularity of the model.

To summarize the section, some discount functions can capture only constant impatience or only limited decreasing impatience. Only CADI and CRDI can accommodate all changes in impatience. A disadvantage of these discounted models is that often a utility

function has to be estimated first. Before introducing the DI-index, other research on changing impatience is reviewed to investigate the relation between changing impatience and observed behavior. This relation will be examined in the next section.

2.3. Empirical Literature on Changing Impatience

The relation between discount functions and observed behavior is well researched in the literature. As mentioned in the introduction, Sutter et al. (2013) did a field experiment with children and adolescents. The level of impatience was an indicator of future alcohol and cigarette expenditures, future BMI increase, and saving decisions. However, what changes of impatience are empirically found? In other words, is impatience constant, or does increasing or decreasing impatience occur more frequently?

Empirical evidence provides mixed answers. Evidence for constant impatience is provided by Halevy (2015), in which a student sample could choose monetary rewards between now (or in 1 week) and 4 weeks (or in 5 weeks). Also, Read (2001) pleas for constant impatience and concludes that time-discounting is sub-additive, which explains declining impatience in studies. Moreover, Attema et al. (2018) found that constant discounting fitted the data on health and monetary choices better than hyperbolic discounting using the direct method.

There is also enough empirical support for decreasing impatience. Papers of Strotz (1955), Thaler (1981), and Frederik, Loewenstein & O'Donoghue (2002) discuss this form of inconsistent behavior already. More recently, Bleichrodt et al. (2016) find that most subjects were decreasing impatient. Also, Zauberman et al. (2009), and Han and Taikahasi (2012) find that most subjects are decreasingly impatient. They argue that the experience of time is subjective, which leads to Zauberman et al. (2009) concluding that the experience of time is non-linear and concave. The best fit for Han and Taikahashi's (2012) data was with a logarithmic time model, following a Weber-Fechner law, which implies again a non-linear time perception, resulting in decreasing impatience. Besides constant and decreasing impatience, increasing impatience is sometimes found in the literature. For instance, Sayman and Öncüler (2009) find 'reverse time inconsistency', which is a synonym for increasing impatience. Lastly, other studies found a mixture of constant, decreasing, or increasing impatience (Abdellaoui et al., 2010).

This section concludes that a variety of impatient changes exists in the empirical literature before the introduction of the DI-index. The next section will describe the DI-index.

2.4. Decreasing Impatience (DI)-Index

A new development in the intertemporal choice literature is the introduction of the decreasing impatience (DI)-index (Rohde, 2019). The main advantage of the DI-index is that no assumptions are required for utility. The DI-index is perceived to be the main theoretical driver of inconsistencies and self-control problems. The subsequent sections will describe the mathematical intuition of the DI-index in section 2.4.1., the two elicitation methods, practical and theoretical of nature, in 2.4.2., and the DIP-index in section 2.4.3.

2.4.1. Mathematical Intuition

The DI-index is designed to find two indifference points over time. An indifference point means that a subject values two options equally. Each option consists of a reward or loss. In this thesis, the rewards and losses will be money and time, but the behavioral economics literature has also experimented with health, gift certificates, lottery tickets, diner vouchers, ice cream, et cetera. A synonym for the type of rewards or losses is the term 'outcome'. Since there are two options, the rewards (or losses) are referred to as x and y for options one and two, respectively. Outcomes x and y are given at a particular time in the format "smaller sooner" as (x, s) and "larger later" as (y, t), where s is sooner, and t is later. x and y can be everything of which it is always desirable to have more. We are only interested in choices made in the present or future, and not in the past. Thus, time is always non-negative $(s, t \geq 0)$. Combining this information, we get an indifference of $(x, s) \sim (y, t)$, where x and y are not zero $(x, y \neq 0)$, and s is smaller than t $(s < t)$. For example, Maddy may value receiving 100 euro today equal to receiving 110 euro in 2 weeks. That is written as $(100, 0) \sim (110, 2)$. For this indifference, individuals are assumed to be able to order their preferences. The ordering of preferences is denoted with commonly used signs; $\succcurlyeq$ (weakly preferred), $\succ$ (strictly preferred), $\sim$ (indifference). We call Maddy impatient if she prefers 100 euro now over 100 euro in 2 weeks or when $(x, s) \succ (x, t)$ for all $s < t$. We assume monotonicity which requires that $(x, t) \succcurlyeq (y, t)$ whenever $x \geq y$.

Since the topic is *changes* in impatience, a second indifference is necessary to see if a change in impatience occurs. After the elicitation of the first indifference, $(x, s) \sim (y, t)$ or $(100, 0) \sim (110, 2)$, the DI-index requires a second indifference by adding an additional time σ and τ. The second indifference becomes $(x, s + \sigma) \sim (y, t + \tau)$. The time of s, representing the "smaller sooner" part, should be increased with σ, where $\sigma > 0$. If we look at Maddy again, she values 100 euro in 10 weeks equal to 110 euro in 13 weeks. That results in the following indifference: $(100, 10) \sim (110, 13)$. Recalling the first indifference of $(100, 0) \sim (110, 2)$, we can observe that Maddy is more patient (or decreasingly impatient), because her willingness to wait is 3 weeks in the second example instead of 2 weeks in the first example. The DI-index can be constructed with the following variables: $s = 0$, $t = 2$, $\sigma = 10$, $\tau = 11$. The DI-index is defined by

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

In the example of Maddy, the equation DI-index will become the following

(5) $DI = \frac{11-10}{10*(2-0)} = \frac{1}{20} = 0.05$.

A positive DI-index means that the impatience decreases over time, implying that $\tau < \sigma$. Hence, Maddy is decreasingly impatient. On the contrary, a negative DI-index entails increasing impatience. The DI-index is equal to zero if $\sigma = \tau$, which is the case in constant discounting.

An interesting feature of the DI-index is that it approximates Prelec's measure. Prelec (2004) developed a logarithmic measure for decreasing impatience with a Pratt-Arrow degree of convexity, which is defined by

(6) $P(t) = -\frac{[\ln (D(t))]''}{[\ln(D(t))]'}$.

2.4.2. Elicitation Methods

Rohde proposes a theoretical and practical method for eliciting the DI-index. In the theoretical procedure, x and σ are elicited. The subjects' t and τ have to be elicited in the practical procedure. There are several advantages and disadvantages per method. The theoretical procedure will always yield a DI-index, whereas the practical procedure is only successful if a $t + \tau$ is found in the second indifference. If a participant never switches and is extremely patient, no DI-index can be constructed. On the other hand, there are several disadvantages of the theoretical procedure and advantages of the practical procedure of which one of both will be discussed. One disadvantage of the theoretical procedure is that it requires chaining to elicit x and σ, whereas the practical procedure is easier to execute without chaining. Another advantage is that the method is easier to understand. Both answer possibilities are expressed in terms of time. Otherwise, subjects have to think first in terms of money and then in time, which might be intricate, and requires a more extended introduction page of the experiment. The method employed in this thesis will be the practical procedure (P procedure). The full P procedure, integrally taken from Rohde (2019, p. 1707), is as follows:

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

2.4.3. The DIP-index

The DI-index has been slightly extended into the DIP-index by Lipman & Attema (2020). The DIP-index consists of the regular DI-index and an additional DP-index, which refers to Decreasing Patience-index. The main difference between the DI-index and the DIP-index lies in the allowance of patient subjects, for which the DP-index is constructed. Patient subjects have a negative discount rate, which is translated to a 'get it over with' attitude. For instance, a person with pain in his teeth and poor tooth brushing habits wonders if he should go today or in the future to the dentist. Logically, he prefers to go today to the dentist rather than waiting for weeks. The DI-index and DP-index are then compiled to the Decreasing (Im)Patience (DIP)-index. This thesis will exclude patient people in order to make a better comparison to Rohde (2019). However, it might be necessary to keep this different method in mind when analyzing the results of Lipman & Attema (2020).

2.5. Experiments with the DI(P)-index

This section will look at the results of the four papers that used the DI(P)-index as a method. The original paper of Rohde (2019) had three indifference points with t_0, t_2, and

t_4. The subjects could choose between €40 in s weeks + 1 day or €50 in t weeks + 1 day. This resulted in two DI-indices from t_0 to t_2 (DI_{02}), and from t_2 to t_4 (DI_{24}), which were compared to several self-control measures. Firstly, she investigated the self-awareness of the discrepancy between actual and optimal behavior. The subjects were asked to indicate to what extent they were studying, sporting, and preparing for classes on an eight-point Likert-scale. Also, she asked the participants to what extent they wished and should do more studying, sporting, and preparations, again on an eight-point Likert scale, to measure this discrepancy. This methodology did not allow for the actual registered hours for these three categories, but dependent on the subjective experience of subjects. Also, the paper investigated saving behavior, alcohol intake per day, alcoholic beverages per week, cigarette consumption, living at one's parents' house, and BMI. However, Rohde did not find any relation between the DI-index and any self-control measures except for sport, which was driven by an outlier. Also, there was no relation between the DI-index and gender nor age.

The second paper was published by Attema & Lipman (2018), who applied the DI-index on the health domain. Two health scenarios were sketched based on a personal and societal situation. In the individual health task, the subjects had to imagine they had chronic back pain. Two available treatments yielded temporary pain relief for one week. Treatment B was strictly better than treatment A, which had more side-effects than treatment B. In the societal task, treatment B could help more patients in comparison to treatment A. The subjects had to indicate how much longer they were willing to wait to be indifferent between immediate use of treatment A and future use of treatment B in both situations. The authors found that the majority of the subjects had a decreasing impatience function. Similar to Rohde (2019), Attema and Lipman (2018) found no evidence for a correlation between self-reported health behavior and the DI-index. Remarkably, the DI-index was positively and significantly related to the self-reported hours of sport, which is counterintuitive (Attema & Lipman, 2018, p. 5). Lastly, they reported some evidence that the DI-index of women was lower than the DI-index of men.

The authors conducted a similar experiment but used the DIP-index, rather than the DI-index (Lipman & Attema, 2020). In contrast to their previous paper, the majority of the subjects had an increasing impatience function. Thus, the willingness to wait over time for a better treatment decreases over time. Furthermore, the authors did not find a significant difference between the DI-indices for health gains and losses.

Shiba & Shimizu (2019) investigate the difference in DI-indices for wins and losses in the financial domain. The study was designed according to the theoretical procedure. Similar to Lipman and Attema (2020), the study finds no significant differences between the DI-indices for gains and losses. Thus, individuals with a strong present bias for gains had the same behavior for losses.

2.6. Behavioral Economics' Perspective on the DI-index's Performance

The question of why Rohde (2019), and Attema and Lipman (2018) find no relation between self-control problems and the DI-index is still open. This section will investigate

four behavioral economic answers to why this is the case. Reason one will critique the measurement of self-control problems, whereas reason two, three, and four investigate the DI-index. Reason two and four are briefly already mentioned by Rohde (2019, p. 1171). The other two arguments come from the literature.

2.6.1. Measurement of Self-Control Problems

An explanation of why the DI-index did not correlate with observed behavior could be that the measurement of self-control problems was incorrect. The literature describes that there is a difference between self-reported beliefs and observed behavior. For instance, Nolan et al. (2008) find little correlation between observed energy-saving behavior and reported desires. The factor "because others are doing it" yielded the highest correlation with observed behavior and was reported to be the lowest-rated argument. Hence, the answers to "should you study more?" can be driven by socially accepted beliefs. These socially accepted beliefs may be caused by the pressure of peers or families in contrast to realistic values. If researchers ask this "should" question, it can be compared to asking students what they would do if a day consisted of 28 hours a day. Both questions rely on an ideal image of hours studying, which is at best hard to achieve and probably impossible. Instead, asking students how many hours they want to study or sport and compare it in the future to the number of two weeks ago would possibly be a better strategy.

2.6.2. Different Levels and Changes in Impatience across Domains

Rohde constructs the DI-index based on intertemporal choices with money, whereas the self-reported control problems were on studying, preparing classes, exercising, and other health-related questions. Thus, Rohde compares decreasing impatience measured through monetary units with behavior in a non-monetary domain. The implicit assumption is that money equals (study, preparation, or exercise) time or health. The relation between levels and changes in impatience between money and health are better studied and are summarized in the next paragraph. Subsequently, the relation between money and time is examined afterward. The relations will be investigated following a (1) micro-economic, (2) psychological bias, and (3) empirical perspective.

Starting with health, we firstly would see that the marginal utility of money could not be equal to the marginal utility of health in a perfect micro-economic world. In an economic world where everything can be traded, the discount rates across all domains should be equal. However, health is a non-marketable good since it is in general impossible to give away one's health to a sick person (Chapman, 1998, pp. 84-85). Besides the different levels of impatience, there are no theoretical reasons why there should be changes in impatience for health and money. Secondly, the domain dependence of discount rates can be explained by different associations between health and monetary decisions. The association with monetary decisions involves investments, mortgages, or credit cards. On the contrary, health is associated with eating, medication, or vaccination, which encompasses a different realm. If the evaluation of schemas and strategies depends on the different associated information, domain dependency can occur (Chapman, 1998, p. 110). Thirdly, the academic literature does provide an ambiguous answer to differences in impatience levels

for health and money. Some studies indicate similar discount rates of health and money (Moore & Viscusi, 1990; Cropper et al., 1994). Other studies show little correlation between health and monetary discount rates (Chapman & Elstein, 1995; Chapman 1996). The literature on changes in impatience that compare health and money is not as extensive as on levels of impatience. Bleichrodt et al. (2016, p. 228) write that "The deviations from constant discounting were more pronounced for health than for money suggesting that time preferences are domain-specific." The conclusion is that the evidence points to somewhat similar levels of impatience for health and money, where health usually has a lower discount rate than money, which is supported by valid theoretical reasons. Moreover, there is no theoretical justification why there should be any changes in impatience for health and money. Nevertheless, the empirical literature points towards this direction.

The issue if the levels and changes in impatience of money and time are equal is also not a-priori solved. If we look at discount functions of time and money, it is realistic to assume they are equal in a micro-economic system. After all, the common saying is 'time is money' (Becker, 1965). A similar reasoning hold for changes in impatience, both should be equal to zero. However, a psychological bias might be the subjective perception of time. As discussed by Zauberman et al. (2009), people experience time subjectively resulting in a flawed perception of time. Interestingly, similar arguments have been put forward by the famous Roman writer Seneca, who already argued that time may seem like an infinite resource and is less sensible than coins in one's pocket. He writes that "Men are thrifty in guarding their private property, but as soon as it comes to wasting time, they are most extravagant with the one commodity for which it is respectable to be greedy (Seneca, 2016, p. 112)." If there exists a gross overestimation of our lifespan, it might be that time has a lower discount rate than money. Also, time should have a higher decreasing impatience than money, because time is considered as an infinite resource in the future. The academic literature has previously focused on time in social preference experiments as Noussair and Stoop (2015), in which they conduct a public goods game with time. Another paper by Festjens et al. (2015) investigates the relationship between certainty equivalents for time and money. The authors conclude that the certainty equivalents for time and money gains decisions are similar, but the certainty equivalents were different for losses, depending on the magnitude of the payoffs. Also, as mentioned before, the studies of Zauberman et al. (2009) and Han and Taikahasi (2012) indeed find evidence in line with the subjective perception of time. However, these findings are not compared to monetary gains. It is thus intriguing to further investigate the relation of changing impatience for time and monetary.

2.6.3. Different Changes in Impatience within Domains

Another potential problem with the DI-index would be that there are potentially different impatient changes within a domain. This difference can originate from either inherent differences or framing effects.

To start with the inherent differences, we can recall that an indifference is formulated as follows: $(x, s) \sim (y, t)$. In this example, an individual might have a change in impatience

with low monetary input, say €40, in comparison to a high monetary incentive, say €40,000. This effect could be analogous to decisions under uncertainty, where (relative) risk aversion increases with higher stakes (Markowitz, 1952). Recalling the study of Festjens et al. (2015), the equivalents for large monetary and time losses were different. The DI-index theoretically is independent of the x and y. However, there exists a possibility that there is an association between the decreasing impatience and the height of the reward.

Another example of different changes in impatience with a domain can be based on the framing of the experiment. This thesis will use weeks as the measurement of the DI-indices following Rohde (2019). However, the results might be different if days or months, instead of weeks, were used as the unit to indicate t in the experiments. In other words, the question is raised if the DI-indices are robust with several frames.

The potential existence of multiple DI-indices within a domain could potentially form a problem to link a DI-index to observed behavior. Which DI-index should one choose then? In this thesis, several DI-indices will be compared to observed behavior to overcome this problem.

2.6.4. Change in Valuation of the Outcome

Another theoretical explanation of why the DI-index might not be correlated with self-observed problems can be due to a change in the valuation of money. For instance, students who will graduate and start working in 40 weeks after the survey may logically prefer a low amount of money now than after 40 weeks. Students may know that being a starting consultant may give them €20 an hour instead of €10 on a regular student job. The difference between €10 and €20 results in practice in a different consumption level instead of a smooth lifetime consumption. Now, the choice between 40 euro now and 50 euro later can be seen from a different perspective when one will earn and spend more in the foreseeable future. This phenomenon is described as the baseline consumption shock (Gerber & Rohde, 2015). A method to overcome this shock is by including a sample that does not have an expected consumption increase. This group can include 40-year old people, who do not have this characteristic. As will be later explained in the data and methodology section, this thesis did have a substantial group of students near finishing their master, which is a limitation.

2.7. Multidisciplinary view on the DI-index's performance

The behavioral economics paradigm is not the only discipline looking at inconsistencies in intertemporal choice. In this section, two other approaches are discussed, which offer another view on self-control problems. The first view entails the skeptical approach, which wonders if mathematical propositions can capture human behavior at all. This behavior would threaten the project as a whole and is, therefore, characterized by the skeptical approach. The second view entails a different methodology from psychology, which can complement behavioral economics in investigating self-control problems.

2.7.1. The Skeptical Approach

The skeptical philosopher Hume would deny that we have stable preferences due to reason. A famous quote reads: "Reason is, and ought only to be the slave of the passions (1739/1896, p. 217)." Consequently, the question arises, considering that these passions may be the main driver of human behavior, if humans act *as if* they are following discounted utility or changing impatience theories. The passions may violate economic axioms like context independence, monotonicity, or transitivity. The point is that the project of behavioral economics at large is not apparent to some writers. It might be merely the case that the project to link the decreasing impatience and self-control problems is doomed to fail. These frameworks are fascinating on their own but are not further examined in this paper as they fall outside this thesis's scope. However, this paradigm would advise keeping the expectations low of future findings.

2.7.2. The Psychological Approach

Psychology is another discipline looking at self-control problems that use different tools than economics to investigate self-control problems. The psychology literature has designed several scales to assess self-control. The intuition behind most of the scales is a scoring system based on how one relates to specific statements. Every statement can be answered on a 5-point Likert-scale, where a higher score implicates more self-control. Examples of the self-control scales are the Self-Control Scale (Tangney et al., 2004), the Barrat Impulsiveness Scale (Patton et al., 1995), and the Low Self-Control Scale (Grasmick et al., 1993). De Ridder et al. (2016) conducted an influential meta-analysis of 102 studies, which looked at the properties of the three aforementioned self-control scales. Throughout all scales, low self-control is associated with obesity, alcohol intake, impulsive purchases, Grade Point Average (GPA) scores, procrastination, and other health behavior. After an evaluation of all scales, the authors write that "the Self-Control Scale had stronger relationships than the Barratt Impulsiveness Scale and the Low Self-Control Scale to behavior overall (de Ridder et al., 2016, p. 89)." [1] The Self-Control scale of Tangney et al. (2004) consists of 36 statements that can be assessed on a 5-point scale. The statements can be valued from 1, indicating *not all like me*, to 5, *very much like me*. Tangney et al. (2004) have narrowed the scale to a brief scale with 13 questions through a principal component analysis. The Brief Self-Control Scale correlated with .93 and .92 with the Total Control Scale in two studies (Tangney et al., 2004, pp. 282-283). This thesis will use the Brief Self-Control Scale (BSCS) because it is a viable option and economic in time (Lidner et al., 2015). Furthermore, it is intriguing to investigate how this psychological scale relates to self-control problems and DI-indices for money and time. There are no studies that relate levels or changes of impatience to the (Brief) Self-Control scale. [2] A study using the Barrat Impulsiveness Scale did not find any relation between this scale and discount rates without a prime (Mcleish & Oxoby, 2007).

[1] I refer to de Ridder et al. (2016) for a complete overview on the advantages and disadvantages of the three scales.

[2] I am not aware of any studies regarding this topic.

3. Hypotheses

This section will explain the hypotheses tested in this thesis. As already mentioned in the introduction, this thesis will conduct an experiment. Recalling the research question, To what extent do the DI-index of monetary and time-domain differ? And to what extent do both indices explain self-control problems?; we will divide the hypotheses into four parts based on the literature review. The first and second part will examine DI-index in the (1) money and (2) time domains. Subsequently, the next part will examine the (3) Brief Self-Control Scale and (4) the observed gaps between planning and doing. The experiments will be explained in more detail in section 4.2.

3.1. Part 1: Money

The first hypothesis will be related to the curvature of the DI-Index over several periods. Considering that there are no theoretical reasons why monetary DI-indices with different time periods should differ, it is interesting to investigate if the monetary DI-indices are constant. The first hypothesis will be the following:

Hypothesis 1: *The DI-indices for monetary gains are not significantly different from each other.*

The second hypothesis will look at the difference between the DI-indices for monetary gains and losses. Following Shiba & Shimizu (2019), and Lipman and Attema (2020), who found no difference in the DI-index for gains and losses, we expect a similar pattern in this thesis. The second hypothesis on gain-loss asymmetry will be:

Hypothesis 2: *The DI-indices for monetary gains and losses are not significantly different from each other.*

3.2. Part 2: Time

The third hypothesis will look at DI-indices for time. Similar to the DI-indices for monetary gains and losses, we do not expect a significant difference between time gains and losses. Therefore, the third hypothesis will be:

Hypothesis 3: *The DI-indices for time gains and losses are not significantly different from each other.*

As discussed in the literature review, changes of impatience can be different across domains. There is an indication that there is a higher index of decreasing impatience for time than for money due to the perception of time. The fourth hypothesis will be the following:

Hypothesis 4: *The DI-indices for time are significantly higher than for money.*

3.3. Part 3: Brief Self-Control Scale

The DI-index was not correlated with observed self-control behavior in Rohde (2019), and Attema and Lipman (2018), and the Brief Self-Control Scale has a correlation with the observed behavior (de Ridder et al., 2018). We might infer that the DI-indices for money

and time are not correlated with the Brief Self-Control Scale. Thus, the fifth hypothesis will be the following:

Hypothesis 5: *The DI-indices for money are not correlated significantly with the Brief Self-Control Scale.*

Similar to the DI-index of money, the DI-index for time should theoretically, without biases, explain self-control problems. However, considering the previous correlations of the DI-index for money and self-control problems, the expectation is that the DI-index with leisure time will not perform better. The sixth hypothesis will be:

Hypothesis 6: *The DI-indices for time are not correlated significantly with the Brief Self-Control Scale.*

3.4. Part 4: Observed Gaps between Planning and Doing

The last part of the hypotheses will relate to observed gaps between planning and doing. The expectation is that the DI-index for money is not correlated with self-reported self-control problems, resulting in hypothesis 7. Time might, again, be better able to explain the reported gaps between planning and doing. However, the expectations remain low, resulting in hypothesis 8. Lastly, the Brief Self-Control Scale will be a better predictor for observed self-control problems. A higher score on the Self-Control Scale will indicate low self-control problems and that yields hypothesis 9.

Hypothesis 7: *The DI-index for money is not correlated with observed self-control problems.*

Hypothesis 8: *The DI-index for time is not correlated with observed self-control problems.*

Hypothesis 9: *The Brief Self-Control Scale is negatively correlated with observed self-control problems.*

Schematic overview

The hypotheses are combined in Figure 1. Boxes and circles represent constructed indices or scales. The arrows with the corresponding H1 to H9 represent all the hypotheses.

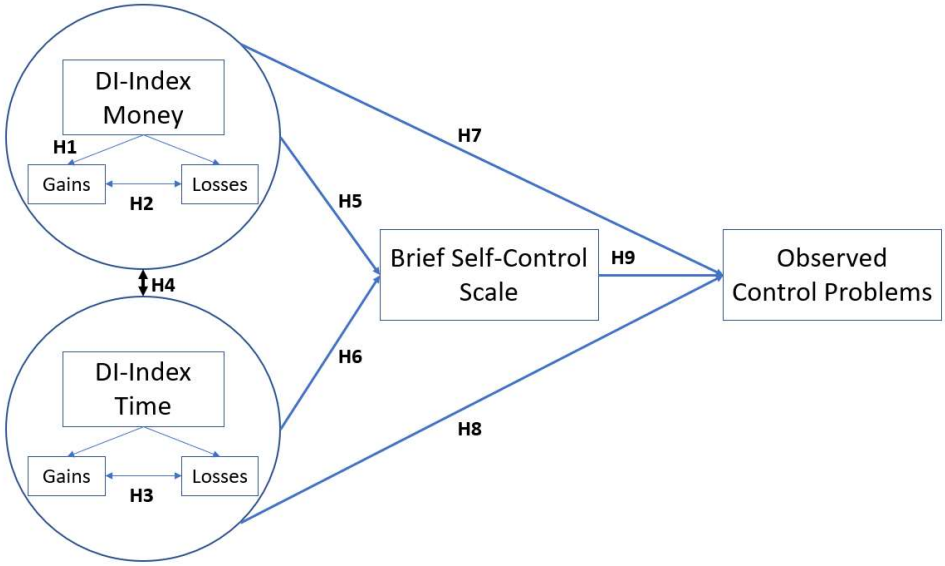

Figure 1: Schematic overview of the hypotheses

4. Data & Methodology

4.1. Subjects

Two online surveys were conducted among students who are mainly from Erasmus University. There were 140 respondents in the first survey, of which 65 were males (46%). Half of the sample consisted of economics or business students (50%), and the average sample age was 22.7 years old. The second survey had 129 respondents, which is 92% of the first survey sample. The subjects were able to win one of the two available €10 if they filled in the two surveys, which incentivized them to answer both surveys. Two winners were randomly selected out of the 129 participants.

4.2. Survey

The experiment was conducted with a digital survey made in Qualtrics. The first survey consisted of an introduction and 4 parts. The participants received a second survey two weeks later that contained three follow-up questions, as will be explained later. The start of the survey was related to contact information and control questions. The first part of the first survey elicited the DI-index of Rohde (2019) for the monetary domain for gains and losses. Similarly, the second part elicited the DI-index for time outcomes. The third part contained the Brief Self-Control Scale by Tangney et al. (2004). Part four included self-control questions and the last part asked for personal characteristics.

4.2.1. Contact Information and Control Questions

The survey started with a strong request to fill in their email address for a second survey that will take place two weeks after the original survey was completed. After the e-mail address, an explanation followed to explaining the practical procedure to the subjects. This introduction was followed by two control questions to assess if the subjects understood the question format. The control questions were on which outcomes the survey used (money and time), and what t stands for (time).

4.2.2. Part 1: DI-index for Monetary Outcomes

The first part of the survey is a replication of the questions of Rohde (2019, p. 1708). All the DI-indices are elicited through a dropdown menu of many potential indifference points. Figure 4, a screenshot of a dropdown menu, is included in Appendix A2. The subjects can choose between receiving €40 at time s and €50 at a later point in time, t_s. t_s is the time that subject is willing to wait t weeks to gain €50 instead of €40 at time s. s is set as 0 (today), 2, 4, and 52 weeks from now. The indifference points will look as follows:

€40 today ~ €50 in t_0 weeks;

€40 in 2 weeks ~ €50 in t_2 weeks;

€40 in 4 weeks ~ €50 in t_4 weeks;

€40 in 52 weeks ~ €50 in t_{52} weeks.

The subjects could indicate their indifference point from 0 to 52 weeks after s in a dropdown menu. t_0 (t_{52}) had a dropdown menu ranging from 0 (52) weeks to 52 (104) weeks. If the subjects were not indifferent after 52 weeks, the indifference changed to "€40 today ~ €50 in t_0 *months*. Hence, the subjects could choose between 13 to 36 months again in a dropdown menu. For t_4 (t_{52}), the subjects could choose between 14 (25) to 37 (48) months. If the subjects were still not indifferent, they could answer how many months they want to wait through a textbox. This system of eliciting t is the same for all the other DI-indices.

In the second part of the monetary DI-index, the subjects can fill in their indifference points for losing money. The subject had to indicate when they were indifferent between losing €50 at time s or losing €60 at time t_s. The indifference points were elicited for 0, 2, and 4 weeks. The indifference points can be written as follows:

-€50 today ~ -€60 in t_0 weeks;

-€50 in 2 weeks ~ -€60 in t_2 weeks;

-€50 in 4 weeks ~ -€60 in t_4 weeks.

4.2.3. Part 2: DI-index for Time Outcomes

The second hypothetical part is related to receiving or losing leisure time. The subject had to imagine that his boss would reward or punish him for his (un)finished work. In the receiving time story, one's boss offers extra free time, whereas the subject has to overwork

if the work is unfinished. The DI-index was elicited with the practical procedure. The second indifference was calculated with the same story that took place two weeks later. The experiment can be found in Appendix B1.6 and B1.7, and can be summarized as follows (where brackets indicate the loss frame).

The subject had to imagine that he works 4 days per week for 8 hours per day at a company, and today is Friday morning. Normally, he (is free) works every Friday. (Un)fortunately, the boss has seen that he did (not) finish all his work in the prior period. She calls him and gives him two options to compensate for his (un)finished work. The first option is that he can (work 4 hours) take 4 hours off today on his (free) workday Friday. The second option is that he (works 8 hours) takes 8 hours off later (in t weeks) on another Friday.

4.2.4. Part 3: The Brief Self-Control Scale

The Brief Self-Control Scale developed by Tangney et al. (2004) is added to the survey. The statements can be assessed on a 5-point Likert-scale. An example of a statement is "I do certain things that are bad for me, if they are fun." The full list can be found in Appendix B1.8.

4.2.5. Part 4: Actual Behavior

In this part of the experiment, the subjects have to tell how many hours they exercised and studied, and how many glasses of alcohol they drunk last week. Furthermore, they have to indicate how many hours they will exercise, study, and drink during seven days two weeks from the date of the first survey. Both variables are answered in the first survey, which will be indicated by w_0, meaning week 0. In the second survey, the subjects only have to answer to what extent they have exercised, studied, and glasses of alcohol consumed the last seven days. The answers of the second survey are indicated with w_2, meaning week 2. The difference is measured as the actual numbers of w_2 to the estimated numbers at w_0.

4.2.6. Part 5: Personal Characteristics

The control variables are similar to Rohde's paper (2019), including age, gender, being an economics or business student, and if they live with their parents, if they smoke (every day, every now and then, not), how many days they drink alcohol per week, and their GPA.

4.3. Question Order and Randomization

Each survey started with an introduction, a contact information page, and an explanation page with control questions. Further, each survey had elicitations of two sub-domains (i.e., monetary gains and time losses), the Brief Self-Control Scale, followed by the two remaining sub-domains (i.e., monetary losses and time gains). Lastly, the actual behavior and personal characteristics were recorded at the end of the survey.

The first survey had eight different versions and each version was evenly presented. The evenly represented option in Qualtrics divides subjects randomly into a version that has the least number of subjects. There were three different variations resulting in eight

different versions (2×2×2=8). The first variation concerned the start of the experiment. Half of the subjects started with a gain scenario and the other half with a loss scenario. The second variation was that half of the surveys had a chronological order of the elicitation questions (i.e., t_0, t_2, t_4) instead of an achronological order (t_4,t_2,t_0). The last variation was that half of the surveys started with DI-index for time and the other half for monetary elicitation. Thus, every elicitation for time is followed by an elicitation for money with an opposite sign (i.e., gain or loss). For instance, the DI-index for time gains is followed by DI-index for time losses, and the DI-index for monetary losses is followed by time gains.

The other questions were not randomized to prevent attrition due to the repetitive nature of the survey. The elicitation questions can be perceived as boring, and the Brief Self-Control Scale is a welcome variation, which may have helped subjects to stay focused during the experiment. Therefore, it was placed in the middle of the experiment. The actual behavior and the personal characteristics were added at the end following an informal convention among student surveys. More information on the procedure can be found in Appendix B1.1.

4.4. Explanation of Variables

The variable names are logically abbreviated according to their meaning. For instance, while discussing the variable *male* or *studying economics,* zero means a female and someone who does not study economics, respectively. The abbreviation of the DI-indices consists of 4 parts. The first part of the variable name is DI, which indicates that we are dealing with the Decreasing Impatience-index. Secondly, the DI is followed by either a 'm' or a 't', indicating the outcome of money or time, respectively. The last letter is a 'g' or an 'l', which denotes a gain or loss scenario, respectively. Finally, two numbers follow, to indicate t has been used. Thus, $DImg_{24}$ means the decreasing impatience index for monetary gains calculated with t_2 and t_4, and $DItl_{02}$ means the DI-index for time losses with t_0 and t_2.

4.5. DI-indices and Statistical Tests

The following DI-indices will be calculated for monetary gains: $DImg_{02}$, $DImg_{24}$, and $DImg_{452}$. This research chose to calculate the DI-indices for $DImg_{02}$ and $DImg_{24}$ for comparability with Rohde (2019), and $DImg_{452}$ as an extension. $DImg_{02}$ represents the very near future, $DImg_{24}$ serves as the near future, and $DImg_{452}$ is the medium-long term future. The indices for the other subdomains are as follows. For the monetary losses, $DIml_{02}$ and $DIml_{24}$ are calculated. The DI-indices for time outcomes are $DItg_{02}$ and $DItl_{02}$. All these indices are the same in order to compare those to the monetary indices.

In the experiments regarding the DI-indices for money and time, a Shapiro-Wilk test will be conducted to see if these indices are normally distributed. In previous papers, the results of the DI-index yielded no normal distribution (Lipman & Attema, 2020). The non-parametric Kruskal-Wallis test is appropriate to see if the DI-indices for gains are constant, which answers hypothesis 1. The potential difference between gains and losses between the DI-indices for money and time are measured through a paired Wilcoxon test

(hypotheses 2 and 3). The last part of the experiment (hypotheses 4 to 9) is related to correlations between the DI-indices, the Brief Self-Control Scale, and the observed control problems. These hypotheses will be reviewed with the Spearman rank-order correlation, which is a non-parametric test that yields the sign and strength of an association between variables.

Also, several robustness checks are conducted. The subjects that answered one of the two control questions wrong are compared to the group that answered the questions correctly. If there is a significant deviation, the answers can be driven by an uncarefully answered survey, and further action is needed. Also, the results of all relatively patient subjects that wanted to wait longer than 52 weeks are removed in a robustness check. These subjects with a high willingness to wait can moderately distort the Spearman correlations and are, therefore, removed.

Another additional analysis is the calculation of several discount function of monetary gains. The one-parameters models and the Quasi-hyperbolic discounting analyzed in section 2.3 will be calculated with the indifference of €40 euros today or 50 euros in t_0 weeks. The Quasi-hyperbolic model uses the second indifference of €40 euros in two weeks or 50 euros in t_2 weeks. The exact calculations are given in Table 7. For instance, the constant discount rate will be calculated with

$$(7)\ r_0 = \left(\ \tfrac{50}{40}\ \right)^{\frac{1}{t_0}} - 1.$$

Consequently, we will analyze if there any correlations between the discount parameters and the self-control problems. Since the one-parameter model's parameters yield similar correlations, a special look is given at the constant discount parameter r_0 and the β of the Quasi-hyperbolic model.

Lastly, the correlation matrices are repeated with a Bonferroni-adjusted significance level. Preferably, a researcher determines the number of variables of interest before the experiment. Since this DI-index is fairly new and many potential correlations between variables are compelling to compare, a problem arises. Testing numerous hypotheses simultaneously increases the chance of a type I error, incorrectly rejecting a true null hypothesis. A Bonferroni adjustment changes the significance level depending on the number of correlations, which is one way to correct this error. However, the Bonferroni correction tends to be conservative, which leads to unnecessary underperformance (Nakagawa, 2004) or in a worst-case scenario, to "deleterious interference (Perneger, 1998)." These authors suggest that the method might be too strict, which has as a consequence that a false hypothesis is not rejected, leading to a type II error. Hence, a correct balance is hard to find, where the general correlation matrix without correction is too lenient and a Bonferonni measure is too strict. Nevertheless, the Bonferroni correction is added in Table 4 with all the correlations for the sake of completeness.

5. Results

5.1. Removal of Subjects Violating Impatience

After examining the answers of 140 subjects, a part of the answers has been deleted due to a violation of impatience. That happens, for example, if a subject answered $t_0 > t_2$ or $t_4 > t_{52}$. If that was the case for a sub-domain of monetary or time with gains or losses, then all the answers for that sub-domain were changed to missing. Thus, if a subject answered $t_4 > t_{52}$ for monetary gains, then her answers for monetary gains for t_0, t_2, t_4, and t_{52} were deleted, but her answers in other sub-domains remained valid. In total, 17, 26, 7, and 21 answers are deleted for monetary gains, monetary losses, time gains, and time losses, respectively. It is worth mentioning that there are more violations of impatience for losses than for gains. Also, 1, 2, 1, and 5 persons, respectively, were never willing to choose the second option in these four sub-domains and no DI-index could be calculated.

5.2. Descriptive Statistics

The descriptive statistics of the sample can be found in Table 2. From these descriptive statistics, one can derive that the sample consists mostly of students in the later phase of their studies. The average age is 22.7 years old, and approximately half of the sample is male (46%) and studies Economics or Business (50%). The sample is relatively smart with a GPA of 7.5, which is an above-average grade (Erasmus School of Economics, 2020). Moreover, the other statistics on studying, drinking, and exercising are reasonable values. This sample has less self-control than observed in the study by Tangney et al. (2014), where the mean score was 39.2 compared to 31.5 in this study.

Table 2: Descriptive statistics

Variable	Obs.	Mean	Min	Max
Age	140	22.73	18	30
Male	140	0.46	0	1
Studying Economics	140	0.50	0	1
Living at one's parents	140	0.21	0	1
Smoking*	140	2.69	1	3
GPA	120	7.48	6.0	9.2
Hours of study (w_0)**	101	24.52	0	70
Expected study hours	79	27.19	2	60
Hours of study (w_2)**	85	21.34	1	56
Hours of sport (w_0)	140	4.55	0	25
Expected hours of sport	140	6.01	0	45
Hours of sport (w_2)	129	4.64	0	25
Alcohol drinking days	140	2.31	0	7
Glasses of alcohol (w_0)	140	10.47	0	55
Expected alcohol glasses	140	8.41	0	35
Glasses of alcohol (w_2)	129	10.83	0	80
Brief Self-Control Scale Score	140	31.46	14	48

* 1=every day, 2=every now and then, 3=not

** w_0 indicates the first survey and w_2 the second survey, two weeks later.

Subjects with 0 hours of (expected) studying are excluded.

5.3. DI-index for Monetary Outcomes

The subjects had a wide range of answers for the indifference $(x, s) \sim (y, t)$. For instance, the answers for t_0 had a range from 0 weeks to 40 months. Similarly, t_2 and t_4 had a variety from 2 and 4 weeks to 40 months, respectively. An overview of all the chosen t can be found in Appendix B in Table 6. From these t, the DI-indices could be computed. All the DI-indices look non-normally distributed, which is confirmed by the rejected H_0 of the Shapiro-Wilk tests. All further tests to compare the DI-indices will be non-parametrical. Table 3 portrays impatience behavior for monetary outcomes. Interestingly, most subjects are constantly impatient, and the number of decreasing and increasing impatient subjects is approximately equal. However, most decreasing impatience behavior can be observed for monetary gains in de medium-long term future t_{452}, where a majority of the subjects are decreasingly impatient.

Table 3: Changing Impatience Behavior for Money

		Monetary gains			Monetary losses	
		DI_{02}	DI_{24}	DI_{452}	DI_{02}	DI_{24}
Decreasing impatience	(DI>0)	33	35	55	23	35
Constant impatience	(DI=0)	50	50	22	45	38
Increasing impatience	(DI<0)	35	30	38	21	23
Total		118	115	115	89	96

Two tests are performed to see if the DI-indices differ significantly from each other. Three Wilcoxon signed-rank tests are conducted between $DImg_{02}$ and $DImg_{24}$, $DImg_{02}$ and $DImg_{452}$, and $DImg_{24}$ and $DImg_{452}$. Also, a Kruskal-Wallis test is performed for the three groups. All tests turn out to be insignificant, which means that there is no significant difference between the indices. However, $DImg_{02}$ and $DImg_{24}$ are not significantly different from zero, whereas $DImg_{452}$ was significantly higher than zero (Wilcoxon signed-rank test, $p = 0.000$).

Moreover, it should be noted that $DImg_{02}$ and $DImg_{24}$ are also negatively correlated ($p = 0.003$), which is visualized by Figure 5 in the Appendix. Interestingly, this significant shift is not visible in Table 3, because the ratios of changing impatience are similar between the very near future and the near future. That would implicate that subjects who showed decreasing behavior in the very near future ($DImg_{02}$) became more increasingly impatient in the near future ($DImg_{24}$) and vice versa. Therefore, the ratios in changing in Table 3 are similar, but a negative correlation between $DImg_{02}$ and $DImg_{24}$ is still possible. Furthermore, there are no other significant correlations between $DImg_{452}$ and $DImg_{02}$ or $DImg_{24}$. The correlations between all other variables can be found in Table 4.

The results of monetary losses should be seen in a similar light. The DI-indices for monetary losses do not differ significantly from each other ($DIml_{02}$ and $DIml_{24}$), nor are different from the monetary gains ($DImg_{02}$ and $DIml_{02}$, and $DImg_{24}$ and $DIml_{24}$), nor from zero with a Wilcoxon signed-rank test. Furthermore, $DIml_{02}$ and $DIml_{24}$ are negatively correlated ($p = 0.002$), meaning, again, that subjects who showed decreasing behavior in the very near future ($DIml_{02}$) became more increasingly impatient in the near future ($DIml_{24}$) and vice versa. In Table 3, we can see that this led to subjects showing more decreasing impatience from $DIml_{02}$ to $DIml_{24}$. Also, $DImg_{02}$ and $DIml_{02}$ are positively correlated ($p = 0.039$).

Table 4A: Spearman Correlation among all variables

	$DImg_{02}$	$DImg_{24}$	$DImg_{452}$	$DIml_{02}$	$DIml_{24}$	$DItg_{02}$	$DItl_{02}$	Bscs Total	Male	Age	Economics	Parents
$DImg_{02}$	1											
$DImg_{24}$	- 0.282**	1										
$Dimg_{452}$	- 0.150	- 0.025	1									
$DIml_{02}$	0.232*	0.131	- 0.094	1								
$DIml_{24}$	0.037	0.135	0.060	- 0.241*	1							
$DItg_{02}$	0.203*	0.082	0.108	0.120	0.161	1						
$DItl_{02}$	0.132	0.066	0.032	0.198	- 0.113	0.328**	1					
Bscs Total	0.057	0.001	0.007	0.170	- 0.255*	- 0.110	- 0.151	1				
Male	- 0.055	0.177	- 0.027	0.003	- 0.017	0.209*	0.161	- 0.137	1			
Age	0.015	0.058	- 0.046	0.010	- 0.142	0.092	- 0.062	0.035	0.172*	1		
Economics	0.009	- 0.020	0.002	0.064	0.001	0.090	0.282**	- 0.040	0.158	- 0.006	1	
Parents	0.088	- 0.121	0.026	- 0.010	- 0.131	- 0.139	- 0.210*	0.256**	- 0.052	- 0.002	- 0.159	1
Smoke	0.106	- 0.117	0.048	0.073	- 0.088	0.052	- 0.029	0.178*	- 0.011	- 0.066	- 0.015	0.092
Days Alc.	- 0.112	0.091	- 0.068	0.023	0.125	0.103	0.085	- 0.255**	0.178*	- 0.238**	0.059	- 0.204*
GPA	- 0.079	- 0.063	0.232*	- 0.091	- 0.135	- 0.047	- 0.012	**0.327****	0.044	0.256**	0.272**	0.006
Hours Sport w_0	0.085	- 0.008	- 0.248**	0.122	- 0.042	0.069	- 0.093	0.159	0.052	0.058	- 0.018	0.002
Hours Study w_0	0.099	0.031	0.035	0.208	- 0.044	- 0.012	0.143	0.213*	0.007	0.088	0.007	0.039
Glasses Alc. w_0	- 0.155	0.142	- 0.006	- 0.042	0.099	0.102	0.184	**- 0.320****	0.209*	- 0.175*	0.070	**- 0.353****
Hours Sport w_2	0.126	0.043	- 0.134	- 0.062	0.210	- 0.057	- 0.069	0.073	0.064	- 0.088	0.084	- 0.055
Hours Study w_2	- 0.163	- 0.108	0.090	0.055	- 0.202	- 0.084	0.231	0.145	- 0.045	0.036	0.123	- 0.165
Glasses Alc. w_2	- 0.135	0.051	- 0.233*	0.060	0.050	0.033	0.237*	- 0.284**	0.176*	- 0.235**	0.054	- 0.240**
Diff hours Sport	0.059	0.001	0.029	- 0.050	0.172	0.103	- 0.052	0.111	- 0.067	0.085	0.028	0.055
Diff hours Study	- 0.069	- 0.149	- 0.008	- 0.014	- 0.082	- 0.071	0.058	0.007	- 0.231*	- 0.131	- 0.107	- 0.223*
Diff Glasses Alc.	- 0.111	0.000	- 0.196*	- 0.040	- 0.160	- 0.036	0.179	- 0.088	0.170	- 0.004	0.009	- 0.199*

Note: This table is based on pairwise comparisons. The number of observations differ per correlation. Significance is denoted by * for $p < 0.05$ and ** for $p < 0.01$. Bonferroni significance level of $p < 0.05$ is denoted by a dark blue bold font.

Table 4B: Spearman Correlation among all variables

	Smoke	Days Alc.	GPA	Hours Sport w_1	Hours Study w_1	Glasses Alc. w_1	Hours Sport w_2	Hours Study w_2	Glasses Alc. w_2	Diff hours Sport	Diff hours Study	Diff Glasses Alc.
Smoke	1											
Days Alc.	- 0.200	1										
GPA	0.056	- 0.172	1									
Hours Sport w_0	0.067	- 0.019	0.025	1								
Hours Study w_0	0.013	- 0.093	0.176	- 0.034	1							
Glasses Alc. w_0	- 0.293**	**0.757****	- 0.179	- 0.082	- 0.175	1						
Hours Sport w_2	- 0.013	0.089	- 0.086	**0.539****	- 0.011	0.054	1					
Hours Study w_2	- 0.070	- 0.098	- 0.081	- 0.073	**0.511****	- 0.110	- 0.137	1				
Glasses Alc. w_2	- 0.170	**0.638****	- 0.159	- 0.027	- 0.083	**0.653****	- 0.016	- 0.109	1			
Diff hours Sport	0.019	- 0.020	- 0.106	- 0.188	- 0.053	- 0.008	**0.433****	- 0.153	- 0.076	1		
Diff hours Study	- 0.190	- 0.089	0.004	- 0.100	0.033	- 0.021	- 0.247	**0.403****	- 0.049	- 0.196	1	
Diff Glasses Alc.	0.084	0.030	0.003	- 0.080	- 0.044	0.077	- 0.037	0.050	**0.508****	0.059	- 0.151	1

Note: This table is based on pairwise comparisons. The number of observations differ per correlation. Significance is denoted by * for $p < 0.05$ and ** for $p < 0.01$. Bonferroni significance level of $p < 0.05$ is denoted by a dark blue bold font.

5.4. DI-index for Time Outcomes

The results for the DI-index for time gains are similar to the outcomes from time losses. The division of behavior is depicted in Table 5. As already noted before, more subjects are removed for time losses due to a violation of impatience. There are relatively more subjects that are increasingly impatient for time losses in comparison to time gains. This view is also confirmed by a Wilcoxon test. $DItg_{02}$ is not significantly different from zero, whereas $DItl_{02}$ was significantly larger than zero ($p = 0.036$). A paired Wilcoxon test testing for significant differences between time gains and losses is also insignificant, emphasizing that they do not differ.

Table 5: Impatience Behavior for Time

		Time gains DI_{02}	Time losses DI_{02}
Decreasing impatience	(DI>0)	41	33
Constant impatience	(DI=0)	43	24
Increasing impatience	(DI<0)	42	43
Total		126	100

Furthermore, the relation between the DI-index of time gains ($DItg_{02}$) and time losses ($DItg_2$) can be seen in Figure 2, and $DImg_{02}$ and $DItg_{02}$ in Figure 3.[3] Both figures look similar, which points towards positive correlations. Indeed, in Table 6 we can observe that both the time indices ($Ditg_{02}$ and $Ditl_{02}$) are correlated (pos., $p = 0.001$) as well as money ($DImg_{02}$) and time ($DItg_{02}$) (pos., $p = 0.036$). The indices for monetary losses and time losses are not correlated. The results from a paired Wilcoxon test show that neither $DImg_{02}$ and $DItg_{02}$ are significantly different nor are $DIml_{02}$ and $DItl_{02}$ from each other. Again, both indices were not correlated with age. A Kruskal-Wallis test for time gains ($DItg_{02}$) found that this DI-index is significantly higher for men than for women ($p = 0.023$). The DI-index for time losses does not have any gender differences.

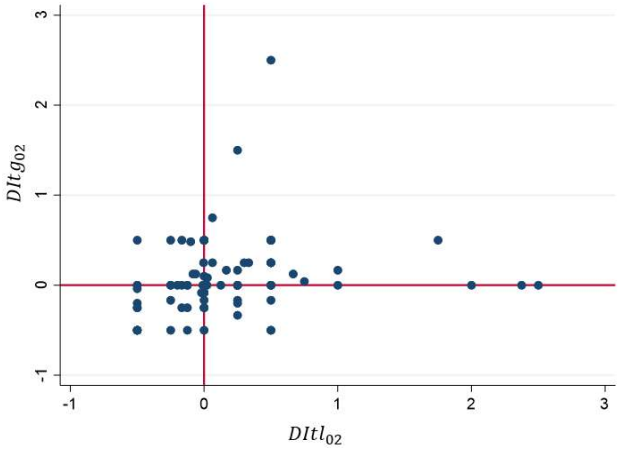

Figure 2: Distribution $DItg_{02}$ and $DItl_{02}$

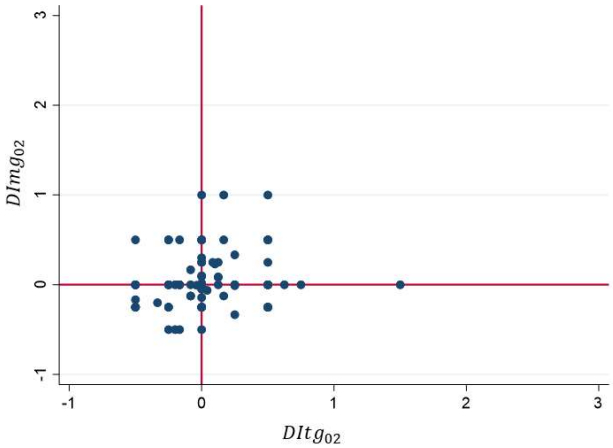

Figure 3: Distribution $DImg_{02}$ and $DItg_{02}$

[3] One observation for Figure 2, 3, and 5 has not been displayed in these graphs for visibility purposes but is included in the statistical analysis.

5.5. Correlations with Self-Control Problems

Consequently, we can look at the correlations between self-control problems, the Brief Self-Control Scale, and the DI-indices. The Brief Self-Control Scale was only correlated with the monetary losses, $DIml_{24}$ (neg., $p = 0.012$). The Brief Self-Control Scale was correlated with the following characteristics. It was positively correlated with living at one's parents' house at a 1% significance level ($p = 0.002$) and correlated with one's GPA (pos., $p = 0.000$). Furthermore, the Brief Self-Control Scale was related to alcohol consumption. It is negatively correlated with both the number of days on which alcohol is consumed ($p = 0.002$) and the glasses of alcohol consumed on w_0 (neg., $p = 0.001$) and w_2 (neg., $p = 0.000$). Lastly, it was positively correlated with not being a smoker (i.e., negatively correlated with smoking) with a p-value of 0.035.

Contrary to the Brief Self-Control Scale, the first two DI-indices for monetary gains, $DImg_{02}$ and $DImg_{24}$ did not correlate with any characteristics. In the monetary domain, only $DImg_{452}$ did correlate with other variables. This index was positively correlated with GPA ($p = 0.038$), and negatively correlated with glasses of alcohol in week 2 ($p = 0.017$), which is counter-intuitive. Also, the index was negatively associated with the expected alcohol minus observed alcoholic beverages ($p = 0.045$), which is again an unexpected sign. The expectation would be that a more positive DI-index would be an indicator of self-control problems, thus, being negatively associated with GPA and positively associated with glasses of alcohol drunk. Also, the indices for monetary losses were not correlated to any variables.

Similarly, the DI-index for time gains does not yield any fruitful results. This index is not correlated with any characteristics. Opposed to these findings, the results of the loss variant of time are fascinating. $DItl_{02}$ is positively correlated with studying economics or business ($p = 0.004$) and negatively correlated living at one's parent's house ($p = 0.034$). Furthermore, $DItl_{02}$ is positively correlated with glasses of alcohol in the second week ($p = 0.022$). Lastly, $DItl_{02}$ has an insignificant negative correlation with the Brief Self-Control, which has an intuitive right sign.

5.6. Robustness Measures

The results did not change significantly with the robustness measures. The survey started with two control questions to see if the subjects understood the questions. Fifteen subjects answered one of the two control questions wrong. A Mann-Whitney U test is conducted for all variables to look for significant differences in answers or characteristics. Since none of these tests are significant, no future action is needed to control for these answers.

The second robustness measure was to exclude people who are willing to wait longer than 52 weeks. This removed several participants, depending on the DI-index, with a maximum of 11 people. As a consequence, $DImg_{24}$ and being a male are now correlated (pos., $p = 0.024$), and $DImg_{452}$ and the hours of sport (w_0) are also correlated (neg., $p = 0.004$).

An analysis of the discount functions was the third robustness measure. The descriptive statistics of the discount parameters are displayed in Table 7. The average constant

discount rate is 13.0% on a weekly basis. The Quasi-hyperbolic discount beta only has 85 observations, because 30 observations were changed to missing because $\beta > 1$. A Mann-Whitney-U test points out that men have a significantly lower constant discount rate than women ($p = 0.019$) and are more patient. If the assumptions of constant discounting hold, men are more patient than women. Also, the constant discount rate is significantly higher for people living at their parent's house (Paired Wilcoxon test, $p = 0.034$), meaning that students living at their parent's house are more impatient than autonomous living students. Remarkably, besides gender and living at their parent's house, there are no other correlations between the constant discount rate with the self-control problems. Also, the beta from Quasi-hyperbolic discounting is not correlated to any characteristic.

The Bonferroni-adjusted significance levels are, as discussed before, rather conservative. All the DI-indices are no longer significantly correlated with the personal characteristics nor self-control problems nor to each other. The only notable remaining significances were the correlation between the Brief Self-Control Scale and alcoholic beverages (w_0), and GPA. Lastly, the correlations between observed behavior at w_0 and w_2, like hours of sport at w_0 and w_2, remain significant, which may not be astonishing.

6. Discussion

6.1. Discussion of the Results

The first difference between Rohde (2019) and this thesis lies in the sample selection. The sample from this thesis is slightly older (22.7 against 19.4 years) and has more females (54% against 25.2%) and less economics or business students (50.0% against 79.2%). Furthermore, fewer students live together with their parents in this sample (21% against 54.2%). Also, the average alcoholic beverages drunk per week (10.8 against 3.5) and total days of drinking (2.5 against 1.3) is substantially higher. There are no other substantial differences between the other variables as smoking or exercising. There can be several explanations of why alcoholic beverages differ much between these studies. There is a negative association between drinking alcohol at w_0 and living at one's parents' house ($p = 0.000$), and between drinking alcohol at w_0 and age ($p = 0.039$). Since this sample is older and lives less often at one's parents' house, the higher alcoholic consumption can be explained. Lastly, it can be the case that students report a desirable answer in a laboratory setting and are more honest in an anonymous survey of a colleague.

Consequently, the results for DI-indices for monetary gains and losses provide interesting results. There was a mixture of constant, decreasing, and increasing impatience. The largest group in Rohde's study (2019) was decreasingly impatient, whereas this paper has more subjects that are constantly impatient. This finding is in line with Attema et al. (2018), where there was a large diversity in answers to these questions, but a majority remained constantly impatient. In that paper, the elicitation method, the direct method, can be seen as the primary contributor to this constant impatience. There is no clear explanation of why the majority of the sample from this paper is constantly impatient. Perhaps this many indifference points resulted in a larger need to be consistent with eleven indifference points compared to answering only three indifference points. One explanation

could be that people are truly constantly impatient and the larger number of questions induced a learning curve. A less favorable explanation could be that this repetition of these indifference points could make the questions boring, leading to a decreased effort to carefully think of an answer, but rely on the previous answer given, causing constant impatience.

There was no significant difference between the monetary gains ($DImg_{02}$ and $Dimg_{24}$), which contrasts Rohde's (2019) findings, but is in line with our hypothesis. There was also no discrepancy between monetary gains and losses, which is in line with Shiba and Shimizu (2019), and Lipman and Attema (2020), and our hypothesis. On a similar note, the DI-indices for time gains and losses were not significantly different nor are the DI-indices for time gains against time losses. Again, these findings are in line with our hypothesis. Interestingly, there is no significant difference between the time losses and monetary losses, which is not in line with our hypotheses. We can conclude that the monetary DI-indices are similar to the DI-indices for time. This evidence could be interpreted that the perception of time, as a resource, is similar to money in the very near future.

Also, a systematic association between gender and changes in impatience is not supported throughout all DI-indices. If there is a difference, it is rather that men have a higher DI-index than women, which is illustrated by one positive correlation between $Ditg_{02}$ and men. This result is similar to Attema and Lipman (2018), where there was little evidence in favor of a higher DI-index for men.

Furthermore, the correlations provide intriguing results. The results of the Brief Self-Control Scale are all in an expected direction and are in line with the general literature. Higher psychological self-control is associated with higher grades, and lower alcohol intake. These results are in line with the literature (de Ridder et al. 2016). What is disappointing, but expected, is the lack of correlations of the DI-indices. For instance, the lack of correlations for $DImg_{02}$, $DImg_{24}$, and $DItg_{02}$, with self-control problems is not what is theoretically predicted, but has been found by Rohde (2019), and Attema and Lipman (2019). Moreover, the results of $DImg_{452}$ are counter-intuitive. Theoretically, one would expect a negative correlation with grades, and a positive correlation with alcohol, whereas the results indicate the opposite. The only promising values are related to the $DItl_{02}$. The correlations of this index are almost always the opposite of the Brief Self-Control Scale, which is the expected correlation sign. Although, the negative correlation with the Brief Self-Control itself is not significant. Furthermore, $DItl_{02}$ is positively correlated with living with one's parents and drinking glasses of alcohol, whereas the Brief Self-Control Scale has a negative correlation. It remains a question why economic or business students have a significant positive correlation with $DItl_{02}$, resulting in a higher decreasing impatience in comparison to other disciplines. These findings make that the $DItl_{02}$ is a candidate for further research to see if the $DItl_{02}$ is suitable for finding other self-control problems.

The robustness measures do not alter the aforementioned analysis. The removal of, relatively patient, impatient subjects did introduce two new significant variables, which concern being a male and hours of sport. As discussed before, males can have a higher DI-index than females. Concerning the sport variable, the situation is similar to that of Rohde (2019), where several sports fanatics (i.e., 15 hours or more) have a more substantial effect on the correlation. Therefore, not too much attention should be paid to this finding.

The results of the discount parameters are substantially high. The discount rate of 13% may not seem extreme if one disregards that this relation is on a weekly basis. Concretely, that means that if one invests €100 with 13% per week, one has approximately €57.500 after one year. This number is too high to be realistic, considering that Attema et al. (2018) found a discount rate of 6.6% annually, which is much closer to the market interest rate. From this elicitation method, it seems that the practical procedure boosts the discount rates. Even though the discount rates are high, it remains puzzling why there is no significant relationship between the constant discount rate and self-control problems. This finding is in contrast with Rohde (2019), where there was a significant relationship between the discount factors and self-control problems. The only two significant findings were the difference between the discount rates between men and women, which is sometimes confirmed by other empirical literature (Sutter et al., 2013). Also, students living at their parent's place are more impatient, which has not been found by Rohde (2019). Further discount fitting should account for a mixture of the findings of the DI-indices. Since increasing, decreasing and constant behavior was found throughout the indices, this paper would recommend using discount functions that are mathematically flexible, like CADI or CRDI (Bleichrodt et al., 2009). In our sample, CRDI would be preferred over CADI, which we base on $DImg_{02}$ and $DImg_{24}$, and $DIml_{02}$ and $DIml_{24}$.[4] These indices did not differ significantly from each other but were negatively correlated. From this, we can conclude that subjects who showed decreasing behavior in the very near future became more increasingly impatient in the near future and vice versa. This evidence shows that DI-index changes on the individual level, which would favor CRDI. All in all, both functions could be useful. Other discount functions, like the Quasi-hyperbolic discounting, cannot account for increasing impatience, which makes them less useful at the individual level.

Lastly, the conservativism in the Bonferroni measures can be seen in the results. Whereas the literature expects a correlation between the Brief Self-Control Scale and GPA and alcohol intake, only the glasses of alcohol at w_0 is significant with the Bonferroni measures. The correlation between GPA and this scale became, presumably, unjustifiably

[4] We compare $DImg_{02}$ and $DImg_{24}$, and $DIml_{02}$ and $DIml_{24}$, because $k = 2$ for these indices, which is based on Theorem 11 of Rohde (2019, p. 1714). If CADI holds, then the following statements are equivalent:
$(x, s) \sim (y, t)$, $(x, s + \sigma) \sim (y, t + \tau)$,
and $(x, s + k) \sim (y, t + k)$, we have $(x, s + \sigma + k) \sim (y, t + \tau + k)$.
For any k, or $k = 2$ in this thesis, we expect that the two DI-indices on the individual level would be equal if CADI holds. Since the indices in this thesis have significant negative correlations but insignificant differences between the indices, we can conclude that CRDI works better on the individual level. I refer to Rohde (2019, p. 1714) for more information.

insignificant, which shows that the measure is rather conservative. Besides this conservatism, the fact remains that any correlation with the DI-indices vanished. That is also a reason why the findings of $DItl_{02}$ need further examination to see if the result is robust.

6.2. Limitations

Several limitations were encountered throughout the process of designing this thesis. First and foremost, COVID-19 made it impossible to conduct the research physically. An offline choice list might have been preferred to a digital dropdown menu to elicit the DI-index. The subjects could not see the entire dropdown list, but how many lines they could see depended on the length of their (mobile) screen. Another limitation of an online survey was that there was no immediate assistance available. The answers of four subjects were adjusted because they were unsure what to click if they did not want to switch. For future research, an "I would never find both options equal" choice should be added since it is not intuitively clear to all subjects that one should wait till eternity if one does not want to switch.

Another limitation is the novelty of this research area. Since there is no strong theoretical basis whether the DI-indices or other self-control indicators are correlated with personal characteristics or observed behavior, this research is like a flashlight in the dark. The number of correlations is so high that the chance of a type I error, wrongly rejecting a true hypothesis, increases to a questionable height. This paper has tried to combat this by implementing a p-value adjustment, which was a Bonferroni correction. However, this measure seemed too conservative, leading to this limitation.

The last limitation of this research is the difficulty of subjects to participate in this study. After receiving informal feedback after the survey, participants communicated that it is unnatural and difficult to express their indifference points. For instance, they did not know if they wanted to wait for 5 or 6 weeks. The difference between choosing 5 or 6 weeks may cause, say, a 20% increase in the DI-index. Imagine that one subject chose 6. However, it is unlikely that this 20% increase in the DI-index should reflect a 20% increase in self-control problems, whereas the subject was unsure between these two answers. Thus, the DI-index might be too precise for indeterminate subjects, which may disturb the correlations.

6.3. Practical Implications

This paper has a few practical implications for, for instance, policymakers. On a positive note, the DI-index is a useful instrument to elicit the impatience behavior of subjects. The index is easy to implement in surveys if one is interested in mathematically capturing this behavior. However, there are several disadvantages to the DI-index. The DI-indices for monetary gains and losses, and time gains were (at best) poorly to adversely correlated to self-control problems in this paper. These results are robust considering the similar evidence of Rohde (2019), and Lipman and Attema (2018). The DI-index, in general, fails to correlate with this behavior and should not be used for practical purposes to measure self-control problems. Only the DI-index for time losses yielded interesting results, but it

needs further research, as will be described in the next section. Practitioners interested in self-control problems are better off using other methods, like the Brief Self-Control Scale (Tangney et al., 2004). Another disadvantage of using the DI-index is that its data is not suitable for calculating individual discount rates. A discount rate of 13% on a monthly basis is unreasonably large compared to market interest rates. Another method, like the direct method of Attema et al. (2018), yields better results aligned with market rates.

6.4. Future Research

Future research could go in several directions. The first direction is to try to explore the results of losing time ($DItl_{02}$) more carefully. The $DItl_{02}$ seemed the most promising of all indices, showing correlations with observed behavior. A similar story about losing leisure time can be taken again to replicate to see if the correlation with self-control problems stays. For instance, a similar experiment as Sutter et al. (2013) is possible, which could investigate the role of decreasing impatience and future self-control problems. Another example could be future research with the DI-index for time losses in cooperation with weight clinics or quit-smoking institutes. In this case, this DI-index for losing time, or other economic models, can be compared to actual behavior instead of using self-reported measures. Another path of research that could be explored is changing the (hypothetical) stakes used in the DI-index. Previous research used small stakes, but it might be interesting to see if the changes in impatience have similar patterns. The last direction of future research could be manipulating the time for reporting t. The dropdown menu in this paper or choice lists in Rohde (2019) to elicit t are expressed in weeks. If the measure is changed to days or months, subjects may indicate a lower or higher waiting time, respectively, because other inputs may nudge towards smaller or greater numbers. A combination of the last two suggestions may be most valuable (i.e., creating an experiment with higher stakes and months as elicitation time).

7. Conclusion

From an economist's perspective, inconsistent behavior is rooted in *changes* in impatience rather than the *levels* of impatience. A new method to calculate these changes in impatience is developed by Rohde (2019) and is called the decreasing impatience (DI-)index. This thesis investigated the relationship between several DI-indices, calculated with monetary and time outcomes, and self-control problems. There were three DI-indices for monetary gains, two for monetary losses, and one for both time gains and losses. Moreover, the Brief Self-Control Scale developed by Tangney et al. (2014) is used as a benchmark. The self-control problems were defined by (not) studying, (not) exercising, and alcohol intake. The data was gathered through two digital surveys targeting students of Erasmus University ($n = 140$).

The most frequently observed behavior throughout all DI-indices was constant impatience, rather than increasing or decreasing. There was no significant difference between monetary gains and losses, and no differences between time gains and time losses. Also, there was no difference between monetary and time gains nor losses. The link between the DI-indices and observed self-control problems might be best summarized by a famous

essay title of Kant "'This may be true in theory, but it does not apply in practice (Kant, 1991, p. 61)." The general DI-indices had (at best) poor correlations with self-control problems or yielded counter-intuitive results. The only DI-index that gave fruitful results was the index for time losses. This index was significantly associated with alcohol beverage intake and had several insignificantly right signs. In contrast to the DI-indices, the Brief Self-Control Scale performed very well. It was correlated with GPA as well as several alcohol intake indicators. Practitioners interested in self-control problems are better off using the Brief Self-Control Scale or other models. Further research is necessary to robustly use the DI-index for time losses for practical purposes, like to identify self-control problems.

8. Bibliography

Abdellaoui, M., Attema, A. E., & Bleichrodt, H. (2010). Intertemporal tradeoffs for gains and losses: an experimental measurement of discounted utility. *The Economic Journal*, 120, 845–866. doi: 10.1111/j.1468-0297.2009.02308.x.

Attema, A. E., Bleichrodt, H., Gao, Y., Huang, Z., & Wakker, P. P. (2016). Measuring Discounting without Measuring Utility. *American Economic Review*, 106(6), 1476-1494. doi: 10.1257/aer.20150208.

Attema, A.E, & Lipman, S.A. (2018). Decreasing impatience for health outcomes and its relation with healthy behavior. *Frontiers in Applied Mathematics and Statistics*, 4, 1–8. doi: 10.3389/fams.2018.00016.

Attema, A.E., Bleichrodt, H., L'Haridon, O. Peretti-Watel, P., & Seror, V. (2018). Discounting health and money: New evidence using a more robust method. *Journal of Risk and Uncertainty*, 56, 117–140. doi: 10.1007/s11166-018-9279-1.

Becker, G. (1965). A Theory of the Allocation of Time. *The Economic Journal*, 75(299), 493-517. doi: 10.2307/2228949.

Bleichrodt, H., Gao, Y., & Rohde, K.I.M. (2016). A measurement of decreasing impatience for health and money. *Journal of Risk and Uncertainty*, 52(3), 213–231. doi: 10.1007/s11166-016-9240-0.

Bleichrodt, H., Kothiyal, A., Prelec, D., & Wakker, P. P. (2013). Compound invariance implies prospect theory for simple prospects. *Journal of Mathematical Psychology*, 57(3-4), 68-77. doi: 10.1016/j.jmp.2013.04.002.

Bleichrodt, H., Rohde, K. I. M., & Wakker, P. P. (2009). Non-hyperbolic time inconsistency. *Games and Economic Behavior*, 66(1), 27–38. doi: 10.1016/j.geb.2008.05.007.

Chapman, G. B., & Elstein, A. S. (1995). Valuing the future temporal discounting of health and money. *Medical Decision Making*, 15(4), 373–386. doi: 10.1177/0272989X9501500408.

Chapman, G. B. (1996). Temporal discounting and utility for health and money. *Journal of Experimental Psychology*: *Learning Memory and Cognition*, 22(3), 771–791. doi: https://doi.org/10.3758/BF03209466.

Chapman, G. B. (1998). *Psychology of Learning and Motivation*. (D.L. Medin, Red.) (illustrated edition, Vol. 38). Amsterdam, Nederland: Amsterdam University Press. doi: 10.1016/S0079-7421(08)60184-X.

Ebert, J., & Prelec, D. (2007). The Fragility of Time: Time-Insensitivity and Valuation of the Near and Far Future. *Management Science,* 53, 1423-1438. doi: 10.1287/mnsc.1060.0671.

Erasmus School of Economics. (2020). *Dutch Grading System*. Retrieved on 13 September 2020 from: https://www.eur.nl/en/ese/exchange/visiting-students/dutch-grading-system.

Festjens, A., Bruyneel, S., Diecidue, E., & Dewitte, S. (2015). Time-based versus money-based decision making under risk: An experimental investigation. *Journal of Economic Psychology*, 50, 52–72. doi: 10.1016/j.joep.2015.07.003.

Frederick, S., Loewenstein, G., & O'Donoghue, T. (2002). Time Discounting and Time Preference: A Critical Review. *Journal of Economic Literature*, 40(2), 351-401. doi: 10.1257/jel.40.2.351.

Gerber, A., & Rohde, K.I.M. (2015). Eliciting discount functions when baseline consumption changes over time. *Journal of Economic Behavior & Organization*, 116, 56–64. doi: 10.1016/j.jebo.2015.03.019.

Halevy, Y. (2015). Time Consistency: Stationarity and Time Invariance. *Econometrica*, 83(1), 335-352. doi: 10.3982/ecta10872.

Harvey, C. M. (1995). Proportional discounting of future costs and benefits. *Mathematics of Operations Research*, 20(2), 381–399. doi: 10.1287/moor.20.2.381.

Hume, D. (1739/1896). *A Treatise of Human Nature*. L.A. Selby-Bigge (Eds.). Oxford: Clarendon Press.

Kant, I. (1991). *Kant: Political Writings* (2nd ed., Cambridge Texts in the History of Political Thought) (H. Reiss, Ed.; H. Nisbet, Trans.). Cambridge: Cambridge University Press. doi: 10.1017/CBO9780511809620.

Laibson, D. I. (1997). Golden eggs and hyperbolic discounting. *Quarterly Journal of Economics*, 112, 443–477. doi: 10.1162/003355397555253.

Lindner, C., Nagy, G., & Retelsdorf, J. (2015). The dimensionality of the Brief Self-Control Scale—An evaluation of unidimensional and multidimensional applications. *Personality and Individual Differences*, 86, 465-473. doi: 10.1016/j.paid.2015.07.006.

Lipman, S. A, & Attema, A. E. (2020). Good things come to those who wait—Decreasing impatience for health gains and losses. *PLoS ONE*, 15(3). doi: 10.1371/journal.pone.0229784.

Loewenstein, G. F., & Prelec, D. (1992). Anomalies in intertemporal choice: Evidence and an interpretation. *Quarterly Journal of Economics*, 107, 573–597. doi: 10.2307/2118482

Markowitz, H. (1952). The Utility of Wealth. *Journal of Political Economy*, 60(2), 151-158. doi: 10.1086/257177.

Mazur, J. E. (1987). An adjusting procedure for studying delayed reinforcement. In M. L. Commons, J. E. Mazur, J. A. Nevins, & H. Rachlin (Eds.), *Quantitative analysis of*

behavior: The effect of delay and of intervening events on reinforcement value. Hillsdale, NJ: Ballinger.

Mcleish, K. N., & Oxoby, R. J. (2007). Measuring impatience: Elicited discount rates and the Barratt Impulsiveness Scale. *Personality and Individual Differences*, 43(3), 553-565. doi:10.1016/j.paid.2007.01.002

Moore, M. J., & Viscusi, W. K. (1990). Discounting environmental health risks: New evidence and policy implications. *Journal of Environmental Economics and Management*, 18(2), 51–62. doi: 10.1016/0095-0696(90)90037-Y.

Nakagawa, S. (2004). A farewell to Bonferroni: The problems of low statistical power and publication bias. *Behavioral Ecology*, 15(6), 1044-1045. doi: 10.1093/beheco/arh107.

Nolan, J. M., Schultz, P. W., Cialdini, R. B., Goldstein, N. J., & Griskevicius, V. (2008). Normative social influence is underdetected. *Personality and Social Psychology Bulletin*, 34(7), 913–23. doi: 10.1177/0146167208316691.

Noussair, C. N., Stoop, J. (2015). Time as a medium of reward in three social preference experiments. *Experimental Economics*, 18, 442–456. doi: 10.1007/s10683-014-9415-y.

Perneger, T. V. (1998). What's wrong with Bonferroni adjustments. *Bmj*, 316(7139), 1236-1238. doi: 10.1136/bmj.316.7139.1236.

Phelps E. S., & Pollak, R. A. (1968). On second-best national saving and game-equilibrium growth. *The Review of Economic Studies*, 35(2),185–199. doi: 10.2307/2296547.

Prelec, D. (2004). Decreasing impatience: A criterion for non-stationary time preference and 'hyperbolic' discounting. *The Scandinavian Journal of Economics*, 106(3), 511–532. doi: 10.1111/j.0347-0520.2004.00375.x.

Read, D. (2001). Is Time-Discounting Hyperbolic or Subadditive? *Journal of Risk and Uncertainty*, 23(1), 5–32. doi: 10.1023/A:1011198414683.

Rohde, K. I. M. (2019) Measuring Decreasing and Increasing Impatience. *Management Science* 65(4), 1700-1716. doi: 10.1287/mnsc.2017.3015.

Samuelson, P. (1937). A Note on Measurement of Utility. *The Review of Economic Studies*, 4(2), 155-161. doi: 10.2307/2967612.

Seneca, L. A. (2016). *Hardship and Happiness*. Amsterdam University Press.

Shiba, S. & Shimizu, K. (2020). Does time inconsistency differ between gain and loss? An intra-personal comparison using a non-parametric elicitation method. *Theory and Decision*, 88, 431–452. doi: 10.1007/s11238-019-09728-1.

Strotz, R. H. (1955-1956). Myopia and Inconsistency in Dynamic Utility Maximization. *The Review of Economic Studies*, 23 (3), 165-180.

Sutter, M., Kocher, G. K., Glätzle-Rützler, D, & Trautmann, S. T. (2013). Impatience and Uncertainty: Experimental Decisions Predict Adolescents' Field Behavior. *American Economic Review*, 103 (1): 510-31. doi: 10.1257/aer.103.1.510.

Thaler, R. (1981). Some empirical evidence of dynamic inconsistency. *Economic Letters*, 8, 201-207. doi: 10.1016/0165-1765(81)90067-7.

Tversky, A., & Kahneman, D. (1992). Advances in prospect theory: Cumulative representation of uncertainty. *Journal of Risk and Uncertainty*, 5(4), 297-323. doi: 10.1007/bf00122574.

Zauberman, G., Kim, B. K., Malkoc, S.A., & Bettman, J.R. (2009). Discounting Time and Time Discounting: Subjective Time Perception and Intertemporal Preferences. *Journal of Marketing Research*, 46(4), 543–556. doi: 10.1509/jmkr.46.4.543.

Appendix A1. Tables

Table 6: Descriptive statistics on the chosen time

Domains	Time	Obs.	Mean	Std. Dev.	Min	Max
Monetary gains	t_0	122	8.6	26.0	0	174
	t_2	122	11.1	26.9	2	174
	t_4	122	13.9	27.2	4	174
	t_{52}	122	72.0	58.6	52	452
Monetary losses	t_0	112	13.8	36.5	0	261
	t_2	112	18.7	40.8	2	261
	t_4	112	23.4	46.4	4	261
Time gains	t_0	132	7.8	45.5	0	522
	t_2	132	10.3	45.9	2	522
Time losses	t_0	119	9.1	30.1	0	261
	t_2	119	13.1	31.9	2	261

Table 7: Discount Statistics

Discounting variable		Obs.	Mean	Min	Max
Constant	r	118	0.130	0.001	0.250
Proportional	k	118	0.133	0.001	0.250
Power	a	118	0.206	0.043	0.322
Quasi-Hyperbolic	β	85	0.960	0.800	1.000

The parameters are calculated assuming that 1 week equals one time unit. The calculation of the parameters is as follows:

(1) Constant discounting: $r_0 = \left(\frac{50}{40}\right)^{\frac{1}{t_0}} - 1$

(2) Proportional discounting $k_0 = \frac{1}{4 * t_0}$

(3) Power discounting $a_0 = \frac{ln\left({}^{50}/_{40}\right)}{ln\ (1 + t_0)}$

(4A) Quasi-Hyperbolic Discounting $r_2 = \left(\frac{50}{40}\right)^{\frac{1}{(t_2 - 2)}} - 1$

(4B) Quasi-Hyperbolic Discounting $\beta_0 = \frac{40}{50} * (1 + r_2)^{t_0}$

Appendix A2. Figures

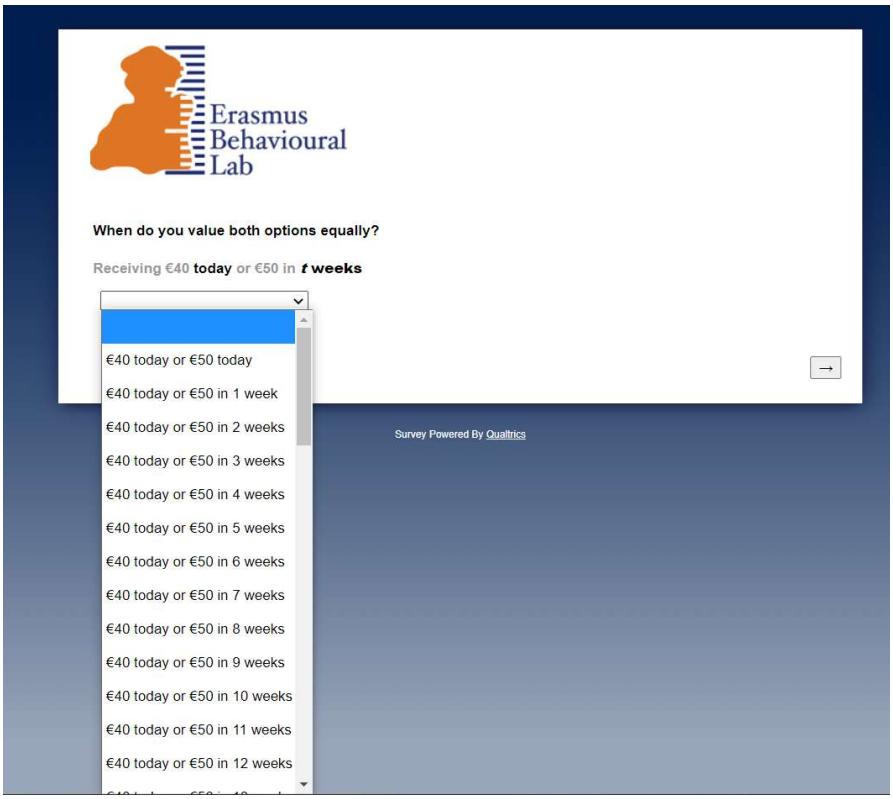

Figure 4: Screenshot of the dropdown menu in the online survey

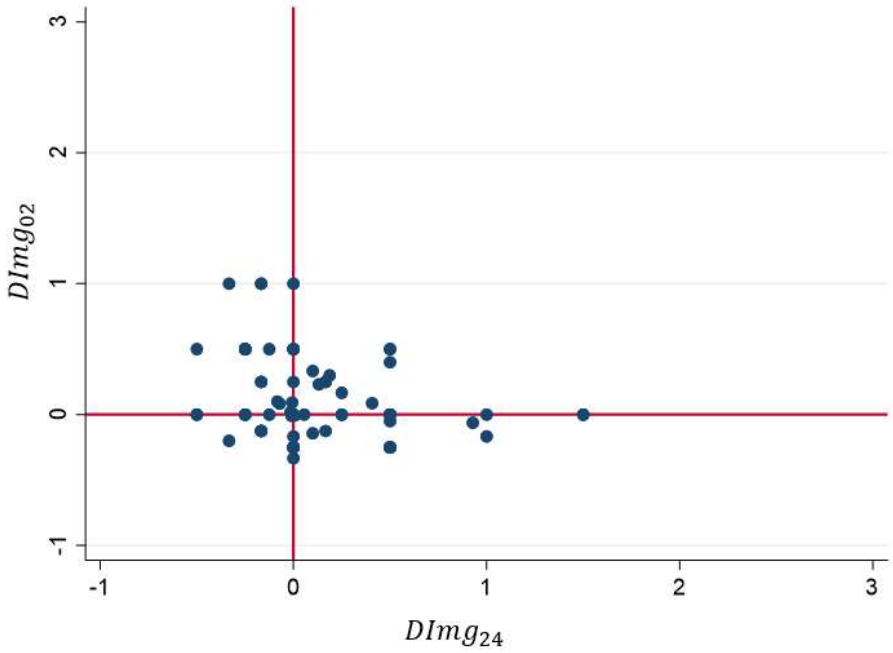

Figure 5: Distributions of $DImg_{02}$ and $DImg_{24}$

Appendix B. Survey Questions

B1.1. Introduction to the Survey

The subsequent chapters in this appendix contain the literal questions of the survey. The bold, cursive, or other font changes in this appendix are also used in the survey. Extra information about the survey will be added with brackets [], for instance, when a dropdown menu appears after a question. As already mentioned in the methodology, there were eight different versions. All odd versions have a chronological time order (i.e., t_o, t_2, t_4, t_{52}) and all even versions have a reversed order of time (i.e., t_{52}, t_4, t_2, t_0), which is randomization number 1. The survey can be divided into the following parts: receiving money, losing time, BSCS, losing money, receiving time, self-control questions, and personal characteristics. The survey placed the BSCS as the third question, and the self-control questions and personal characteristics were always last. Then, questions 1, 2, 4 and 5 are left. To keep the survey interesting, a question on time should be followed by a question reversed on money and vice versa, which is randomization number 2. Furthermore, a question on reward is always followed with a loss question, which is randomization number 3. Thus, a question about losing time is followed by a question on receiving money. There are then 8 ($2 \times 2 \times 2 = 8$) different randomizations possible. For instance, one order was: money gains, time losses, the Brief Self-Control Scale, money losses, time gains, self-control questions, and personal characteristics. All these questions had a chronological order. Another order was: time gains, money losses, the Brief Self-Control Scale, time losses, money gains, self-control questions, and personal characteristics. All these questions had a reversed chronological order. Qualtrics had an option where all eight surveys orders were evenly presented. This means that every order has an equal chance of being selected, unless it has more subjects in that group. From section 1.2. onwards, the text will be the literal content of the survey.

B1.2. Introduction of the Survey

Dear respondents,

Welcome to this experiment and thank you in advance for answering this survey for my master thesis!

The questionnaire consists of **two parts**. The first survey takes 9 minutes. You cannot go back to previous questions. The second survey will be sent in two weeks and will take 1 minute. You can help to make this study insightful by filling in both surveys. You can win one of the two available 10 euros if you answer both surveys.

The data will be used for academic purposes only.

You confirm that you are 18 years and older and agree with participating in this study.

- I am 18 years or older and want to participate in this study

- I wish not to participate

B1.3. Contact Information

Thank you very much in advance for answering the questions. As mentioned in the introduction, I need your contact information for the second survey. The second survey will take 1 minute and I will give away 2 vouchers of 10 euros, which you can win if you fill in the second survey.

How can I reach you in two weeks?

You can fill in your (student) e-mail, telephone number, Facebook, or Instagram so that I can send the second survey. All answers will be saved and processed anonymously, and your contact information will be deleted immediately afterward.

[A text box appeared]

Do you think you will fill in the second survey?

- Yes
- No

B1.4. Explanation of the DI-index

The survey will consist of several questions that will take the following form.

"When do you value both options equally?

Receiving (or losing) €40 **today** or €50 in ***t* weeks**".

Thus, there are always two options. Both options have a fixed reward (money or leisure time), but the second option has an unknown time (time "*t*"). If t is small, say 1 week, it is more likely that you prefer €50. However, if t is big, say 100 months, the chance is high that you prefer €40. I want to know when you value both options equally. You fill in the value of "t" so that you like both options equally. There are four different variants: you can receive or lose money or leisure time.

As a control question, what does "t" stand for in the example above?

- A monetary amount
- The time that I have to wait to receive 50 euros
- The “t” stands for temperature

In this hypothetical experiment, I can:

- Win or lose money or leisure time depending on the question
- Only win money
- Only lose leisure time

B1.5. DI-index Money Experiment

[The DI-index questions were answered with a dropdown menu. The first screen was the number of weeks. If we take the first indifference of €40 today ~ €50 in t_0 weeks. Then dropdown menu to elicit t_0 started in the same week continued till 52 weeks. If the second

indifference was €40 in 4 weeks ~ €50 in t_0 weeks, then the dropdown menu to elicit t_0 started at 5 weeks and continued till 56 weeks. If the subject indicated that he would want to wait longer than 52 weeks, a new menu appeared with months. The subject could then choose to from 13 to 36 months in the first indifference. If the subject wanted to wait longer than 36 months, he could answer the number of months in a text entry box.

The following text was used:]

When do you value both options equally?

Receiving €40 today or €50 in t weeks

[After which the dropdown menu continued. The other indifference points were:

€40 in 0 weeks ~ €50 in t_0 weeks;

€40 in 2 weeks ~ €50 in t_2 weeks;

€40 in 4 weeks ~ €50 in t_4 weeks;

€40 in 52 weeks ~ €50 in t_{52} weeks;

-€50 in 0 weeks ~ -€60 in t_0 weeks;

-€50 in 2 weeks ~ -€60 in t_2 weeks;

-€50 in 4 weeks ~ -€60 in t_4 weeks;]

B1.6. DI-index Time Gains Experiment

Please imagine that you work 4 days per week for 8 hours per day at a company, and today is Friday morning. Normally, you work every Friday.

Fortunately, the boss has seen that you did finish all your work in the prior period. She calls you and gives you two options to compensate for your finished work. The first option is that you can take 4 hours off today on your workday Friday. The second option is that you take 8 hours off later (in t weeks) on another Friday.

When do you value both options equally?

Take 4 hours off **today** or 8 hours in ***t* weeks**

[A dropdown menu appeared to answer the question. The text of two weeks later is identical to this text. However, "today" is replaced by "two weeks".]

B1.7. DI-index Time Losses Experiment

Please imagine that you work 4 days per week for 8 hours per day at a company, and today is Friday morning. Normally, you are free every Friday.

Unfortunately, the boss has seen that you did not finish all your work in the prior period. She calls you and gives you two options to compensate for your unfinished work. The first

option is that you can work 4 hours today on your free Friday. The second option is that you work 8 hours later (in t weeks) on another Friday.

When do you value both options equally?

[A dropdown menu appeared to answer the question. Again, the text of two weeks later is identical to this text. However, “today” is replaced by “two weeks”.]

B1.8. Brief Self-control Scale

Using the scale provided, please indicate how much each of the following statements reflects how you typically are.

		not all like me — *very much like me*
	1. I am good at resisting temptation.	1——2——3——4——5
(R)	2. I have a hard time breaking bad habits.	1——2——3——4——5
(R)	3. I am lazy.	1——2——3——4——5
(R)	4. I say inappropriate things.	1——2——3——4——5
(R)	5. I do certain things that are bad for me, if they are fun.	1——2——3——4——5
	6. I refuse things that are bad for me.	1——2——3——4——5
(R)	7. I wish I had more self-discipline.	1——2——3——4——5
	8. People would say that I have iron self- discipline.	1——2——3——4——5
(R)	9. Pleasure and fun sometimes keep me from getting work done.	1——2——3——4——5
(R)	10. I have trouble concentrating.	1——2——3——4——5
	11. I am able to work effectively toward long-term goals.	1——2——3——4——5
(R)	12. Sometimes I cannot stop myself from doing something, even if I know it is wrong.	1——2——3——4——5
(R)	13. I often act without thinking through all the alternatives.	1——2——3——4——5

[(R) stands for Reversed Items and means that the score has to be reversed to get a correct score. The questions are integrally taken from Tangney et al. (2004).]

B1.9. Self-Control Questions

[The following questions could be answered through a text entry box unless differently specified]

How many hours of sport did you do over the last 7 days?

How many hours of sports will you do over a 7-day period, 2 weeks from now?

How many hours of school work did you do over the last 7 days?

How many hours of school will you do over a 7-day period, 2 weeks from now?

How many glasses of alcohol did you drink over the last 7 days?

How many glasses of alcohol will you drink over a 7-day period, 2 weeks from now?

B1.10 Personal Characteristics

How old are you?

What is your gender?

- Female
- Male
- Other

Are you an economics or business student?

- Yes
- No

Do you live in the same house as your parents?

- Yes
- No

Do you smoke?

- Every now and then
- Every day
- No

On how many days do you drink alcohol

- 0 days per week
- 1 day per week
- 2 days per week
- 3 days per week
- 4 days per week
- 5 days per week
- 6 days per week
- 7 days per week

What is your current GPA? (i.e., with one decimal)

B1.11. Contact Information

Thank you very much for answering all the questions. As mentioned in the introduction, I need your contact information for the second survey. This survey will take 1 minute and I will give away 2 vouchers of 10 euros, which you can win if you fill in the second survey.

Will you fill in the second survey?

- Yes
- No

How can I reach you in three weeks?

You can fill in your (student) e-mail, telephone number, Facebook or Instagram so that I can send the second survey.

B1.12. Second Survey Questions

What is the ID number I assigned to you?

(Please do not provide your government ID-number. In case you don't know the ID number I assigned to you, you can enter your e-mail or phone number how I reached you. But preferably, you enter your ID number.)

(Only answer the number of hours or glasses. Only 1 or 2 digits are possible.)

How many hours of sport did you do over the last 7 days?

How many hours of school work did you do over the last 7 days?

How many glasses of alcohol did you drink over the last 7 days?