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What is a better predictor of self-control problems in physical activity decisions: Changes in impatience versus self-control

Name student: F. I. (Floor) Boonen
Student ID number: 430755
Supervisor: Prof. Dr. K. I. M. (Kirsten) Rohde
Second assessor: to be determined
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Abstract

Self-control problems in physical activity decisions have been extensively researched as they can have damaging health consequences. Economists explain self-control problems by changes in impatience, while psychologists use the concept of self-control. This thesis examines both explanations and compares them by using the DI-index and the Brief Self-Control Scale to explain self-control problems in physical activity decisions. As previous research focused on one of the two factors in isolation, little is known about which factor better predicts self-control problems in physical activity decisions. An online experiment was used to gather data from 195 subjects. OLS regressions with robust standard errors and ordered logit models found preliminary evidence of a statistically significant correlation between the DI-index and self-control problems in physical activity decisions. Moreover, a statistically significant correlation was detected between self-control and the dependent variable. Since the model that includes self-control fits the data better than the model that includes the DI-index, self-control was found to be a better predictor of self-control problems in physical activity decisions than changes in impatience. Future research in this area is required to see if these results are robust.

Keywords: self-control, Brief Self-Control Scale, changes in impatience, DI-index, self-control problems, physical activity

Preface

Acknowledgements

This master's thesis marks the end of my academic career at the Erasmus University during which I was able to explore various disciplines and specialized in psychology, business, economics and sustainability. I would like to give a special thank you to my coach Prof. dr. K.I.M. (Kirsten) Rohde for guiding me throughout this process with valuable and prompt feedback and advice. I enjoyed our meetings during which I gained important insights and background knowledge on the topic as we discussed my thesis progress and process. Furthermore, I would like to thank my friends and family for supporting me throughout the writing of this thesis.

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1. Introduction

Physical activity is essential in the prevention of cardiovascular disease, cancer, diabetes, hypertension and osteoporosis (Waburton et al., 2006). Physical inactivity, on the other hand, has damaging health consequences and was identified as the fourth leading risk factor of death worldwide (Kohl et al., 2012). Nonetheless, 31 per cent of the worldwide population does not meet the minimum recommendation for physical activity (Hallal et al., 2012). This leads to increased national health care costs (World Health Organization, 2004; Colley et al, 2011; de Souza de Silva et al., 2019) and imposes a significant burden on societies and health care systems (Kohl et al., 2012). For instance, in 2010 in the Netherlands, 1.3 billion euros was spent on illnesses caused by physical inactivity which translates into 1.8 per cent of total health care expenditures (Rijksinstituut voor Volksgezondheid en Milieu (RIVM), 2012). Furthermore, engaging in physical activity regularly can have a positive direct and indirect effect on an individual's earnings (Kosteas, 2012). The direct effect postulates that exercise leads to improved mental functioning (Etnier et al., 1997; Tomporowski, 2003; Hillman et al., 2008), psychological conditions and higher energy levels that increase productivity resulting in higher earnings. Lechner (2009) described an indirect impact in which exercise can serve as a signal to potential employers that the individual is focused and disciplined, resulting in increased pay.

As engaging in physical activity regularly has multiple benefits and a lack thereof may pose a serious burden on individuals themselves and society at large, many people aspire to be more physically active (Withall et al., 2011). However, although individuals may want to spend more time engaging in physical activities as they plan to go to the gym, they often refrain from going (Rohde, 2019). Thereby, self-control problems in decisions regarding physical activity are revealed by the difference between this individual's ideal action (going to the gym) and his actual action (not going to the gym). An example of such a self-control problem is that one may plan to go to the gym in one week, but when the next week arrives, refrains from going.

The goal of the current study is to research which factor can predict self-control problems in physical activity decisions by combining literature on self-control problems, physical activity and the economic as well as the psychological determinants of self-control problems.

Various scholars from the economic and psychological domains attempted to explain self-control problems in decisions regarding physical activity (Kosteas, 2015). Firstly, economists theorise that time-preferences and changes in impatience cause self-control

problems in physical activity decisions. Another explanation is provided by psychologists who argue that self-control affects an individual's engagement in physical activity (Bray et al, 2008; Stadler et al., 2009; Dishman et al, 2014; Gerber et al., 2015; Hagger et al., 2010; Englert, 2016) and causes self-control problems in physical activity decisions. Both views are extensively discussed in the theoretical framework.

Although both economists and psychologists researched the determinants of self-control problems in decisions regarding physical activity, several gaps in the literature remain that will be addressed in the present study. First of all, to the best of my knowledge no previous study has compared the economists' and psychologists' explanations or tested both views on the same subjects. Additionally, from an economic viewpoint, the correlation between changes in impatience and self-control problems remains theoretical as experimental research was unable to detect this relationship (Rohde, 2019; Lipman & Attema, 2020). Therefore, future research was requested to look into this correlation (Ashraf et al., 2006; Rohde, 2019). Thirdly, previous studies used models of time preference that were not able to provide pure measures of changes in impatience which is the main driver behind self-control problems (Rohde, 2019). To fill these gaps in the literature, this study compares the economic and psychological predictors. Moreover, it uses the recently developed decreasing impatience (DI)-index to detect the potential correlation between changes in impatience and self-control problems in physical activity decisions.

The present study is relevant from a societal perspective as it has implications for policies aimed at improving population health and reducing health care costs through increased levels of physical activity. Thereby it addresses the urgent request made by Guthold et al. (2018) for prioritising and scaling up policies aimed to increase the amount of time spent on physical activities. The importance of such policies increased since the COVID-19 pandemic struck in December 2019 (Pan et al., 2020). Several lockdown measures that were used as a means to prevent the virus from spreading, drastically decreased levels of physical activity as people for instance no longer had to transport to and from their jobs (Sharp et al., 2022). At the same time, gyms and other sports facilities were closed. Thereby, physical activity levels that were already below health recommendations, further decreased by 30 per cent (Strain et al., 2022). To develop a policy that is aimed at increasing physical activity, Harris and Bray (2019) reported that increased comprehension of the processes that underlie decision-making about physical activity is essential. Thus, a better understanding of the relation between changes in impatience, self-control and self-control problems in physical activity decisions may help shape policies aimed at increasing physical activity levels. Moreover, if one factor better

predicts self-control problems, future policies could focus on addressing that specific factor. Therefore, the following research question was formulated:

Do changes in impatience and self-control predict self-control problems in physical activity decisions? Does their predictive power differ?

To formulate an answer to the research question, this paper is structured as follows. In section 2, the current study is positioned in the existing body of literature as the main concepts and hypotheses are discussed. Section 3 presents the conceptual framework. In section 4 the experiment used to answer the research question is described. Section 5 contains a full explanation of the data, variables and statistical methods. In section 6 the results are presented and used to answer the hypotheses. In section 7, a summary of the main findings and an answer to the research question are provided. This section also includes the limitations of the study, and it provides suggestions for future research as well as some practical implications.

2. Theoretical framework

This section aims to provide an understanding of the core concepts and how self-control problems in physical activity decisions are explained in the literature. A distinction is made between the economic and psychological determinants of these decisions. Additionally, hypotheses are formulated throughout the section to provide a structured approach to answering the research question.

2.1 Background of core concepts

To be able to better understand how changes in impatience and self-control relate to self-control problems in decisions concerning physical activity, definitions and background information on self-control problems and physical activity are provided.

2.1.1 Physical activity

Physical activity is defined as ‘any bodily movement produced by the skeletal muscles that results in energy expenditure’ (Caspersen et al., 1985, p. 126). According to the World Health Organization (WHO) (2020) physical activity encompasses all forms of movement, whether it is done for recreation, for transportation from point A to point B, or as part of one's job. It includes walking, cycling, sports, active recreation and play at any skill level and for enjoyment (World Health Organization, 2020). Such activities can be divided

into moderate- and vigorous-intensity activities (World Health Organization, 2020). Moderate activity is defined as any activity that causes an increase in breathing and heart rates (e.g., brisk walking or bicycling) (Physical Activity Guidelines Advisory Committee, 2008). Vigorous activity is defined as any activity that induces significant increases in breathing and heart rates (e.g., running or aerobics) (Will et al., 2011).

2.1.2 Self-control problems in physical activity decisions

Various scholars developed theories to explain what self-control problems are and how they arise. These include the time-inconsistent framework (Strotz, 1955; Laibson, 1997), the model of temptation and self-control (Gul & Pesendorfer, 2001), the model of triggered mistakes (Bernheim & Rangel, 2004) and dual self-models (Thaler & Shefrin, 1981; Benhabib & Bisin, 2005; Fudenberg & Levine, 2006). All these theories contend that self-control problems share a similar structure (Ameriks et al., 2007). They imply that self-control problems exist when there is a discrepancy between an agent's ideal and actual action. Although an agent wants to take an ideal action, there is some temptation that makes him deviate from this ideal (Ameriks et al., 2007). Thereby, the actual action depicts a balance between the ideal action on the one hand and the temptation on the other (Ameriks et al., 2007). Following that line of reasoning, self-control problems in physical activity decisions exist when the ideal action is to engage in physical activity, but the individual is tempted and does not engage in physical activity. Thereby, the actual action deviates from the ideal action due to some temptation and a self-control problem in the decision regarding physical activity is revealed.

In the remainder of this section, both the economic and psychological determinant of self-control problems in physical activity decisions are discussed and several hypotheses are formulated.

2.2 Economic determinant of self-control problems in physical activity decisions

2.2.1 Time preference

The economic explanation of self-control problems is centred around the concept of time preference. More specifically, economists argue that time-inconsistent preferences lead to self-control problems. Time preferences are preferences over intertemporal trade-offs (Cohen et al., 2020) as they require the consideration of decision outcomes at various points in time (Rohde, 2019). They are time-inconsistent when preferences for decisions change

over time (Hoch & Loewenstein, 1991) from the long-term outcome to the short-term outcome (Sayman & Öncüler, 2009). Previous research shows that time-inconsistent preferences can lead to decisions that are in conflict with decision makers' long-term interests, resulting in inferior consumption choices (DellaVigna & Malmendier, 2004; DellaVigna & Malmendier, 2006; Elliaz & Spiegler, 2006; Heidhues & Köszegi, 2010), saving too little (Laibson, 1997; O'Donoghue & Rabin, 1999, Madrian & Shea, 2001), suffering from addictions (Gruber & Köszegi, 2001; 2004) and choosing unhealthy diets (Read & Van Leeuwen, 1998).

Several studies used time preferences to explain individuals' levels of physical activity (Adams & Nettle 2009; Bradford, 2010; Daugherty & Brase 2010; Hunter et al. 2018; Kosteas 2015; Shuval et al. 2017; Eberth et al., 2020). Time preferences are revealed in health decisions, as for instance, the decision to go to the gym has consequences at various points in time. Moreover, health decisions involve a trade-off between immediate costs and long-term benefits (Eberth et al., 2020). Costs can be both monetary and non-monetary. Present costs include financial costs and costs in terms of time, as one has to pay for instance for a gym membership and has to give up time otherwise spent on for instance social interactions to go to the gym with the longer-term benefit of increased life expectancy (Eberth et al., 2020). Inconsistent time preferences concerning physical activity arise when one's preferences shift from a long-term outcome (e.g. wanting to lose weight) to a short-term outcome (e.g. wanting to lay on the couch). More specifically, an individual may plan to engage in physical activity next week as the costs occur in the future but may refrain from doing so when next week arrives as the costs have become immediate costs (Eberth et al., 2020). The shift from the long-term outcome to the short-term outcome reflects a time-inconsistent preference, as today's preference for next week's decision has changed once next week arrives.

As self-control problems arise when preferences shift over time (Ariely & Wertenbroch, 2002), they can be viewed as an embodiment of time-inconsistent preferences. Self-control problems exist when an agent deviates from an ideal action to an actual action due to some temptation. In our example, the ideal action is to go to the gym. However, the person is tempted to lay on the couch and thereby his actual action deviates from his ideal action which is to go to the gym. To develop a deeper understanding of how self-control problems can result from time-inconsistent preferences, the drivers behind time-inconsistent preferences as well as ways to measure time-inconsistencies will be discussed in the following subsections.

2.2.2 Decreasing impatience and time-inconsistent preferences

Time-inconsistent preferences are mainly driven by changes in impatience (Rohde, 2019). To develop a better understanding of what changes in impatience are, some background information on impatience, impatience types and impatience levels is provided.

Impatience entails that the utility of present outcomes is weighted more than the utility of future outcomes (Baucells & Sarin, 2007). Consequently, people are disproportionately attracted to immediately available rewards (Hoch & Loewenstein, 1991). Moreover, impatient individuals dislike delays of favourable outcomes and like delays of unfavourable outcomes (Rohde, 2019). Thereby, impatience can result in a momentary and involuntary departure from the consumer's dominant and long-term preferences (Hoch & Loewenstein, 1991).

There are three types of impatience including constant, increasing and decreasing impatience. Each impatience type affects decisions differently. Increasing and decreasing impatience can lead to time-inconsistent behaviours and self-control problems (Strotz, 1955). The level of impatience refers to how impatient an agent is for one decision (Rohde, 2019). When one behaves according to a high level of impatience, a task is postponed once (Rohde, 2019). Changes in impatience refer to deviations from constant impatience in the form of increasing and decreasing impatience and can lead to task delays on a regular basis (Rohde, 2019). Moreover, changes in impatience are theorised to cause time-inconsistent preferences and self-control problems (Strotz, 1955; Rohde, 2019).

To develop a better understanding of the consequences of changes in impatience on the time-consistency of behaviour, the three types of impatience and their effect on decision making are discussed next.

Many researchers and other economic bodies assume that agents act according to constant impatience. *Constant impatience* implies that in case a person is indifferent between receiving outcome x at time s and receiving outcome y at a later point in time t, this preference remains unchanged if both outcomes are postponed by the same amount of time τ. It holds if for all $x, y \succ 0$, all $s < t$, and all $\tau > 0$ with $s, t, \ s + \tau, \ t + \tau \in T$ we have that $(s : x) \sim (t : y)$ implies that $(s + \tau : x) \sim (t + \tau : y)$ (Rohde, 2019). Koopmans (1960) proved that constant impatience implies constant discounting. Constant discounting entails that individuals discount the future at a constant rate (Frederick et al., 2002). This means that delaying two outcomes by the same amount of time should not change preferences between the outcomes (Frederick et al., 2002). Thereby, agents who discount the future at a constant

rate will behave time consistently as preferences will not change over time (Frederick et al., 2002).

Deviations from constant impatience in the form of decreasing and increasing impatience are frequently reported (Loewenstein, 1987; Sayman & Öncüler, 2009; Scholten & Read, 2006; Takeuchi, 2011; Bleichrodt et al., 2016) and lead to time-inconsistent behaviour (Rohde, 2019). *Increasing impatience* implies that agents are less willing to wait for a larger outcome when a common delay τ is added (Bleichrodt et al., 2016). It holds if for all $0 < x < y$, $\tau > 0$, $s < t$ and $(s : x) \sim (t : y)$ then $(s + \tau : x) \geq (t + \tau : y)$ (Bleichrodt et al., 2016). Thus, individuals who behave increasingly impatient are more impatient for more distant larger rewards and their implied preferences are reversed as time passes (Rohde, 2019). Increasing impatience is reflected through an increasing discount rate (Frederick et al., 2002).

Decreasing impatience holds in two cases. First of all, if for all $s < t$, and all $\tau > 0$ with $s,\ t,\ s + \tau,\ t + \tau \in T$ and $y > x > 0$ we have that $(s : x) \sim (t : y)$ implies $(s + \tau : x) \preccurlyeq (t + \tau : y)$. Secondly, if for all $s < t$, and all $\tau > 0$ with $s,\ t,\ s + \tau,\ t + \tau \in T$ and $y < x < 0$ and $(s : x) \sim (t : y)$ implies $(s + \tau : x) \succcurlyeq (t + \tau : y)$. This means that in case both outcomes are desirable and delayed by the same time factor τ, people are more willing to wait for the better outcome (Bleichrodt et al., 2016). Moreover, decreasingly impatient agents are more patient in more distant trade-offs, as they are more patient in the trade-off between t and $t + 1$ as t increases (Noor, 2009). Thereby, they discount the future at a decreasing rate (Frederick et al., 2002). Consider the following example for which we assume monotonicity, *x = 40 euros*, *y = 50 euros*, *s = today*, *t = next week* and the common delay is one day. From today's perspective, a decreasingly impatient individual would prefer receiving *50 euros* in one week and one day over receiving *40 euros* tomorrow. However, decreasing impatience also entails that as the reward moment approaches, the weight of the instant reward increases. Thereby, although an individual prefers the *50 euros* in one week and one day over *40 euros* tomorrow, when tomorrow arrives this individual prefers to receive *40 euros* that day. This is a time-inconsistent preference as over time this preference has shifted. The time-inconsistent preference reflects a self-control problem if receiving *50 euros* would be the ideal action and receiving *40 euros* would be the actual action.

Although there is some indirect evidence of increasing impatience (Attema, 2012; Attema et al., 2013) the majority of empirical research found that subjects behave according to decreasing impatience for health decisions (Redelmeier & Heller, 1993; Bleichrodt &

Johanesson, 2001; van der Pol & Cairns, 2002; Khwaja et al., 2007; van der Pol & Cairns, 2011; Bleichrodt et al., 2016). Since decreasing impatience causes time-inconsistent preferences and self-control problems, and since self-control problems exist in physical activity decisions, we can reason that changes in impatience can explain self-control problems in physical activity decisions. However, limited evidence concerning the correlation between changes in impatience and field behaviour is available (Rohde, 2019). One reason for this is the fact that few tools are available that can measure changes in impatience. Therefore, in the next paragraph, some of the most commonly used time preference measurement tools and why they are not suited to measure changes in impatience are explained.

2.2.3 Measuring time preferences

Over the years various tools were developed and used to measure time preferences. These time preference measurements are typically based on utility curvature, impatience levels, and changes in impatience levels. As a result, they are unable to determine which of these components is responsible for the observed field behaviour. The most commonly used measures as well as their advantages and disadvantages are discussed in the following subsections.

2.2.3.1 The discounted utility model

The first widely acknowledged measure of time preferences is the discounted utility (DU) model that was introduced by Samuelson in 1937. The classical DU model assumes that all motives underlying intertemporal choice are represented by the discount rate. Moreover, it specifies intertemporal preferences of consumption patterns across time as $(c_t, \dots, c_T)$ where c_t represents consumption now and c_T represents consumption in the most distant future. Intertemporal utility (U^t) depends on the utility of all consumption streams from now *(t)* until the most distant future *(T)*, discounted by the discount function that varies over time and is given by the following function:

$$U^t(c_t, \dots, c_T) = \sum_{k=0}^{T-t} D(k)u(c_{t+k})$$

Where $D(k) = (\frac{1}{1+\rho})^k$

In this model, T again represents the most distant future outcome, *k* represents the temporal distance between the present and the moment of utility and $u(c_{t+k})$ is the utility perceived at point *t+k*. Furthermore, *D(k)* is the discount function, in which ρ represents the discount rate or pure rate of time preference. This function discounts future utilities at a constant rate where future utilities are weighted less heavily compared to the current utility due to the discount function's exponential character. As the discount rate is constant, the model predicts that agents behave according to constant impatience and have time-consistent preferences (Strotz, 1955; Frederick et al., 2002). Thereby, individuals are expected to do exactly what they plan to do (Cohen et al., 2020).

The major disadvantage of the model is that it cannot estimate discount factors for people who deviate from constant impatience (Bleichrodt et al., 2016) while people tend to behave according to decreasing impatience for health decisions. Thereby, the DU model is unable to explain empirical patterns that reflect time-inconsistencies and explain self-control problems (Cohen et al., 2020) in physical activity decisions.

2.2.2.2 Hyperbolic discounting models

As a reaction to the limited applicability of the DU model to deviations from constant impatience, hyperbolic discounting models were developed (Bleichrodt et al., 2016).

There are two types of hyperbolic discounting models: the quasi-hyperbolic discounting model and the generalised hyperbolic discounting model. The most commonly used version is the quasi-hyperbolic discounting model as developed by Phelps and Pollack (1968) and is given by the following discount function:

$$D(t) = \begin{cases} 1, & t = 0 \\ \beta\delta^t, & t > 0 \end{cases}$$

In this model, δ is a constant discount factor and captures the difference between future moments in time. A preference for the smaller, sooner alternative over the larger, later option is indicated by smaller values of δ. β represents the present-bias parameter which indicates that an agent attaches more weight to the present than to the future (Bleichrodt et al., 2016). It accounts for time-inconsistency by giving less weight to the later ($t > 0$) but not to the immediate ($t = 0$) outcome. Thereby, it leads to decreasing impatience in the first period and constant impatience in future periods (Bleichrodt et al., 2016). Moreover, smaller values of β lead to more time-inconsistency, while the model does not demonstrate time-inconsistency when $\beta = 1$.

The generalised model of hyperbolic discounting was proposed by Loewenstein and Prelec (1992). It is given by the following discount function:

$$D(t) = (1 + \alpha t)^{-\frac{\beta}{\alpha}} \qquad for\ \alpha, \beta > 0$$

In this function, α is a coefficient that captures decreasing impatience (Bleichrodt et al., 2016). If $\alpha = 0$ the model predicts constant discounting and the larger α is, the more this person deviates from constant discounting. In this model, decreasing impatience occurs in all time periods. β is a constant discount factor.

Previous research found that hyperbolic discounting fits the health domain better than both constant discounting and quasi-hyperbolic discounting (Bleichrodt & Johannesson, 2001; Van der Pol & Cairns, 2011). However, although hyperbolic discounting models make better predictions than the DU model, there are several drawbacks related to the use of these models. First of all, hyperbolic discounting models are unable to disentangle the effects of changes in impatience from levels of impatience (Rohde, 2019). This is problematic since, as was mentioned earlier, changes in impatience are regarded as the primary driver behind time-inconsistencies and self-control problems. With hyperbolic discounting models, the effect of the main driver of self-control problems can thus not be examined in isolation. Secondly, most hyperbolic discounting models assume linear utility. As utility is rarely linear (Pratt, 1964), this assumption may distort the measurement of time preferences (Broome, 1991; Loewenstein & Prelec, 1993; Attema et al., 2012). Finally, these models can only account for a restricted range of impatience as sharply decreasing or any increasing impatience cannot be captured (Rohde, 2019). In conclusion, hyperbolic discounting measures have limited applicability for this study, as agents behave according to decreasing impatience in the health domain for which these methods may provide biased estimates (Bleichrodt et al., 2016).

2.2.2.3 CADI and CRDI

The constant absolute decreasing impatience (CADI) discounting and constant relative decreasing impatience (CRDI) discount functions were developed by Ebert and Prelec (2007), and Bleichrodt et al. (2009) in response to criticism on hyperbolic discounting models. An advantage of these models is that CADI and CRDI discount functions can handle any degree of decreasing or increasing impatience while hyperbolic discounting models are not flexible enough to accommodate increasing impatience or strongly decreasing impatience. Additionally, CADI and CRDI discount functions are flexible enough for

analyses at the individual level whereas hyperbolic models are not due to their limited flexibility in capturing all degrees of impatience.

The discount function *D(t)* is a CADI discount function if there are constants $r > 0$ and *c*, and the normalisation constant $k > 0$ such that*:*

$$for\ c > 0, \quad D(t) = ke^{re^{-ct}};$$
$$for\ c = 0, \quad D(t) = ke^{-rt};$$
$$for\ c < 0, \quad D(t) = ke^{-re^{-ct}}.$$

The discount function *D*(t) is a CRDI discount function if there are constants $r > 0$ and *d*, and the normalisation constant $k > 0$ such that:

$$for\ d > 1, \quad D(t) = ke^{rt^{1-d}}\ (only\ if\ 0\ \notin T);$$
$$for\ d = 1, \quad D(t) = kt^{-r} (only\ if\ 0\ \notin T);$$
$$for\ d < 1, \quad D(t) = ke^{-rt^{1-d}}.$$

The parameter *k* is a scaling factor and does not affect preferences (Doyle, 2013). Parameter *r* represents the power of the discount function and determines the degree of discounting (Doyle, 2013). The constant, *c* for CADI and *d/t* in CRDI represent the degree of decreasing impatience (Doyle, 2013).

A disadvantage of the CADI and CRDI functions is that they require unique and complicated computation of impatience at the individual level since they rely on complex logarithmic functions (de Roos & Sarafidis, 2009). Thereby, these functions are a complicated way to obtain a comparative measure of impatience.

2.2.2.4 DI-index

All previously discussed time preference measures, simultaneously depend on utility curvature, the level of impatience and changes in the level of impatience (Rohde, 2019). Recently, a new tool to measure impatience called the Decreasing Impatience (DI)-Index was introduced by Rohde (2019). This tool overcomes the drawbacks of the previously discussed models. Firstly, it was designed to obtain pure measures of changes in impatience for decreasing as well as increasing impatience (Attema & Lipman, 2020). Additionally, no assumptions of linear utility need to be satisfied (Rohde, 2019). Finally, the DI-indices of different individuals are easily comparable.

The DI-index can be computed from two indifferences in the following way. For $x, y \neq 0,\ s < t, \sigma > 0\ and\ \tau\ with$:

$$(s, x) \sim (t, y) \text{ and}$$
$$(s + \sigma, x) \sim (t + \tau, y)$$

The DI-index can be computed using the following formula:

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

In this formula, $(t - s)$ reflects the level of impatience. Then, for a given t and s, $(\tau - \sigma)$ represents the degree of decreasing impatience. The larger the difference between τ and σ, the larger the degree of decreasing impatience. The DI-index takes $\tau - \sigma$ relative to σ and corrects for the level of impatience by dividing this by the difference between t and s. For constant discounting, an agent is assumed to have constant impatience $\tau = \sigma$. Thereby, constant impatience is reflected by a DI-Index of zero. Increasing impatience is reflected by the DI-index through values smaller than zero, with lower values indicating more increasing impatience. For decreasing impatience, the DI-index will be larger than zero, with larger values indicating more decreasing impatience.

Thus, as the DI-index is able to capture the degree of decreasing impatience and since this is thought to drive self-control problems in the health domain, the DI-index is used to measure the degree of changing impatience. Furthermore, the DI-index is able to capture all deviations from constant impatience as opposed to previous models (Attema & Lipman, 2020). This is useful as decreasing impatience is most commonly found in the health domain and more decreasing impatience refers to a larger deviation from constant impatience (Rohde, 2019). Moreover, the larger the degree of decreasing impatience, the more likely an agent is to behave time-inconsistently (Rohde, 2019). Thereby, the larger the level of decreasing impatience the more likely an agent is to suffer from self-control problems in decisions regarding physical activity. Thereby, the following hypothesis is formulated:

Hypothesis 1: The DI-index is positively correlated with self-control problems in physical activity decisions.

2.3 Psychological determinant of self-control problems in physical activity decisions

Although economists propose that changes in impatience are the main driver behind self-control problems, the school of psychology uses self-control to explain self-control problems in decisions regarding physical activity. Before describing how self-control may lead to self-control problems in decisions regarding physical activity, background information on the concept of self-control and how it is used in the field of psychology is provided.

Previous research identified two theories of self-control. Firstly, the dispositional theory of self-control assumes that self-control is an individual characteristic or trait related to various behaviours (Tangney et al., 2004). It is believed that it will remain relatively stable throughout time (Gottfredson & Hirschi, 1990; Rothbart et al, 2003).

More recently, the state model of self-control emerged (Baumeister et al., 2007). This model postulates that self-control is not a stable characteristic, but rather a limited resource that is consumed by usage and depletes over time (Baumeister et al., 1998). Despite the state model's popularity, it received major criticism. A multi-laboratory replication failed to provide evidence for the hypothesised decrease in self-control (Hagger et al., 2016). This led to a multitude of analyses and discussions concerning the usage of the state model (e.g., Baumeister & Vohs, 2016; Blazquez et al., 2017). Therefore, this study will use the dispositional or trait model of self-control as it remains the most commonly accepted theory of self-control.

Although various studies provide definitions of trait self-control (Duckworth & Kern, 2011), researchers acknowledge that self-control can be described as one's ability to override dominant responses and regulate emotions, thoughts and behaviours (Carver & Scheier, 1981; 1982; Rothbaum et al., 1982; Bandura, 1989; Metcalfe & Mischel, 1999; Vohs & Baumeister, 2004). More specifically, according to Baumeister (2002; 2007; 2014), the concept refers to the act of overriding dominant responses to pursue long term goals. This implies that self-control involves overriding one's dominant responses repeatedly to reach a desired end.

High self-control was linked to positive behavioural outcomes and low self-control to negative outcomes in different areas including in the health domain (e.g., Ariely & Wertenbroch, 2002). Tangney and colleagues (2004) developed a self-control measure, the widely used Self-Control Scale. With this tool, they found that individuals with high levels of self-control reported less substance abuse, psychopathology, eating disorders and verbal

aggression. On the contrary, individuals with low self-control reported increased alcohol use, increased tobacco use, increased marijuana use, increased saturated fat intake (Wills et al., 2001; Wills et al., 2006; Wills et al., 2007) and a higher probability of risky driving, committing fraud and using force (Pratt & Cullen, 2000; Vazsonyi et al., 2001).

Moreover, self-control was linked to physical activity. The capacity to stick to training regimes and exercise plans requires self-control (Martin & Bray, 2010). Following the conceptualization of self-control as described above, physical activity requires an individual to override dominant responses in order to reach long term fitness goals. This suggests that to attain long-term goals, agents must block out any distractions or temptations (Vohs & Heatherton, 2000). Thus, self-control must be exerted to overcome any obstacles to adherence in physical activity (Iso-Ahola, 2013).

A study by Bertrams and Englert (2013) also highlights the relevance of self-control for physical activity. The researchers measured trait self-control by asking subjects to state how frequently they planned and how often they actually worked out during the week. The findings revealed that higher levels of self-control resulted in smaller discrepancies between intended and actual behaviours. These results are supported by Toering and Jordet (2015) who found that higher levels of trait self-control increased exercise adherence as professional soccer players reported higher levels of self-control than the general population. A study on obesity and self-control that made use of four nationally representative data sets of the American population, was conducted by Fan and Jin (2014). The results indicated that individuals who lack self-control prefer to procrastinate for tasks that impose present costs and have delayed advantages, such as engaging in physical activity. Additionally, Wills et al. (2007) conducted a survey with a multi-ethnic sample in a metropolitan area and concluded that individuals with higher self-control engaged in sports more often compared to individuals with lower self-control. Moreover, Hagger et al. (2010) conducted a review on self-regulation and self-control in exercise with a specific focus on the strength-energy model. After reviewing a multitude of articles on this topic, they suggest that physical inactivity results from low self-control.

In literature, a general pattern appears: agents with higher self-control are less likely to suffer from self-control problems in decisions regarding physical activity compared to agents with lower self-control. Thereby, the following hypothesis was formulated:

Hypothesis 2: Self-control is negatively correlated with self-control problems in physical activity decisions

2.4 Economic versus psychological determinant of self-control problems in physical activity decisions

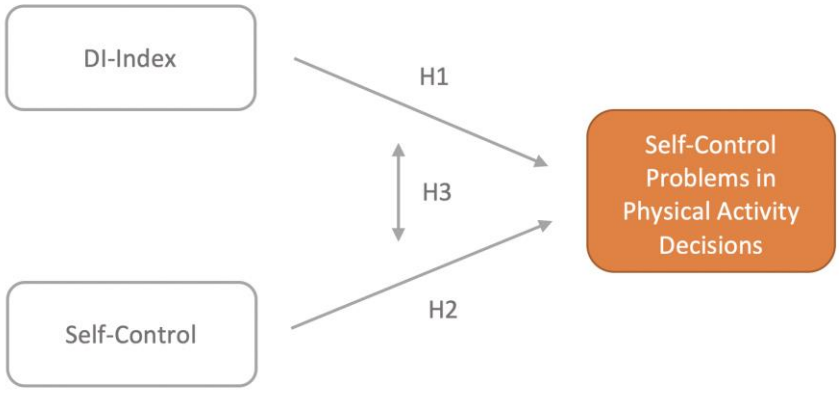
To the best of my knowledge, previous research focused on either the economic explanation, centred around changes in impatience, or the psychological explanation, centred around self-control, in attempts to explain self-control problems. As no previous study compared the aforementioned predictors, it remains unclear which domain is better able to explain self-control problems in decisions regarding physical activity. As such, there is no reason to believe that either changes in impatience or self-control are a better predictor of self-control problems in decisions regarding physical activity.

In case a correlation is found between one or both of the independent variables and the dependent variable, it may be interesting to compare which independent variable has more predictive power. The factor that has more predictive power would be better able to explain self-control problems in physical activity decisions. Isolating that determinant in future research on self-control problems in physical activity decisions may lead to a more thorough understanding of these problems. This may provide a useful first step in the process of finding a solution to physical inactivity and its damaging consequences on health and society. Therefore, the following hypothesis was formulated:

Hypothesis 3: There is no significant difference between the predictive power of the DI-index and self-control of self-control problems in physical activity decisions.

3. Conceptual framework

Based on the aforementioned literature and hypotheses, the conceptual framework below is developed in which an overview of the independent and dependent variables per hypothesis is presented.



Hypothesis 1: The DI-index is positively correlated with self-control problems in physical activity decisions.

Hypothesis 2: Self-control is negatively correlated with self-control problems in physical activity decisions.

Hypothesis 3: There is no significant difference between the predictive power of the DI-index and self-control of self-control problems in physical activity decisions.

4. Experiment

In this section, the experiment that was conducted to gather the data needed to test the hypotheses and formulate an answer to the research question is discussed.

4.1 Subject recruitment

Subjects were recruited through text message, Facebook, Whatsapp, friends and family. The experiment was conducted by means of an online survey in Qualtrics. The survey ensured respondent anonymity, which may encourage respondents to give more honest replies (Weaver & Prelec, 2013). As an incentive for participation, subjects could take part in a lottery for a twenty-euro Amazon gift card by filling out their email address at the end of the survey. In the remainder of this subsection, a description of the experiment is provided.

4.2 Introduction

At the beginning of the survey, subjects received a short introduction that explained some details on the length of the survey and ensured the anonymity of answers (Appendix A1). By proceeding to the first part of the survey, subjects confirmed that they were eighteen years or older and agreed that their answers could be used for the purpose of this study.

4.3 DI-index

Rohde (2019) proposed two ways to calculate the DI-index, of which the more practical method, procedure P, was used as it has several advantages over the theoretical method, Procedure T. First of all, procedure P is not chained which makes it possible to elicit the two indifferences independently from each other. Secondly, individuals are requested to report their preferences in the same time dimension. This eliminates the option of overweighting one dimension over the other. The third advantage of procedure P is that

indifferences that are elicited in the time dimension are easy to understand and describe for subjects (Rohde, 2019). Thereby, procedure P is better suited for the health domain than the theoretical method, procedure T (Attema & Lipman, 2020). Finally, the developer of the DI-index, Rohde, proposes to use procedure P in experiments (Rohde, 2019).

Following procedure P, first two indifferences were elicited. A choice list was used to collect the information required to elicit these indifference points. This method has the advantage of producing fewer inconsistencies than asking subjects for their indifference values directly (Bostic et al., 1990).

To make sure subjects understood the questions in the choice list, a short explanation of what was expected of the subjects and questions aimed at determining comprehension were provided before they were asked to fill out the choice list. After this explanation, a control question was asked to ensure subjects would understand the DI-index questions.

Next, the indifferences were elicited as follows. In the choice list, subjects were asked to indicate for which value of t they would be indifferent between receiving *40 euros* at time s and *50 euros* at a later point in time t. They faced the following three indifferences to determine the values of t_0 , t_2 and t_4 :

$$40\ euros\ today \sim 50\ euros\ in\ t_0\ weeks$$
$$40\ euros\ in\ 2\ weeks \sim 50\ euros\ in\ t_2\ weeks$$
$$40\ euros\ in\ 4\ weeks \sim 50\ euros\ in\ t_4\ weeks$$

Subjects were able to select values for t from a drop-down menu. For t_0 answer options ranged from zero to 51 weeks, for t_2 answer options ranged from two to 53 weeks and for t_4 answer options ranged from four to 55 weeks. As Rohde (2019) indicated that subjects may be willing to wait longer than 51, 53 or 55 weeks a more extreme option was added. Only if subjects selected that they were willing to wait for longer than the maximum number of weeks provided, they faced a follow-up question with answer options ranging from 13 to 24 months. The 13-month option was only included for t_0 as 53 and 55 weeks are both longer than 13 months. The full list of questions, including the control question, can be found in Appendix A2.

Finally, these indifferences were used to calculate the DI-indices using the formula that was discussed in subsection 2.2.2.4.

4.4 Self-control

In the second part of the experiment, subjects' self-reported self-control was measured using the Brief Self-Control Scale (BSCS) that was developed by Tangney et al. (2004). The BSCS is a shortened version of the Self-Control Scale that consists of 13 instead of 36 items (Tangney et al., 2004). For these 13 statements, subjects were asked to report how well each statement reflected 'how they are' on a 5-point Likert-scale ranging from (1) not all like me, till (5) very much like me. This measure was chosen as it measures self-control at one point in time in line with the dispositional or trait model. Moreover, it has high internal reliability and test-retest reliability, with a Cronbach's alpha of on average 0.84 and 0.87 (Tangney et al., 2004). Additionally, the test is highly valid (Tangney et al., 2004). A control question was added to ensure subjects were providing considerate answers. In Appendix A3 the full list of questions, including the control question, can be found.

4.5 Self-control problems in physical activity decisions

To the best of my knowledge, no existing survey allows for the measurement of self-control problems in physical activity decisions. Therefore, Ameriks et al.'s (2007) measure of general self-control problems was used and adjusted to detect potential self-control problems in physical activity decisions through a self-report questionnaire.

Amerik et al.'s (2007) measure uses a hypothetical scenario. It follows the idea that self-control problems exist when there is a discrepancy between an ideal and actual action by including three components: (i) ideal action (ii) temptation (iii) actual action. According to this method, self-control problems exist in case a certain temptation causes a discrepancy between the ideal and the actual action.

Following the method of Ameriks et al. (2007), the measure of self-control problems in physical activity decisions that was used in the present study consisted of four components. First, subjects were asked to estimate the ideal number of hours they would like to devote to physical activities over the next seven days (part a). Next, they were asked whether they would be tempted to deviate from this ideal (part b). Thirdly, subjects were asked to estimate the number of hours they would spend on physical activities over the next seven days if they were to give in to their temptation (part c). Finally, subjects were asked to state their most accurate forecast of the actual number of hours they would spend on physical activities over the next seven days (part d). An overview of the exact questions can be found in Appendix A4.

4.6 Control variables

To control for other factors that could influence the relationship between my variables of interest, several control variables were added. Studies on impatience, self-control, self-control problems and physical activity were consulted to determine which variables should be included for control. The variables that were controlled for most frequently in previous research, were used as control variables in the present study. These are the following variables: age, gender, education and ethnicity.

Studies that researched impatience control for gender as women exhibit lower degrees of impatience (Kirby & Maraković, 1996; Coller & Williams, 1999; McLeish & Oxoby, 2007). Studies on impatience also control for cognitive ability, as participants with higher cognitive ability report lower discount rates (Kirby et al., 2005; Jaroni et al., 2004; Frederick, 2005; Shamosh & Gray, 2008; Benjamin et al., 2013). Since the number of years of formal education completed by an individual is positively correlated to their cognitive function (Lövdén et al., 2020), the present study uses the highest level of completed education to control for cognitive ability.

Studies on self-control problems most commonly account for age and gender (Karoly & Ruehlman, 1982; Ameriks et al., 2007). Firstly, older individuals report fewer self-control problems (Ameriks et al., 2007). Moreover, females report self-control problems more frequently than males (Karoly & Ruehlman, 1982).

Age, gender, education and ethnicity are often included in studies on physical activity. Age, gender and ethnicity have previously been demonstrated to be important predictors of physical activity levels (e.g., Farrel & Shields, 2002; Södergren et al., 2008; Lechner, 2009; Ebert & Smith, 2010; Hagger et al., 2010; Pawlowski et al., 2011; Humpreys & Ruseki, 2011; Guthold et al., 2018). According to research into gender differences in physical activity participation, older males engage in physical activity more frequently than older women (Smith & Baltes, 1998; Newsom et al., 2004; Chad et al., 2005; Ammouri et al., 2007). Furthermore, physical activity decreases with age (e.g., August & Sorkin, 2011). Education was found to be positively related to physical activity, with lower education being associated with less engagement in physical activity (e.g., Shaw & Spokane, 2008). Finally, ethnicity and race are commonly controlled for. A study focused on ethnic differences in exercise behaviours reported that in comparison to whites, ethnic minorities engage less in exercise (August & Sorkin, 2011).

An overview of all the questions used to gather information on the control variables can be found in Appendix A5.

4.7 Randomization

As a means of randomization, two versions of the choice list were created to cancel out the order effect that was described by Harrison et al. (2005). One group of subjects faced the choice list in ascending order from $t_0 - t_2 - t_4$ and the other group faced the choice list in descending order from $t_4 - t_2 - t_0$. The randomization option in Qualtrics ensured that subjects were divided approximately equally over both versions.

5. Data analysis

This section describes the way in which data was analysed using Excel and STATA software. Moreover, it elaborates on the operationalization of variables and discusses the types of correlations and statistical tests that were used to test the various hypotheses.

5.1 DI-index

The DI-index was computed for each subject. As two indifferences were needed to elicit one DI-index, two DI-indices were elicited using either t_0 and t_2 or t_2 and t_4. The DI-indices were labelled *DI02* and *DI24* respectively. As previously mentioned, for values larger than zero, the DI-index reflects decreasing impatience (DI > 0), values lower than zero reflect increasing impatience (DI < 0) and a DI-index of zero reflects constant impatience (DI = 0) (Rohde, 2019). Larger values of this index, so a higher degree of decreasing impatience, imply that a subject more strongly satisfies decreasing impatience (Rohde, 2019).

5.2 Self-control

Self-control was operationalized through the variables *SCScore* and *SCLevel.* Self-control scores were calculated per subject by adding the value of all statements of the BSCS to one another. These scores are represented by the variable *SCScore*. *SCScore* is a continuous variable that can take on any value between 13 and 65. Based on values for *SCScore* subjects were divided into self-control levels, represented by the variable *SCLevel*. Subjects could either be grouped into the low self-control category, the middle self-control category, or the high self-control category. The 33.3 per cent of subjects with the lowest scores, were labelled as individuals with ‘low self-control’. The ‘high self-control’ category

consisted of 33.3 per cent of the individuals with the highest self-control scores. The middle category consisted of 33.3 per cent of individuals with scores in between the low and high self-control categories. *SCLevel* can take on any value between one and three (1 = high self-control, 2 = low self-control, 3 = medium self-control).

5.3 Self-control problems in physical activity decisions

Self-control problems in physical activity decisions were represented by both a continuous variable (*EI-Gap*) and a binary variable (*SCProb*).

Self-control problems in physical activity decisions were measured by taking the numerical difference between ideal consumption, the answer to part a (question 18), and expected consumption, the answer to part d (question 21). This difference was labelled the *EI-Gap*. The variable *EI-Gap* can take on any value higher than zero for which higher values indicate more severe self-control problems. Self-control problems in physical activity decisions are reflected by *EI-Gaps* larger or smaller than zero. The larger the distance from zero, the more severe the self-control problem. The variable *SCProb* takes on a value of zero if a person does not suffer from self-control problems in physical activity decisions and one if a person does suffer from self-control problems in physical activity decisions.

5.4 Control variables

Female, Age, Education and *Ethnicity* were included as control variables. *Female* is a dummy variable that takes on a value of zero if a subject is male and one if a subject is male. *Age* is a continuous variable that represents a subject's age and can take on any value higher than zero. *Education* is a categorical variable that can take on any value between one and six and represents the highest level of education that a subject completed (1 = Applied Sciences Degree (HBO), 2 = Bachelor's Degree (WO), 3 = High School Degree, 4 = Master's Degree (WO), No High School Degree, 6 = Postdoctoral (PhD)). *Ethnicity* is a categorical variable that represents the ethnicity one identifies as and can range from one to four (1 = Asian, 2 = Black/ African American, 3 = Hispanic/ Latino, 4 = White/ Caucasian).

5.5 Statistical models and robustness checks

Several ordinary least squares (OLS) regression models and ordered logit models were used to detect a correlation between the DI-index, self-control and self-control problems in physical activity decisions. OLS models with robust standard errors were used to test for

correlations between *DI02*, *DI24*, *SCScore*, *SCLevel* and *EI-Gap*. To test for potential correlations between *DI02*, *DI24*, *SCScore*, *SCLevel* and *SCProb* ordered logit models were used as they require a binary dependent variable. Sign tests and Wilcoxon signed-rank tests were used to test for deviations from constant discounting for *DI02* and *DI24* and to test whether the DI-indices differed significantly from one another.

Assumptions of OLS and ordered logit models need to be met for robustness purposes and to ensure analyses of quality. Linearity, multicollinearity and heteroskedasticity were tested or accounted for to ensure that the analysis was performed well. Multicollinearity occurs when several independent variables are statistically significantly correlated with one another. This can bias linear regression models and can thereby have a negative influence on regression quality (Shrestha, 2020). Heteroskedasticity is described as the error variance not being constant and can have a significant impact on the regression standard errors of OLS regressions (Rigobon, 2003).

Linearity of the OLS models was checked by means of residual plots and was not regarded as problematic (see Appendix C). Multicollinearity was tested using Spearman's correlation coefficient and Variance Inflation Factors (VIF). Spearman's correlation coefficient quantifies strictly monotonic correlations between two variables by utilising ranks, as the ranking of data converts a nonlinear strictly monotonic relationship into a linear relationship (Schober et al., 2018). As opposed to Pearson's correlation, Spearman's correlation can be used with data at the ordinal level and it does not require the assumptions of normality and linearity to hold (Schober et al., 2018). Furthermore, because Spearman's correlation is not highly sensitive to outliers, the inclusion of these extreme data points does not immediately invalidate conclusions (Schober et al., 2018). The threshold for Spearman's correlation coefficient is considered to lie around absolute values of 0.8 or 0.9, reflecting potential multicollinearity problems (Senaviratna & Cooray, 2019). Appendix B1 presents Spearman's correlation coefficients for all variables of interest in the performed regressions. For the VIF, the threshold is set at ten with values higher than ten indicating an issue of multicollinearity (Woolridge, 2020). To overcome potential issues of heteroskedasticity, OLS models with robust standard errors were used.

For each OLS and logit model, robustness tests were performed to ensure validity and consistency and allow for a more complete understanding of the results. More specifically, all models were rerun using a smaller subset of the data from which those subjects who answered the control questions incorrectly were excluded. Results of these robustness checks can be found in Appendix D. Additionally, various versions of the main models were run in

which certain variables were included and excluded to test whether that would affect results from the main analysis.

Finally, goodness of fit measures were used to evaluate whether the DI-index or self-control was better able to explain self-control problems in physical activity decisions. For all OLS regressions, the Adjusted R^2 was used to evaluate the goodness of fit of the models. The Adjusted R^2 represents the share of variance in the dependent variable that can be explained by the predictor variables in the model (Wooldridge, 2020). The larger the Adjusted R^2, the more variation the model is able to explain and the better the model fits the data. For all ordered logit models, Akaike Information Criterion (AIC) was used to evaluate the goodness of fit of the ordered logit models. AIC estimates the prediction error which allows one to assess the relative quality of a statistical model (Cavanaugh & Neath, 2018). The model with the lowest AIC-statistic relatively best fits the data (Cavanaugh & Neath, 2018).

These statistics were chosen as they penalise the number of variables that are included in the model (Wooldridge, 2020). This is necessary for the analysis as some models (OLS Model 1 and Logit Model 1) include more variables than other models (OLS Model 2 and Logit Model 2).

The model with the highest Adjusted R^2 and lowest AIC-statistic is best able to predict self-control problems in physical activity decisions. Based on these statistics, the model with the highest predictive power can be identified. Thereby, it can be concluded whether the DI-index or self-control best predicts self-control problems in physical activity decisions.

6. Results

This section provides an overview of the sample, descriptive statistics and correlation between all variables of interest. Additionally, the results from the OLS and logit models are presented.

6.1 Sample and descriptive statistics

A total number of 262 people filled out the survey. After dropping 67 subjects, as they did not complete more than 80 per cent of the survey, the final sample consisted of 195 subjects of which 66 were male and 129 were female. The ages of the subjects ranged from 18 to 72 years, with an average age of 34 years. Moreover, 153 subjects identified as White/ Caucasian (78.5%), 19 as Asian (9.7%), 14 as Hispanic/ Latino (7.2%) and nine (4.6%) as

Black/ African American. In terms of education, most subjects were highly educated people that obtained a Bachelor's degree, 60 subjects (30.8%), or a Master's degree, 57 subjects (29.2%). Moreover, 49 subjects (25.1%) obtained a high school degree at most. Finally, 18 subjects (9.23%) obtained at most an Applied Sciences Degree and 11 subjects (5.6%) obtained at most a Postdoctoral degree. The scores for the BSCS ranged from 20 to 65 with an average score of 40.5. Finally, 53 subjects (27.2%) did not suffer from self-control problems in physical activity decisions (*EI-Gap* = 0, *SCProb* = 0). The remaining 142 subjects (72.8%) did have self-control problems in physical activity decisions (*EI-Gap* $\neq$ 0, *SCProb* = 1). The descriptive statistics of the study can be found in tables 1 to 3.

Table 1. Descriptive statistics

Variable	N	Mean	Std. Dev.	Min.	Max.
Age	195	33.9	16.4	18	72
Female	195	0.7	0.5	0	1
DI02	142	-0.0	0.3	-0.5	1.5
DI24	142	0.1	0.4	-0.5	1.5
SCScore	195	40.3	7.9	20	65
EI-Gap	195	3.0	5.0	0	48

Table 2. Tabulation of education

	Frequency	Percentage
High School Degree	49	25.1
Applied Sciences Degree	18	9.2
Bachelor's Degree	60	30.8
Master's Degree	57	29.2
Postdoctoral	11	5.6
Total	195	100.0

Table 3. Tabulation of ethnicity

	Frequency	Percentage
Black/ African American	9	4.6
Hispanic/ Latino	14	7.2
Asian	19	9.7
White/ Caucasian	153	78.5
Total	195	100.0

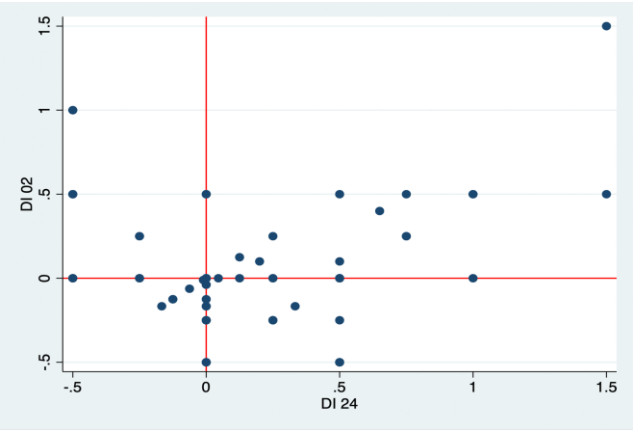
6.2 DI-index

Several subjects were excluded from the DI-index analyses. First of all, 27 subjects were excluded as they violated impatience. Of the 168 subjects that remained, those subjects for whom one or both DI-Indices could not be computed were excluded from the analysis. These subjects elicited the same value for s_i and t_i for a certain indifference and as a result, the denominator of the DI-index became zero and the index could not be calculated. Thereby, either *DI02* or *DI24* were successfully computed for 142 subjects, and both could be computed for 124 subjects. Of these subjects, 43 were male (34.7%) and 81 were female (65.3%) with ages ranging between 18 to 72 (average = 32.0). For these subjects, decreasing impatience was observed at the aggregate level for *DI02* (p = 0.014 for sign test) and *DI24* (p= 0.023 for sign test). According to Wilcoxon signed-rank tests, both *DI02* and *DI24* were significantly different from zero (p = 0.034 for *DI02* and p = 0.034 for *DI24*). An overview of impatience types of subjects for whom the DI-indices were successfully computed is shown in Table 4. The scatter plot in figure 2 shows the relation between *DI02* and *DI24*.

Table 4. Classification of degree of impatience

	DI02	DI24
Decreasing impatience (DI > 0)	26	45
Constant Impatience (D = 0)	68	72
Increasing impatience (DI < 0)	48	25
Total	142	142

Figure 2. Scatterplot of DI-indices



OLS Model 1 and Logit Model 1 were used to test for a correlation between the DI-indices and self-control problems in physical activity decisions. An overview of the main models and results can be found in table 5.

Overall, multicollinearity between *DI02*, *DI24*, *Age*, *Female*, *Education*, *Ethnicity* and *EI-Gap* is not an issue as Spearman's rank correlations are smaller than the critical value of 0.8 and VIF factors are smaller than the critical value ten. Further investigation of Spearman's correlation coefficients shows that there were no significant correlations between *DI02* and *DI24* ($\rho = -0.075$, $p = 0.729$). Therefore, both DI-indices were included in the models used to test for a correlation between the DI-index and self-control problems in physical activity decisions.

First of all, OLS Model 1 found no statistically significant correlations between the DI-indices and the *EI-Gap*. This means that the DI-index does not appear to affect the severity of self-control problems in physical activity decisions. Secondly, Logit Model 1 found a statistically significant correlation between *DI24* and *SCProb* at a five per cent significance level ($b = 1.228$, $p = 0.048$). This means that as *DI24* increases by one unit, the probability that one suffers from self-control problems in physical activity decisions increases by 122.8 percentage points ceteris paribus. These results were confirmed by the robustness checks.

In conclusion, some evidence in support of hypothesis 1 was found for a positive correlation between the DI-index and self-control problems in physical activity decisions.

Table 5. Results OLS and Logit Models - Coefficients

Variables	OLS Model 1	OLS Model 2	Logit Model 1	Logit Model 2
DI02	-0.885		0.177	
	(1.146)		(0.713)	
DI24	0.071		1.228*	
	(0.711)		(0.673)	
SCScore		-0.055		-0.036*
		(0.044)		(0.024)
Age	0.004	-0.011	-0.026	-0.022
	(0.026)	(0.022)	(0.017)	(0.014)
Female	-0.392	-0.800	0.088	0.234
	(0.892)	(0.888)	(0.439)	(0.372)
2.Education	0.812	1.504*	-0.269	0.406
	(1.006)	(0.809)	(0.819)	(0.655)
3.Education	1.405	2.150**	-0.153	0.922
	(1.052)	(0.871)	(0.892)	(0.730)
4.Education	1.764	1.920*	-0.014	0.711
	(1.342)	(1.152)	(0.736)	(0.620)
5.Education	0.090	0.928	0.014	0.568
	(1.214)	(1.077)	(0.962)	(0.839)
2.Ethnicity	-2.207*	1.022	-1.277	0.058
	(1.249)	(2.022)	(1.241)	(1.019)
3.Ethnicity	1.215	1.647	-0.246	0.672
	(1.245)	(1.024)	(1.129)	(0.996)
4.Ethnicity	0.050	0.928	-0.576	0.162
	(0.978)	(0.774)	(0.835)	(0.634)
Constant	1.844	3.595**	2.391*	2.373**
	(1.504)	(1.495)	(1.399)	(1.195)
Observations	142	195	142	195
Adjusted R^2/ AIC	0.026	0.030	180.598	176.841

Robust standard errors in parenthesis, *** p<0.01, ** p<0.05, *p<0.1

6.3 Self-control

When investigating the correlations between the *SCScore*, *Age*, *Female*, *Education*, *Ethnicity* and *SCProb*, multicollinearity is found not to be an issue as Spearman's rank correlation coefficients and VIF factors are smaller than their critical values of 0.8 and ten respectively.

OLS Model 2 found no significant correlations between *SCScore* and *EI-Gap*. Logit analysis detected a significant correlation between *SCScore* and *SCProb* (b = -0.036, p = 0.071). Accordingly, as self-control scores increase by one unit, the probability that that person suffers from self-control problems in physical activity decisions decreases by 3.6 percentage points, ceteris paribus. This means that as one has higher self-control, the probability that this person suffers from self-control problems in physical activity decisions decreases. However, since the OLS results were not statistically significant, self-control does not appear to affect the severity of self-control problems.

All results from the robustness checks are consistent with the results from the main analysis and the robustness of these findings can therefore be guaranteed. These results indicate that self-control is negatively correlated with self-control problems in physical activity decisions, thereby confirming hypothesis two.

6.4 DI-index versus self-control

From the Adjusted R^2 and AIC-statistics of OLS Model 1 and 2 and Logit Model 1 and 2, can be concluded that *SCScore* is a better predictor of self-control problems in physical activity decisions than *DI02* and *DI24*. More specifically, as the Adjusted R^2 and AIC-statistic for the models that contain *SCScore* are respectively higher and lower than the models that contain *DI02* and *DI24*, self-control can explain a larger share of the variation in physical activity decisions than the DI-index. These results are supported by the results from the robustness checks. Thereby, hypothesis three is rejected as there is a difference between the predictive power of the DI-index and self-control of self-control problems in physical activity decisions.

6.5 Additional correlations

Spearman's correlation coefficients show statistically significant correlations between the remaining variables of interest. These include correlations between *Female* and *Age*, *Education* and *Age*, *Ethnicity* and *Age*, *EI-Gap* and *Age*, *Education* and *Female*, *Ethnicity* and

Female, *SCProb* and *Age*, *EI-Gap* and *Female*, *SCScore* and *Age*, *SCScore* and *Education*, *SCScore* and *EI-Gap*, *SCProb* and *SCScore* and *Ethnicity* and *Education*.

A statistically significant correlation between identifying as Black/ African American compared to being Asian was found in OLS model 1 (b = -2.207, p = 0.079). This means that for subjects who identify as Black/ African American the *EI-Gap* is 2.207 points lower compared to those subjects who identify as Asian.

OLS Model 2 found correlations between having a High School Degree compared to having an HBO Degree (b = 2.150, p = 0.015), having a Bachelor's Degree compared to having an HBO Degree (b = 1.504, p = 0.065), and having a Master's Degree compared to having an HBO degree (b = 1.920, p = 0.097). These results indicate that those subjects who have at most a High School Degree, Bachelor's Degree or Master's Degree have a higher *EI-Gap* than those who have at most an HBO Degree.

7. Discussion and conclusion

In this section, the results from section 6 are interpreted and used to formulate an answer to the research question. Additionally, limitations as well as suggestions for future research are discussed. Finally, some practical implications of the results are provided.

7.1 Interpretation of results

This study used both economic and psychological theory to research what determinant better predicts self-control problems in physical activity decisions: changes in impatience or self-control. The DI-index was used to measure changes in impatience and the BSCS was used to measure self-control. In the remainder of this section, the results from both the DI-Index and the BSCS are examined separately as this is one of the first papers that examines both factors at the same time to explain self-control problems in physical activity decisions. Following that, the predictive power of both determinants is evaluated to see if one is more powerful in predicting self-control problems in physical activity decisions than the other.

By means of the DI-index, the present study found that most subjects satisfied decreasing impatience. These results contradict the results from Attema et al. (2018) as they imply that agents have time-consistent preferences and act according to constant impatience. However, they are in line with Rohde's (2019) findings as in her research most subjects satisfied decreasing impatience as well. A difference between Rohde's (2019) study and the present study is related to the presence of a correlation between the DI-index and self-control

problems. More specifically, Rohde (2019) was unable to detect a correlation between the DI-index and self-control problems, whereas the present study found preliminary evidence for a correlation between the DI-index and self-control problems in physical activity decisions. These results indicate that changes in impatience may drive self-control problems in physical activity decisions. However, it should be noted that this correlation was only statistically significant in the ordered logit models and for only one of the two DI-indices (*DI24*). Finally, the heterogeneity of DI-indices among subjects supports the use of the DI-index, as previous measures of time preferences are not able to account for all levels of impatience.

Furthermore, this study detected a correlation between self-control and self-control problems in physical activity decisions. This result is in line with the findings of previous studies. For instance, Iso-Ahola (2013) found that self-control must be exerted to adhere to physical activity. This suggests that a correlation between self-control and self-control problems in physical activity decisions exists: the more self-control an individual has, the less likely this person is to experience self-control problems in physical activity decisions and the more likely one is to overcome obstacles to adherence in physical activity. Additionally, this correlation supports the results from a study by Betrams and Englert (2013) who found that higher levels of self-control resulted in smaller discrepancies between the intended and actual number of workouts in a certain week. Moreover, the results from the present study align with the conclusions from Toering and Jordet (2015) that higher self-control increases exercise adherence. Moreover, the present study supports the finding of Fan and Jin (2014) that a lack of self-control leads to procrastination of activities that include delayed rewards such as physical activity. Additionally, the results align with the finding of Hagger et al. (2010) that physical inactivity results from low self-control.

Finally, an answer to the research question: '*Do changes in impatience and self-control predict self-control problems in physical activity decisions? Does their predictive power differ*?' can be formulated. Results from the present study suggest that self-control is a better predictor of self-control problems in physical activity decisions for two reasons. First of all, the predictive power of the model that includes self-control is larger than the predictive power of the model that includes the DI-indices. Second of all, only a significant correlation was found between only one of the two DI-indices (*DI24*) and self-control problems in physical activity decisions. No such correlation was established between the other DI-index (*DI02*) and self-control problems in physical activity decisions. To the best of my knowledge, previous research failed to compare the predictive ability of either changes in impatience and

self-control. Thereby, the finding that self-control is better able to predict self-control problems in physical activity decisions cannot be compared to an existing body of literature on this comparison specifically. Future research should test for the robustness of these results and establish whether self-control is indeed a better predictor of self-control problems in physical activity decisions.

7.2 Limitations and suggestions for future research

This research was in many ways an interesting and valuable exploration of the predictors of self-control problems in physical activity decisions. It is important to reflect on the possible limitations of the study.

First of all, the experiment was conducted during the COVID-19 pandemic. These were unusual times and affected various types of behaviours, including people's physical activity behaviours. Lockdown measures, for instance, fundamentally decreased work and transport-related physical activities for a large part of the working population (Guthold et al., 2018). Moreover, sports and fitness clubs, as well as outdoor exercise facilities, and leisure time activities were closed which complicated engagement in physical activities. This led physical activity levels to decline drastically (Sharp et al., 2022). Additionally, gyms, exercise facilities and training friends can work as commitment devices and help people engage in higher levels of physical activity. Thereby the role of self-control is limited as instead of fully relying on self-control, one's favourite gym or training buddy might motivate one to engage in physical activity. Thereby, the reported levels of physical activity in this study may not be generalizable to non-pandemic times. Subsequently, future research should conduct a similar study in non-pandemic times.

Additionally, several methodological limitations should be mentioned. The first methodological limitations are related to the elicitation of the indifference points and computation of the DI-index. After filling out the survey, several subjects shared, in informal feedback conversations, that they had some difficulty in understanding what was asked of them for the DI-index questions. Future research could provide more sample questions to ensure that participants understand what they are being asked and overcome this issue. Secondly, as method P was used, DI-indices could not be computed for those individuals for whom t_i and s_i were the same which required the exclusion of these subjects from the study. Future research could make use of method T as it will always yield an indifference pair although this method has limited practical applicability (Rohde, 2019).

Another methodological limitation is concerned with the method that was used to detect self-control problems in physical activity decisions. In this study, self-control problems were reflected through the variable *EI-Gap* which is calculated based on predictions of behaviour in a hypothetical scenario. To calculate the *EI-Gap*, subjects were asked to predict how much time they would like to spend on physical activities over the upcoming seven days. Next, they were asked to report how much time they thought they would actually spend on physical activity during the same period. Discrepancies between predicted ideal and predicted actual behaviour were captured in the variable *EI-Gap*. Although hypothetical scenarios are commonly employed to better understand behaviour, experimental research shows that these scenarios may fail to predict real-life behaviour (Bostyn et al., 2018). Thereby, in the present study, subjects' predictions of their behaviour may differ from their behaviour in a real-life setting. Moreover, since the *EI-Gap* is based on predictions, it only reflects self-control problems for those subjects who are aware that they have such problems. These subjects are able to predict that there is a discrepancy between their ideal and actual physical activity behaviour. However, for subjects who are unaware that they experience self-control problems in physical activity decisions, such problems may still exist although this is not reflected through their *EI-Gap*. Nonetheless, if they were to be faced with a real-life scenario, they may find out that they do suffer from self-control problems. Another issue with the use of the *EI-Gap* is that social desirability bias might have influenced subjects' reported levels of physical activity. Social desirability bias occurs when subjects underreport socially unfavourable activities and overreport good ones due to self-presentation concerns (Krumpal, 2013). This bias may have led subjects to report higher levels of physical activity than they would engage in if they were asked the same question in a real-life setting.

Since the use of the *EI-Gap* as a measure of self-control problems in physical activity decisions has limitations, several other measures were considered. These include self-report activity diaries, self-report follow-up questionnaires and the use of devices that measure physical activity levels. For instance, Schöndube et al. (2017) used self-report activity diaries. Subjects were asked to report all the time they spent in physical exercise in an electronic diary every day over the course of 20 days. The advantage of this method is that it allows subjects to report on physical activity levels after they engage in such activities and is thus based on behaviours rather than predictions of behaviour. There are two disadvantages related to the use of this experimental design. A disadvantage is that in experiments that last for several days subjects are more likely to drop out which can lead to bias and diminished statistical power (Kristman et al., 2004). Secondly, as subjects are asked to self-report their

physical activity levels, social desirability bias can occur. More specifically, subjects may report higher levels of physical exercise than they actually engaged in. Another way to measure self-control problems in physical activity decisions is to make use of a self-report follow-up questionnaire. One can split the survey into two parts, of which the first one asks subjects to state their ideal level of physical activity over the next seven days. After one week, the second part of the survey asks subjects to report how much time they have actually spent engaging in physical activity. However, dropout rates in such studies are generally high which weakens the study's statistical power (Kristman et al., 2004). Additionally, social desirability bias may still be an issue. One way to overcome social desirability bias is to make use of devices such as accelerometers, pedometers and heart-rate monitors. These devices allow researchers to detect the exact amount of time subjects spend engaging in physical activities. However, they are costly and might reduce the number of subjects willing to participate in the study as subjects' every movement can be reviewed by the researcher.

After carefully considering the advantages and disadvantages of all previously described measures of self-control problems in physical activity decisions, the *EI-Gap* method was chosen. Under the restrictions of the present study, including a limited budget, and since social desirability bias was also present in most alternative methods, the *EI-Gap* method was preferred as it was expected to have the highest statistical power. Future research should carefully consider the advantages and disadvantages given the restrictions of their study to determine what measure of physical activity aligns best with their purposes and the type of data they want to collect. The practical guide to measuring physical activity that was developed by Sylvia et al. (2014) can be used to direct this process.

Finally, this study asked subjects for the number of hours they spend on physical activity. Although a short explanation of physical activity was provided, the short informal feedback conversations showed that some subjects were confused about the difference between 'physical activity' and 'exercise'. Future research should emphasise even more that subjects are asked for physical activity levels by for instance conducting the experiment offline and verbally expanding on the difference between physical activity and exercise behaviours. Furthermore, subjects were asked to indicate how much time they would spend on physical activity in a given week, which was sometimes mistaken for a given day. Therefore, future research could use control questions to check whether participants correctly understood the concepts they are asked to report.

7.3 Practical implications

In conclusion, the present study found that self-control is a better predictor of self-control problems in physical activity decisions than changes in impatience. To increase physical activity and prevent all negative consequences that can result from a lack thereof including increased health care costs, health policies should focus on increasing self-control (Guthold et al., 2018). Self-control training (STC) was found to be an effective intervention to increase self-control (Friese et al., 2017; Beames et al., 2017; Hagger et al., 2010). SCT is a simple intervention that involves participants performing tasks that demand self-control. For a predetermined period, usually two weeks, they must override an impulse and replace it with a chosen reaction (Berkman, 2016; Friese et al., 2017). Participants practise suppressing instinctual responses and replacing them with nonautomatic responses, such as using one's non-dominant hand, which, according to the strength model, strengthens the self-control muscle' (Baumeister et al., 2007). Strengthening this muscle is supposed to have a positive impact on self-control driven behaviour, such as physical activity behaviours (Haggers et al., 2010). Kip et al. (2021) developed an app that successfully boosted self-control for violent behaviours. A similar model could be developed to address self-control in physical activity behaviours.

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Appendices

Appendix A

Survey

A1 Introduction to the survey

Dear participant,

Welcome to this experiment and thank you in advance for answering this survey for my master thesis. The survey consists of 4 parts and takes about 8 minutes.

The data will be used for academic purposes only and your answers will remain anonymous. By filling out this survey, you confirm that you are 18 years or older and agree with participating in this study.

Please read the instructions and questions carefully.

Thank you in advance,

Floor Boonen

A2 DI-index

In this part of the survey you are asked 3 questions between amounts of **money** and the specified number of **weeks (t)** in which that amount will be received.

Sample question:
For which number of **weeks (t)** would you value both options equally?
Receiving €40 **today** or €50 in **t weeks**.

In this sample question, you can choose between receiving a smaller amount (40€) and a larger amount (50€) of money at two different points in time. You would receive the small amount **today**, and the large amount in **t weeks**. For all questions, the monetary amounts stay the same. You are only asked to state the **t (number of weeks)** that makes you value both options equally. So: 'What number of weeks makes you indifferent between receiving a smaller reward right now, or a larger amount in **t weeks**?'.

Note: in the following questions, there are no 'right' or 'wrong' answers, I am only interested in your preferences!

After carefully reading the instructions, please answer the following practice question:

In this experiment, I have to state:

- The amounts of money
- The numbers of weeks (t)

Question 1: For which number of **weeks (t)** would you value both options equally? Receiving €40 **in 0 weeks** or €50 in **t weeks**.

[Dropdown menu]

** in case the more than 55 weeks option was selected a follow-up question was asked:*

*In the previous question, you selected the 'More than 55 weeks' options. Therefore, you are now asked for the number of **months** instead of **weeks** that makes you value both options equally.*

*For which number of **months (t)** would you value both options equally? Receiving €40 **in 0 weeks** or €50 in **t months**.*

[Dropdown menu] *

Question 2: For which number of **weeks (t)** would you value both options equally? Receiving €40 **in 2 weeks** or €50 in **t weeks**.

[Dropdown menu]

** in case the more than 53 weeks option was selected a follow-up question was asked:*

*In the previous question, you selected the 'More than 53 weeks' options. Therefore, you are now asked for the number of **months** instead of **weeks** that makes you value both options equally.*

*For which number of **months (t)** would you value both options equally? Receiving €40 **in 2 weeks** or €50 in **t months**.*

[Dropdown menu] *

Question 3: For which number of **weeks (t)** would you value both options equally? Receiving €40 **in 4 weeks** or €50 in **t weeks**.

[Dropdown menu]

** in case the more than 55 weeks option was selected a follow-up question was asked:*

*In the previous question, you selected the 'More than 51 weeks' options. Therefore, you are now asked for the number of **months** instead of **weeks** that makes you value both options equally.*

*For which number of **months (t)** would you value both options equally? Receiving €40 **in 4 weeks** or €50 in **t months**.*

[Dropdown menu]*

A3 Brief Self-Control Scale

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

Using the scale provided, please indicate how much each of the following statements reflects how you typically are. Answer options range from (1) not all like me, till (5) very much like me.

Question 4: I am good at resisting temptation. 1———2———3———4———5 (R)

Question 5: I have a hard time breaking bad habits. 1———2———3———4———5 (R)

Question 6: I am lazy. 1———2———3———4———5 (R)

Question 7: I say inappropriate things. 1———2———3———4———5 (R)

Question 8: I do certain things that are bad for me, if they are fun. 1———2———3———4———5

Question 9: I refuse things that are bad for me. 1———2———3———4———5 (R)

Question 10: I wish I had more self-discipline. 1———2———3———4———5

Question 11: People would say that I have iron self- discipline. 1———2———3———4———5 (R)

Question 12: Please validate your continued participation by selecting the 'Not at all like me' option. 1———2———3———4———5

Question 13: Pleasure and fun sometimes keep me from getting work done. 1———2———3———4———5 (R)

Question 14: I have trouble concentrating. 1———2———3———4———5

Question 15: I am able to work effectively toward long-term goals. 1———2———3———4———5 (R)

Question 16: Sometimes I cannot stop myself from doing something, even if I know it is wrong. 1———2———3———4———5 (R)

Question 17: 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).]

A4 Self-control problems in physical activity decisions

In this part of the survey, you are asked about the amount of time you spent engaging in physical activities. First you are provided with a short definition of what counts as physical activity.

Description physical activity

Physical activity refers to all movement including during leisure time, for transport to get to and from places, or as part of a person's work. It contains both low- and high-intensity physical activity. Popular ways to be active include walking, cycling, wheeling, sports, active recreation and play, and can be done at any level of skill and for enjoyment by everybody. **

**This definition was provided alongside each question regarding physical activity *

The questions below concern the time you would ideally be physically active, how tempted you would be to deviate from this ideal, and what you expect you would do in practice.

Question 18: From your current perspective, how much time would you ideally like to spend on physical activity over the course of the next 7 days? Please provide your answer in **hours**.
[Dropdown menu]

Some people might be tempted to depart from their ideal physical activity in the previous question. Which of the following best describes you? Please mark only one answer.

Some people might be tempted to depart from their ideal allocation in (a). Which of the following best describes you (please mark only one).***

A. I would be strongly/somewhat tempted to keep more certificates for use in the second year than would be ideal;
B. I would have no temptation in either direction

***In case subjects selected option B, they skipped question 20 and were directed to question 21. ***

Question 20: If you were to give in to your temptation, how much time would you spend on physical activities over the course of the next 7 days? Please provide your answer in **hours**.
[Dropdown menu]

Question 21: Based on your most accurate forecast of how you think you would actually behave, how much time would you end up spending on physical activities over the course of the next 7 days? Please provide your answer in **hours**.
[Dropdown menu]

A5 Demographics

Question 22: What is your age?
[Dropdown menu]
Question 23: What gender do you identify as?
Male
Female
Non-binary
Prefer not to say
Question 24: What ethnicity do you identify (most) as?
American Indian/ Alaska Native
Asian
African American/ Black
Hispanic or Latino
Native Hawaiian/ Pacific Islander
White
Question 25: What is the highest level of education you completed?
No High School Degree
High School
Applied Sciences (HBO)
Bachelor's degree (WO)

Master’s degree (WO)
Postdoctoral (PhD)

Appendix B

Spearman Correlations

B1 OLS Model 1

Spearman's rank correlation coefficients based on sample excluding subjects who violated impatience (N=142).

Spearman's rank correlation coefficients

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) DI02	1.000						
(2) DI24	-0.075	1.000					
(3) Age	-0.021	-0.052	1.000				
(4) Female	0.029	0.060	-0.279***	1.000			
(5) Education	-0.102	0.029	0.330***	-0.152*	1.000		
(6) Ethnicity	0.127	-0.011	0.262***	-0.189**	0.107	1.000	
(7) EIGAP	-0.024	0.124	-0.171**	0.104	0.030	-0.072	1.000

Spearman rho = -0.072 *** p<0.01, ** p<0.05, * p<0.1

B2 OLS Model 1 robustness check

Spearman's rank correlation coefficients based on sample excluding subjects who violated impatience and subjects who answered the DI-index control question incorrectly (N=124).

Spearman's rank correlation coefficients

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) DI02	1.000						
(2) DI24	-0.031	1.000					
(3) Age	-0.085	0.011	1.000				
(4) Female	0.074	0.004	-0.281***	1.000			
(5) Education	-0.090	0.066	0.386***	-0.186**	1.000		
(6) Ethnicity	0.149*	0.067	0.257**	-0.157*	0.091	1.000	
(7) EIGAP	-0.015	0.144	-0.173*	0.180**	0.105	-0.061	1.000

Spearman rho = -0.061 *** p<0.01, ** p<0.05, * p<0.1

B3 OLS Model 2

Spearman rank correlations based on whole sample including subjects who violated impatience and subjects who answered the control questions incorrectly (N=195).

Spearman's rank correlation coefficients

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) SCScore	1.000						
(2) SCLevel	-0.427***	1.000					
(3) Age	0.297***	-0.098	1.000				
(4) Female	-0.093	0.180**	-0.298***	1.000			
(5) Education	0.269***	-0.193***	0.323***	-0.159**	1.000		
(6) Ethnicity	0.149**	-0.037	0.316***	-0.182**	0.144**	1.000	
(7) EIGAP	-0.181**	0.000	-0.225***	0.113	0.024	-0.060	1.000

Spearman rho = -0.060 *** p<0.01, ** p<0.05, * p<0.1

B4 OLS Model 2 robustness check

Spearman rank correlations based on sample excluding subjects who answered the self-control control question incorrectly (N=179).

Spearman's rank correlation coefficients

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) SCScore	1.000						
(2) SCLevel	-0.453***	1.000					
(3) Age	0.292***	-0.100	1.000				
(4) Female	-0.095	0.153**	-0.306***	1.000			
(5) Education	0.273***	-0.191**	0.342***	-0.1618*	1.000		
(6) Ethnicity	0.143*	0.003	0.305***	-0.212***	0.150**	1.000	
(7) EIGAP	-0.140*	0.034	-0.220***	0.125*	0.016	-0.091	1.000

Spearman rho = -0.091 *** p<0.01, ** p<0.05, * p<0.1

B5 Logit Model 1

Spearman's rank correlation coefficients based on sample excluding subjects who violated impatience (N=142).

Spearman's rank correlation coefficients

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) DI02	1.000						
(2) DI24	-0.075	1.000					
(3) Age	-0.021	-0.052	1.000				
(4) Female	0.029	0.060	-0.279***	1.000			
(5) Education	-0.102	0.029	0.330***	-0.152*	1.000		
(6) Ethnicity	0.127	-0.011	0.262***	-0.189**	0.107	1.000	
(7) SCProb	-0.009	0.172**	-0.192**	0.098	-0.033	-0.079	1.000

Spearman rho = -0.079 *** p<0.01, ** p<0.05, * p<0.1

B6 Logit Model 1 robustness check

Spearman's rank correlation coefficients based on sample excluding subjects who violated impatience and subjects who answered the DI-index control question incorrectly (N=124).

Spearman's rank correlation coefficients

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) DI02	1.000						
(2) DI24	-0.031	1.000					
(3) Age	-0.085	0.011	1.000				
(4) Female	0.074	0.004	-0.281***	1.000			
(5) Education	-0.090	0.066	0.386***	-0.186**	1.000		
(6) Ethnicity	0.149*	0.067	0.257***	-0.157*	0.091	1.000	
(7) SCProb	-0.003	0.179**	-0.183**	0.160*	0.037	-0.090	1.000

Spearman rho = -0.090 *** p<0.01, ** p<0.05, * p<0.1

B7 Logit Model 2

Spearman rank correlations based on whole sample (N=195)

Spearman's rank correlation coefficients

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) SCScore	1.000						
(2) SCLevel	-0.427***	1.000					
(3) Age	0.297***	-0.098	1.000				
(4) Female	-0.093	0.180**	-0.298***	1.000			
(5) Education	0.269***	-0.193***	0.323***	-0.159**	1.000		
(6) Ethnicity	0.149**	-0.037	0.316***	-0.182**	0.144**	1.000	
(7) SCProb	-0.183**	0.014	-0.247***	0.123*	-0.020	-0.091	1.000

Spearman rho = -0.091 *** p<0.01, ** p<0.05, * p<0.1

B8 Logit Model 2 robustness check

Spearman rank correlations based on sample excluding subjects who answered the self-control control question incorrectly (N=179).

Spearman's rank correlation coefficients

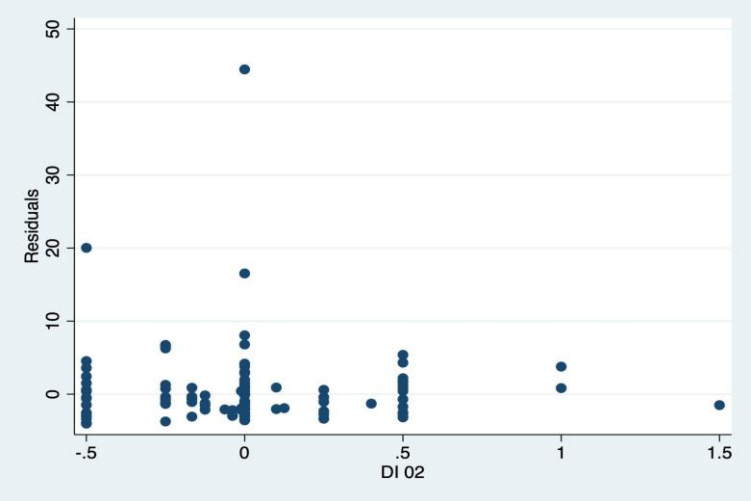
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) SCScore	1.000						
(2) SCLevel	-0.453***	1.000					
(3) Age	0.292***	-0.100	1.000				
(4) Female	-0.095	0.153**	-0.306***	1.000			
(5) Education	0.273***	-0.191**	0.342***	-0.161**	1.000		
(6) Ethnicity	0.143*	0.003	0.305***	-0.212***	0.150**	1.000	
(7) SCProb	-0.157**	0.040	-0.259***	0.144*	-0.022	-0.136*	1.000

Spearman rho = -0.136 *** p<0.01, ** p<0.05, * p<0.1

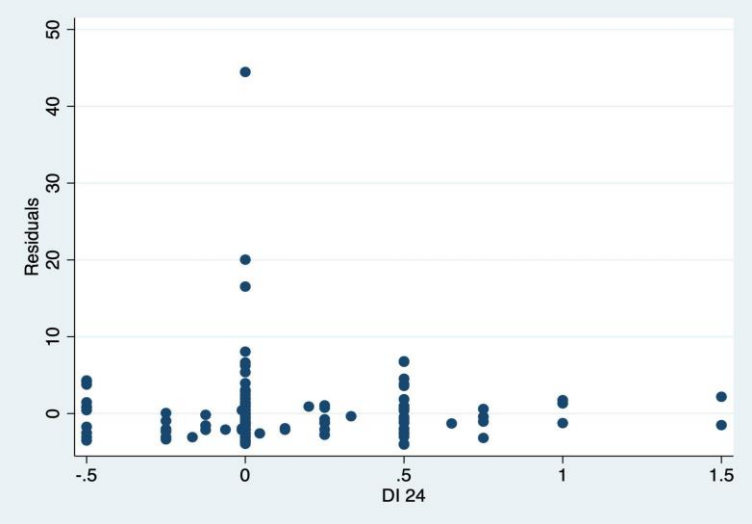
Appendix C

Linearity Check OLS regression

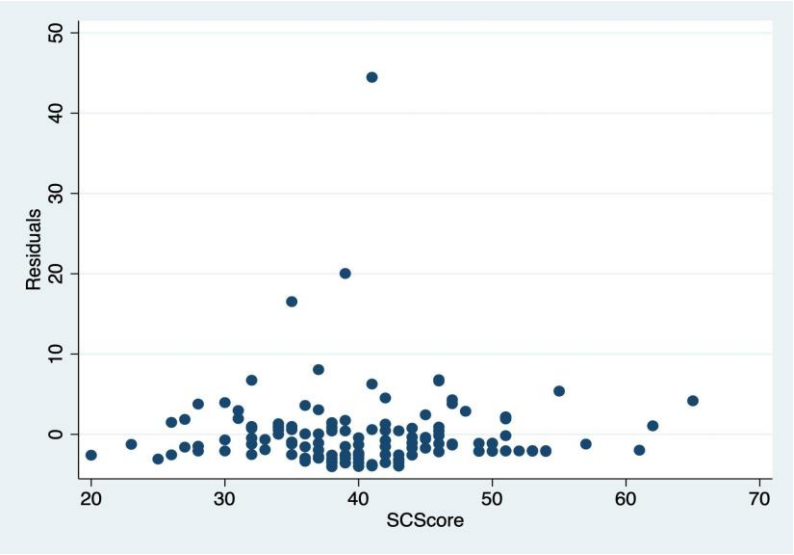
C1 Linearity check DI02



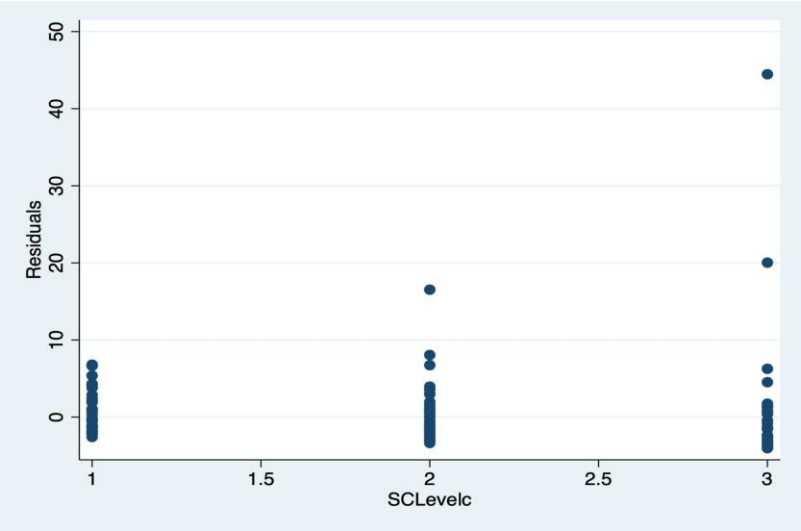
C2 Linearity check DI24



C3 Linearity check SCScore



C4 Linearity check SCLevel



Appendix D

Results robustness checks OLS and Logit Models - Coefficients

Variables	OLS Model 1	OLS Model 2	Logit Model 1	Logit Model 2
DI02	-1.317		-0.008	
	(1.112)		(0.758)	
DI24	0.235		1.440*	
	(0.576)		(0.760)	
SCScore		-0.031		-0.026
		(0.045)		(0.025)
Age	-0.018	-0.009	-0.041**	-0.022
	(0.021)	(0.023)	(0.021)	(0.014)
Female	-0.641	-0.561	0.591	0.275
	(0.910)	(0.889)	(0.484)	(0.390)
2.Education	1.175	1.468*	0.358	0.519
	(0.932)	(0.861)	(1.006)	(0.659)
3.Education	1.550	1.857**	0.141	1.217
	(0.932)	(0.900)	(1.072)	(0.797)
4.Education	1.550	1.733*	1.119	0.762
	(1.134)	(1.243)	(0.971)	(0.627)
5.Education	0.129	0.918	1.539	0.872
	(1.153)	(1.150)	(1.241)	(0.918)
2.Ethnicity	-1.657	-0.611	-1.069	0.186
	(1.115)	(1.151)	(1.290)	(1.314)
3.Ethnicity	1.459	1.519	0.539	0.980
	(1.146)	(1.030)	(1.354)	(1.256)
4.Ethnicity	0.456	0.717	-0.520	-0.111
	(1.376)	(0.781)	(0.862)	(0.704)
Constant	2.351*	2.749*	1.702	2.099*
	(1.376)	(1.401)	(1.580)	(1.255)
Observations	124	179	124	179
Adjusted R^2/ AIC	0.027	0.032	166.845	161.324

Robust standard errors in parenthesis, *** p<0.01, ** p<0.05, *p<0.1