Measuring Impatience Across Different Domains with the Direct Method

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Introduction

Impatience, the lack of patience, is a well-known phenomenon of people's behaviour. People can be impatient about many different things; e.g. receiving money (now instead of later) or having leisure time. Impatience is a widely-researched subject. In practical terms, impatience implies that people value present gains more than future gains. Sometimes this is rational, for instance when an instant amount of money can be invested and the potential future pay-outs are presumably larger than the proposed future monetary amount. However, people often show irrationally impatient behaviour due to focus on present necessities or lack of self-control (Thaler R. , 1997). In addition to making decisions about money, other aspects in life and the corresponding decisions can also involve impatience. All future outcomes in life are generally devaluated by measuring temporal discounting, using a discount rate. In general, the more future gains are discounted, the more impatient people are for receiving such a gain. For government policy, the same discount rate is often used for different domains (Attema, Bleichrodt, l'Haridon, Perreti-Wattel, & Seror, 2016). As a result, research stresses the importance of correct discount rates for evaluating projects (Gollier & Hammitt, 2014). Therefore, it is of major interest to examine how people actually (de)valuate future outcomes across different domains.

In this paper, I extend on a proposed method of measuring temporal discounting. While previous research employed utility-based methods to measure temporal discounting, weighing their utility by a discount factor to evaluate future outcomes, recent studies have introduced the so-called Direct Method. This method does not require knowledge nor measurement of utility (Attema, Bleichrodt, Gao, Huang, & Wakker, 2016). This simplifies the process and makes the results of the research more robust, as less assumptions are needed. I build on the research of Attema et al. (2016) by extending the application of the Direct Method by using it to measure the temporal discounting of money as well as health and environmental gains. The main goal of my research is to compare the level of discounting of individuals when impatience involves money, health and environment. By comparing these elements, I intend to reveal possible different levels of impatience in these areas. When the degree of impatience turns out to be different per domain, this could be important for policy as the behaviour and impatience of people could be reflected in different discount rates for different domains. On the other hand, if people are equally impatient for different domains, it would mean that the same discount rate can be used for the domains. In such case, there is rich literature – focused on discount rates for money – which could then be applied to the other domains.

While investigating the degree of impatience for monetary gains and its effects on people's lives is quite logical and straightforward, impatience for health and environmental gains is also very relevant for the impact of governmental campaigns. It is an interesting question whether descriptive results of researches can be used for prescriptive governmental campaigns.

For instance, health campaigns, or so-called prevention programs, are often focused on promoting better lifestyles, improving people's long-term health by – for example – quitting smoking or adapting their behaviour to reduce the risk of diseases. As investments for such programs are of considerable size, it is important to evaluate their effectiveness (Koepsell, et al., 1992). When such an investment is successful, it significantly improves people's health and thus decreases future health care costs such that it compensates for the investment – and accomplishes an improved quality of health and life. The degree of people's impatience for health gains is a very important factor for the discount rate that should be used. This is also stressed by Bos et al. (2005), who emphasize the importance of a fitting discount rate for health effects, such as vaccination programmes.

Comparing people's impatience for environmental gains to health and monetary gains is a challenge, as environmental gains are likely to be further away in the future and less tangible. Environmental projects are likely to have a longer maturity, which is likely to influence the discount rate (Gollier & Hammitt, 2014). The degree of impatience for environmental gains, such as improved air quality or sustainable governmental initiatives, can be of great importance for considering such expensive campaigns. On the other hand, lack of impatience for environmental gains could mean that people have a long-term focus on this subject, less interest in the subject or the feeling that these kinds of subjects are beyond their control.

Previous research on impatience for gains and losses in different domains has used the traditional utility-based method for measuring temporal discount rates. Chapman (1996) concludes that discount rates for money and the health are domain-independent, meaning that the correlations between the discount rates of domains are low: she found that someone who is impatient for money is not necessarily impatient for better health. Gains were discounted significantly more than losses for in both domains, which is in accordance with the sign effect (Thaler R. , 1981).

Hardisty & Weber (2009) investigated impatience for gains and losses in money, health and the environment. In line with Chapman (1996) and Thaler (1981), they found a significantly higher degree of discounting for gains than losses in all domains. In different studies, they found that subjects discounted monetary and environmental gains significantly, but there was no

significant difference between impatience in money and the environment. Interestingly however, subjects were significantly more impatient for health gains than for monetary and environmental gains. On the contrary, Cairns (1992) reported significantly higher discount rates for wealth, investigating the discounting of wealth and health. In a later research from Cairns (1994), discount rates for health were higher than for money when health questions comprised choices of saving lives, meaning that subjects were significantly more impatient for saving lives than receiving money. This finding does not match with the theory of the magnitude effect, which states that discount rates are lower for large magnitude outcomes (Benzion, Rapoport, & Yagil, 1989). That is, assuming that people value saving lives more than receiving money. This could be explained by the fact that the magnitude effect is normally for differences in discounting within one domain, whereas the research of Cairns (1994) focused on different domains. The ambiguity of the discussed outcomes shows that the type of choices presented to subjects has significant impact on the behaviour subjects show during experiments.

There are several challenges and biases to account for when researching impatience across different domains (Chapman, 1996). As stated before, considering the magnitude effect, it is important that presented choices to subjects have a comparable weight such that subjects value it as equally as possible. This will always be a challenge, as it is very hard to know whether subjects value a certain monetary gain equally as a certain health or environmental gain. Secondly, it is arguable that people find it difficult to reflect their true behaviour in short experiments, in which choices about different domains, periods of time and values are presented. This challenge also depends on the type of subjects: students are likely to be impatient for monetary gains, but are they also thinking about their future health and the environment already?

The method of my research – and the difference with the traditional utility-based method – is described in the next paragraph, after which I explain how it can be applied to different domains using an experiment.

Method

In the traditional discounted utility model, a preference relation over discrete outcome streams $(x_1, \dots, x_t)$ is assumed, yielding outcome (monetary) x at time t. Outcome stream x is evaluated as follows:

$$\sum_{t=0}^{t} \delta_t \, U(x_t)$$

In this equation, discounted utility holds if preferences maximize the discounted utility of outcome stream *x*. *U* is the subjective utility function, which is strictly increasing and satisfies $U(0) = 0$. δ is the subjective discount factor, which is always positive as receiving an outcome sooner is preferred to receiving an outcome later. It follows from the equation that utility-based methods require knowledge of *U* to measure discounting: discounting and utility interact, which makes the measurements more difficult. This interaction can be prevented by making assumptions about utility, but this could influence the discount rate outcomes. In my research, I will use the Direct Method as proposed by Attema et al. (2016), for which no assumptions about utility are needed.

Measuring discounting using the Direct Method

For measuring discounting without measuring utility, the following equation is used:

$$C(0,t) = \sum_{t=0}^{t} \delta_t$$

The main difference with the Direct Method and traditional methods is that choices for subjects in the Direct Method are matched to each other, finding a point of indifference, such that utility can be dropped out of the equation. This process is explained later in this paragraph. As utility drops out of the equation, the method of measuring the way people value monetary amounts and health gains or losses is simplified. By leaving out the utility, assumptions of outcomes are reduced which increases the robustness of discounting. *C* is the cumulative discount weight of period $(0, t)$. To determine an individual's level of impatience, one should find out how he/she makes decisions about certain pay-outs (monetary, health-wise or environmentally) in certain future periods. In the Direct Method, this is done by determining points of indifference of subjects in different periods of time.

For example, a subject must make choices for monetary gains during the next year. He/she can choose between receiving €10 every week from now until week *x*, or receiving €10 every week from week *x* until week 52: what happens after week 52 is irrelevant. From now on, this point of indifference is called $c_{1/2}$. Indifference implies that $C[0, c_{1/2}]\, U(10) = C[c_{1/2}, 52]\, U(10)$. As choices are matched to each other, the utility element $U(10)$ consequently drops out, setting

$C[0, 52] = 1$, which is allowed by the uniqueness of the properties of discounted utility. Then it follows that $C\left(c_{\frac{1}{2}}\right) = \frac{1}{2}$.

As an example of finding $c_{1/2}$, when a subject is indifferent between receiving €10 every week from now until week 20 (total amount = €200, gaining €10 per week) and receiving €10 from week 21 until week 52 (total amount = €320), the discount weight of weeks 1-20 equals the discount weight of weeks 21-52. In this case, $c_{1/2}$ = 20. If α is the value a subject receives, this point is called $c_{1/2}$, as $\alpha_{(0,c\frac{1}{2}]}0 \sim \alpha_{(c\frac{1}{2},52]}0$, which means that the subject is indifferent between $\alpha_{(0,20]}$ and $\alpha_{(20,52]}$This means that a subject is willing to receive a lower amount of money in an earlier stage, which implies impatience.

The procedure continues by again finding an indifference point, but now the choice is between receiving €10 every week from now until a new point in time, or receiving €10 every week from that certain point until week 20. This point is called $c_{1/4}$, as $\alpha_{(0,c\frac{1}{4}]}0 \sim \alpha_{(c\frac{1}{4},c\frac{1}{2}]}0$. It follows that $C\left(c_{\frac{1}{4}}\right) = \frac{1}{4}$. The next step is establishing point $c_{3/4}$, by making the respondent choose a point between $c_{1/2}$ and week 52. Here, $\alpha_{(c\frac{1}{2},c\frac{3}{4}]}0 \sim \alpha_{(c\frac{3}{4},52]}0$, ensuring that $C\left(c_{\frac{3}{4}}\right) = \frac{3}{4}$.

After the described measurements, these steps could be continued to determine more detailed points of indifference such as $c_{1/8}$ and $c_{7/8}$ when the research requires it, but I chose not to do so, to not overburden subjects.

By computing the area under curve C based on the stated $c_{1/4}$, $c_{1/2}$ and $c_{3/4}$, the level of discounting can be determined. This will be discussed more thoroughly in the results.

Experiment

35 students from Erasmus University Rotterdam were recruited for the experiment. To collect the data, I chose not to use a survey, as the second answer of each subject depends on the previous ($c_{1/4}$ and $c_{3/4}$ depend on $c_{1/2}$). Because of this, I chose having individual interviews instead of surveys to improve the data quality. A survey could make it harder for subjects to understand the different choices to be made, and any doubts of respondents could be easily clarified during interviews.

To make it easier for subjects to make choices, and considering their possible lack of understanding of the method, I chose not to tell them anything about the method or goals of my

research. Consequently, I presented questions with two possible options such that it was relatively easy for respondents to make choices. In a one-on-one interview, subjects were asked questions about choices for the three different domains money, health and the environment until reaching indifference point $c_{1/2}$ as described in the method. Then the same procedure was used to determine the subject's $c_{1/4}$ and $c_{3/4}$. As previous research has thoroughly shown that people generally discount gains more than losses, and to not overcomplicate the procedure, I only focus on the discounting of gains in the different domains.

Monetary gains

For the monetary choices, I composed a questioning method which entails weekly pay-outs of €10 for the next year (t = 52). The choice of weekly pay-outs until reaching one year was made given the financial situation (most) students are in. As students are expected to have a different spending pattern in a few years, it is the most suitable to measure their spending behaviour during a relatively short period.

Firstly, the subject's $c_{1/2}$ must be determined. In the experiment, subjects were asked to state their indifference point on the following matter: weekly pay-outs of €10 until week t. Consequently, the pay-out as of the stated point of time (t) would be (52 - *t*) * 10, with weekly pay-outs of €10. For instance, when a subject chooses a (t) of 20 weeks, he/she is indifferent between receiving €10 every week from week 1 to week 20, and receiving €10 every week from week 21 to week 52. In such a case, the subject's $c_{1/2}$ is 20.

Secondly, a subject's $c_{1/4}$ must be determined by following the same steps as above, but now the subject must state a point of indifference between the starting point of time (t = 0) and the chosen $c_{1/2}$. Likewise, $c_{3/4}$ is determined by finding the indifference point between $c_{1/2}$ and the end point in time (t = 52).

During every interview, a subject was told that he or she was required to make financial choices. Hereafter, a subject was asked to make a choice between two options. The following was stated: "*What do you prefer: receiving €10 every week from this week until week 26, or receiving €10 every week from week 27 until week 52?".* When a subject chose to receive €10 from this week until week 26, the next question would be more in favour of the other choice. This went on until an indifference point was reached. When the indifference point of a subject was in between two choices, I used the same rounding methods as used by (Attema, Bleichrodt, Gao, Huang, & Wakker, 2016). This procedure was also used to determine a subject's $c_{1/4}$ and $c_{3/4}$, where the subject's $c_{1/2}$ was used as input.

Health gains

As making decisions regarding health generally differs from making choices about money – mainly because of the different time span in which these decisions are usually made – I chose to ask questions about slight health gains. Subjects were told to imagine that they were in poor physical health for a certain period. This poor physical health entailed a lower level of energy as well as a lower degree of resistance to illness. Subjects were told that there was a treatment available which would improve their health to the usual situation, which means full health condition. Next, subjects were asked to indicate their preference between having full physical health as of now (week 1) until in half a year (week 26), or from week 26 until week 52 opposed to having a worsened physical health. After having indicated their preference, the next questions would be aimed at finding the indifference point $c_{1/2}$. The procedure continued – like in the monetary gains scenario – with the determination of the subject's $c_{1/4}$ and $c_{3/4}$ regarding health gain choices.

Environmental gains

For decisions about environmental gains, I chose a similar procedure. I told respondents that the average level of nitrogen dioxide in the Rotterdam Rijnmond area was 40 milligrams in 2015 (Snijder & van Breugel, 2015), which negatively influences normal life and the environment. Subjects were asked to imagine that the government was considering a new emission campaign, which would decrease the level of nitrogen dioxide with over 50 per cent during the campaign. Next, subjects were asked to indicate their preference between improved air quality as of now (week 1) until week 26, or from week 26 until week 52. Like in the other scenario's, the procedure continued with determining the subject's $c_{1/2}$, $c_{1/4}$ and $c_{3/4}$ for environmental gain choices.

Results

35 Erasmus University Rotterdam students were interviewed in 15-minute sessions. Descriptive statistics of the interviews are reported below.

Money	Mean	SD	Min	Max	N
c1/4	10.49	2.49	6	16	35
c1/2	22.71	3.07	16	29	35
c3/4	35.83	3.41	25	42	35

Health	Mean	SD	Min	Max	N
c1/4	12.89	3.55	6	20	35
c1/2	24.56	3.87	16	32	35
c3/4	37.34	3.72	24	44	35

Environment	Mean	SD	Min	Max	N
c1/4	13.09	1.89	9	23	35
c1/2	25.94	1.51	21	33	35
c3/4	38.94	1.00	35	43	35

Table 1: Descriptive Statistics

To have a nonparametric measure of the degree of discounting for the different domains, I computed the area under the cumulative weighting function C. The graph below (with hypothetical results) illustrates this process: by adding up the different areas based on subjects' choices, the area under cumulative weighting function C can be determined.

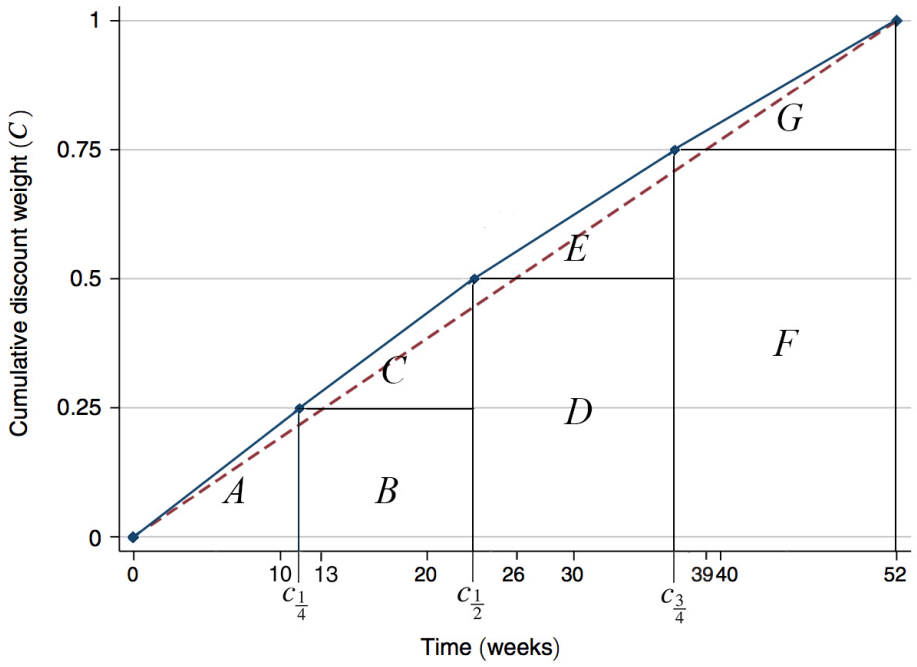

Figure 1: Computing the area under C-curve

In this specific hypothetical case, the curve is concave. This means that subjects would prefer receiving smaller gains sooner than larger, later gains (values of $c_{1/4}$, $c_{1/2}$ and $c_{3/4}$ are lower than 13, 26 and 39), implying impatience. A concave curve would result in a computed area larger than 0,5, while a convex curve would mean that the area is smaller than 0,5. Obviously, a linear curve would result in an area of exactly 0,5, corresponding with no discounting.

As stated before, the concavity of the function reflects the degree of impatience for the specific domain. The table below shows the different computed areas for money, health and environment (air quality). To ensure that the area would be between 0 and 1, results were divided by 52.

Descriptives	N	Mean	SD	Minimum	Maximum
MonCurve	35	0.544	0.042	0.46	0.65
HeaCurve	35	0.517	0.052	0.42	0.65
AirCurve	35	0.500	0.020	0.40	0.56

Table 2: Descriptives of computed areas

It follows that the computed area below the money curve is the largest (0.544), followed by health (0.517) and environment (0.500). This means that the money curve is most concave, implying impatience. The differences between domains and the computed areas are graphically illustrated below.

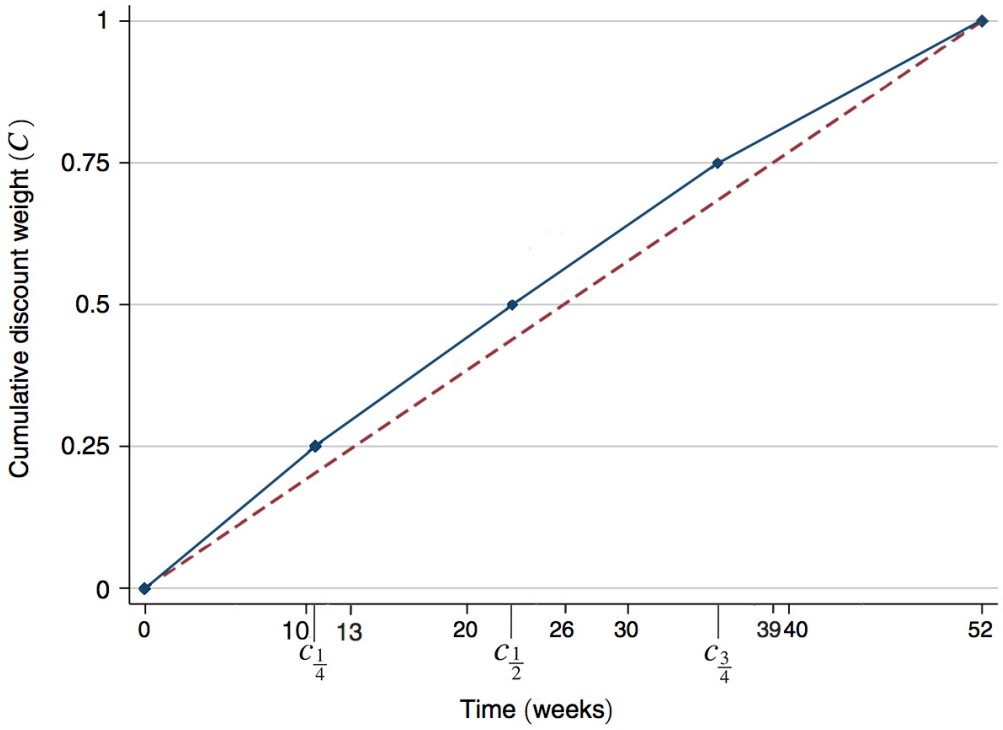

Figure 2: C-curve for money

The graph confirms the concavity of the curve, showing impatience for monetary gains. Comparing it to the graph of health below, the difference in the computed area and thus degree of discounting and impatience is clear.

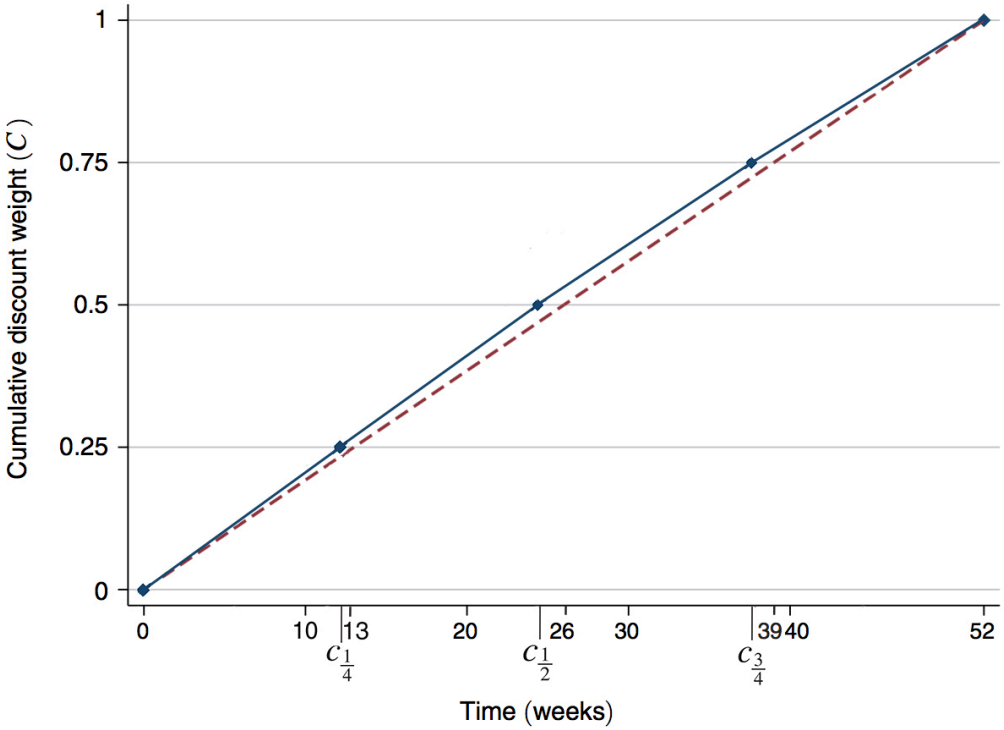

Figure 3: C-curve for health

As the C-curve for environment was nearly perfectly linear (following the red dotted line), a graph is not included. To test the significance of impatience per domain, I ran Wilcoxon tests for each domain separately comparing with an area of 1/2 (linear: no impatience).

Wilcoxon	Money	Health	Environment
p-value	0.000	0.062	0.492

Table 3: Significance of the test

Table 3 shows that respondents were significantly impatient for receiving money, marginally significantly impatient for health gains and not impatient for environmental gains, in accordance with the shape of the different curves. For money, the chance of having this result given the H0 was 0,00002. As could be expected from the linearity of the environment curve, no discounting whatsoever was associated with having better air quality.

By estimating constant discounting – assuming equal discount rates over time – I computed the discount rates per domain by finding a constant rate through which subjects discounted their future gains. I did this by combining the discount rates of $c_{1/4}$, $c_{1/2}$ and $c_{3/4}$, and computing the average rate for each domain. The discount rate was 15,4% for money and 4,5% for health.

The lack of discounting for environmental gains was reflected in a corresponding discount rate of 0,03%. The results show that respondents valued the environmental future more than the present compared to money and health, for which the present was considered more important.

To judge how the three domains compared to each other, I ran Wilcoxon tests in which the computed areas of the domains' curves were tested in pairs.

Wilcoxon	Health vs Money
p-value	0.014
Wilcoxon	Health vs Environment
p-value	0.100
Wilcoxon	Money vs Environment
p-value	0.000

Table 4: Comparing the domains

It follows that respondents were significantly more impatient for monetary gains compared to both health gains and environmental gains. Another interesting case is to test whether there is a correlation between the degree of impatience in the different domains; did respondents show consistent behaviour across domains?

		MonCurve	HeaCurve	AirCurve
MonCurve	Pearson Correlation	1	0.062	0.310
	Sig. (2-tailed)		0.731	0.079
HeaCurve	Pearson Correlation	0.062	1	0.127
	Sig. (2-tailed)	0.731		0.481
AirCurve	Pearson Correlation	0.310	0.127	1
	Sig. (2-tailed)	0.079	0.481	

Table 5: Correlations

There were no significant correlations between different domains, as shown in the table above. This finding implies that someone who shows impatient behaviour moneywise, is not necessarily impatient for health or environmental gains. This confirms the domain-independence of discount rates which was also found by Chapman (1996) and means that it is hard to generalize someone's degree of impatience for different domains, having the knowledge of the degree of impatience from less than all domains. Therefore, policy makers should be careful in drawing conclusions for people's behaviour across domains. This is one of the findings that will be further explained in the discussion.

Discussion

From the results, it follows that the degree of impatience was different for each of the three domains studied. These findings contribute to the discussion whether the discount rates used for policy and by the government should be equal, or that they need to be adapted for different domains to have a more realistic estimation of people's discounting behaviour.

There was no correlation between discounting for either money, health or environment. This domain-independency is in line with findings of Hardisty and Weber (2009) and Chapman (1996), and shows that someone who is impatient for monetary gains is not necessarily impatient for health or environmental gains.

The degrees of impatience across domains differ from the findings of both Hardisty and Weber (2009) and Chapman (1996). In their researches, respondents had comparable discount rates for monetary and environmental gains (Hardisty & Weber, 2009), and a higher discount rate for health gains (Chapman, 1996; Hardisty & Weber, 2009). There are several possible reasons for these differences. Firstly, the method is different. In my research, there is no utility involved such that no underlying assumptions – which can distort the reflection of respondents' behaviour – need to be made. Such assumptions could influence the reported degree of impatience for the different domains, although it may not rightly reflect the true behaviour of respondents. For example, Hardisty and Weber (2009) assumed a linear utility function for measuring discounting. When the utility function of subjects in reality is concave, this assumption would lead to an overestimation of discount rates and thus give a biased view on the degree of impatience.

Further focusing on the research of Hardisty and Weber (2009), another difference is the manner in which choices were presented to respondents. For comparison - looking at choices on the environment - in their research, respondents preferred 31 weeks of improved air quality in one year's time to 21 weeks of immediate improved air quality (discount rate of 32%). In my research, respondents were generally indifferent between having 26 weeks of improved air quality either immediately or in a half years' time (discount rate of 0,03%). Furthermore, respondents in their research were in general indifferent between having improved health for 21,2 weeks in one year's time and 12 weeks of immediate better health, making it the domain with the highest degree of impatience (discount rate of 43%). Comparing it to my results (discount rate of 4,5% for health) it can be argued whether the results of Hardisty and Weber (2009) are realistic. The very high discount rates they found are a probable result of this overestimation of discount rates due to utility assumptions. Subjects in my research had more

reasonable discount rates, which is quite likely because of the lack of utility assumptions of the Direct Method. Looking at the differences, another factor to consider is the type of subjects. This will be discussed more thoroughly in the limitations.

In consideration of these differences, it can be argued that the choices people make regarding money, health and the environment are – among other things – dependent on the questioning method. Still, the observed differences, in particular those related to the degrees of impatience across the domains studied, are quite interesting. To determine whether the Direct Method truly reflects people's behaviour as opposed to more traditional methods, it is recommendable for future research to further use the Direct Method for measuring impatience by applying it to more domains and periods: we could learn to what extent the method is applicable and use it for existing policy-related programmes. Moreover, results of researches using the Direct Method should be compared to traditional utility-based researches, so that differences in results – and the effect of utility assumptions on discount rates – can become clear. By doing so, the ease of use for researchers and comprehensibility of respondents should be evaluated. Consequently, a deeper understanding of human behaviour and degrees of impatience across domains can be obtained and used for prescriptive decision making.

Limitations

During interviews, respondents were asked about personal preferences for the different domains for a period of one year. This method was chosen to make a convenient comparison of the degree of impatience in the different domains. However, it can be argued whether this procedure realistically reflects how people generally make decisions and therefore whether this reflects their behaviour in real life, as people normally may evaluate other period lengths for different domains. All respondents were students, who – due to their general lack of money and irregular lifestyle – are likely to be more impatient for monetary gains. Moreover, students are expected to attach more value to fast monetary gains and are perhaps not thinking as much about the environment and their health during this stage of their lives. The relatively large discount rate I found (15,4%) compared to the discount rate of 4,4% found by Attema et al. (2016) with a more representative sample supports this assumption. The significant differences between the degrees of impatience across the domains – and the differences with the research of Hardisty and Weber (2009) – could have resulted from the influences of these factors.

Another limitation of my research is the hypothetical manner in which the questions were presented to subjects. It is quite understandable that subjects may have found it difficult to imagine what it would be like to undergo gains – especially for health and environmental gains

which are less tangible and quantifiable than monetary gains – and the corresponding effects on their future lives. Therefore, choices of respondents may not have been their choices in the field and thus not reflect their true behaviour. Although there is no clear evidence of the effect of real incentives on the degree of discounting of gains (Frederick, Loewenstein, & O'Donoghue, 2002), hypothetical choices may still be difficult for respondent to become realistic. This will always be a difficulty in researching impatience for future choices, as people may generally find it difficult to think about the future instead of the present.

Furthermore, subjects may have found it difficult to think about health and environmental gains for a relatively short period of one year, while it may have seemed more logical to use longer time spans for these domains. I still decided to use a one year period to easily compare the different domains and to not overcomplicate the choices for subjects.

Despite these limitations, the interviews and the corresponding results do indicate that people consider future gains differently depending on the specific domain. Moreover, the Direct Method was easily comprehended by respondents and therefore has shown to be a suitable method of measuring impatience across different domains.

Conclusion

The main goal of my research was to compare the level of discounting of individuals when impatience involves money, health and environment. By using the Direct Method, no information of utility was required which simplified the process and made the results more robust. In accordance with research of Hardisty and Weber (2009), results indicated significant impatience for monetary gains. However, opposed to their research, I found only marginally significant impatience for health gains, no impatience for environmental gains, and significantly more impatience for money than for health and the environment. A possible reason for these differences may be that they assumed linear utility, while I did not have to make any assumptions about utility.

For government policy, it is recommended to continue research on this matter to identify whether and why people truly value future gains in multiple domains differently. As stated before, researching the different degrees of impatience and using the results for governmental campaigns – stimulating prescriptive decision making – is a challenging endeavour. The behaviour and decision-making of the subjects in my research is appealing, and the Direct Method has shown to be a feasible way to measure impatience in different domains. Regarding the selective nature of respondents and the limited, equal time spans that I used to measure impatience for different domains, the next step is to apply the method to more representative

samples and projects with varying time spans, considering more specific campaign- and programme maturities.

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