The Effect of Socio-Environmental Cues of Harshness on the Discounting of Future Negative Health Consequences

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August 22nd, 2022

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Abstract

The concept of discounting of future negative health consequences is a relatively new idea in health psychology. It entails prioritizing immediate rewards while disregarding later health consequences. Life History Theory states that decision-making is influenced by an environment's level of harshness (risk for disability or death due to uncontrollable factors in the environment). Harsh environments lead to the preference for immediate rewards. This study investigated the influence of socio-environmental cues of harshness on the discounting of future suffering. It was hypothesized that participants exposed to harsh environments show higher discounting of future suffering than participants exposed to non-harsh environments. Furthermore, it was hypothesized that impulsivity moderates this effect. An experimental between-subject design was utilized. Participants were randomly assigned to one condition (harsh vs. non-harsh) in Virtual Reality. The variable "discounting of future suffering" was measured with a delay discounting task. On a scale from 0 (not miserable at all) to 100 (very miserable), participants were asked to indicate how miserable they would feel if diagnosed with a life-threatening disease for six delay periods. "Impulsiveness" was measured using the Balloon Analogue Risk Task. To test the first hypothesis, a Mann-Whitney U test was conducted (U = 307, Z = -.228, p = .819). A Multiple Linear Regression was executed to test the second hypothesis (R^2 = .021, F (3, 47) = .335, p = .8). Results indicated no significant effect, therefore, both hypotheses had to be rejected. Based on the strengths and limitations that were discussed, recommendations for future research were made.

Keywords: delay discounting, future suffering, life history theory, harshness, impulsivity

Contents

Every day, humans face various decisions which can have immediate or delayed consequences for themselves and their environment. These can range from health behaviour and academic performance to engaging in violence or aggression. Daily choices may include how much time is invested in health-promoting means like exercising or eating healthily. In 2018, a study revealed that 62% of men living in Germany are overweight, even though the health consequences of being overweight are widely known (Statistisches Bundesamt, 2018). People who eat fast food regularly might satisfy their cravings for greasy and salty food as an immediate pleasant reward. However, they increase their likelihood of developing illnesses including cardiovascular diseases, certain types of cancer and type 2 diabetes, later in life (WHO, 2009). Moreover, smoking can lead to immediate stress relief perceived by an individual (Fidler & West, 2009) but carries serious consequences like lung cancer and death (WHO, 2021). According to the WHO (2021), approximately 8 million deaths yearly can be attributed to tobacco consumption. Individuals might have to abstain from some immediately pleasurable activities like smoking and eating fast food, to be rewarded with better health in the future such as a lower risk of developing a serious illness (Daugherty & Brase, 2010). People engage in these health-impairing behaviours while knowing the possible consequences (Kassam et al., 2008). One reason could be that the effects of health-related behaviours are usually only visible in the future.

Intertemporal Choice and Delay Discounting

These trade-offs between immediate pleasant rewards and later negative consequences are referred to as intertemporal choices. In behavioural psychology the terms ‘intertemporal choice’, ‘delay discounting’ and ‘temporal discounting’ are often used interchangeable (Daugherty & Brase, 2010). Intertemporal choices can be defined as the cognitive processes in which individuals decide between immediate or delayed consequences (Read et al., 2018). It is considered a behavioural tendency, as it is not a fixed trait but rather can be influenced by environmental, personal, or social circumstances the person is facing at a certain moment (Matta et al., 2012). Moreover, preferences about when to receive a reward play a role in that process (Bickel et al., 2014). Odum (2011) states that the concept of delay discounting describes a “decrease in the present value of an outcome when its receipt is delayed”. Hence, people make decisions based on weighting the outcomes (Li et al., 2012). More specifically, costs and benefits are evaluated based on different variables, like visceral influences (e.g., fear) (Loewenstein, 1996; Matta et al., 2012). Concludingly, these decisions are highly relevant to many situations in daily life. For example, research has shown that stimuli that cause fear (e.g., high rate of criminality) lead to the preference for immediate smaller rewards rather than later larger ones (Daugherty & Brase, 2010). Matta et al. (2012) found a relationship between choosing larger future rewards instead of smaller, immediate rewards and positive outcomes like better academic performance, healthy social relationships, and more adaptive social functioning.

Research has shown that delay discounting is associated with negative health consequences. The concept of discounting of future suffering is relatively new in health psychology. It includes prioritizing immediate rewards while discounting later negative health consequences (Chapman, 1996). Kassam et al. (2008) concluded that people engage in health-impairing behaviours even though they know about the possible long-term consequences. This can be a result of either unwillingness or inability to put their knowledge into action. Furthermore, individuals make decisions about how much time and effort they invest into health-promoting behaviour to ensure the likelihood of better health in older age (Chapman, 1996). Decisions like engaging in unprotected sex or drinking alcohol concern long-term consequences regarding future health. Therefore, individuals who engage in discounting, attempt to maximise rewards by enjoying them in the present and minimise costs by paying them in the future (Kassam et al., 2008). According to Daugherty and Brase (2010), one reason for discounting negative health consequences is that long-term consequences are only noticeable after a few years and impact an individual's quality of life only after years or even decades of engaging in detrimental health behaviours. Moreover, the study of Kassam et al. (2008) aimed to analyse whether participants' reaction to an event would be less intense in the future than in the present. Therefore, they asked participants in several different experiments to indicate their present reaction to a present event and their future reaction to a future event. The results indicated that people engaged in delay discounting as they stated to be happier about the event in the present as they would be about the same event in the future. Concludingly, representations of future consequences evoke less intense emotions than representations of immediate rewards (Kassam et al., 2008). Moreover, monetary delay discounting is commonly measured using a binary choice task in which participants have to choose between a smaller immediate reward and a later larger reward. In contrast, discounting of future negative health consequences does not entail choosing between two rewards. But rather, it is measured using a behavioural task where participants indicate how they would feel about an event in the present and the future. Considering this, choosing a later larger reward can be regarded as a reward for not engaging in immediate gratification. Thereby, individuals maximize their chances of good health in the future (Chapman, 1996).

Evolutionary Developmental Perspective on Decision-Making

Several theories explain the reasons behind human decision-making. Evolutionary developmental psychology encompasses the internal and external factors that influence the behaviour of individuals (Confer et al., 2010; Cosmides & Tooby, 2006). More precisely, it offers a theoretical framework to understand how people acquire and process information from their environment and how this influences their behaviour (Daly & Wilson 1999). Hence, it considers human information processing and decision-making. Evolutionary developmental psychology is based on Darwin's theory of natural selection, which states that "natural selection is a process that results in the adaption of an organism to its environment using selectively reproducing changes in its genotype" (The Editors of Encyclopaedia Britannica, 2018). Consequently, organisms that adequately adapt to an environment increase their reproductive success as an outcome of an evolutionary process (Barrett et al., 2002). According to Kenrick et al. (2009), some decisions that people make might seem irrational but often have a rational background from an evolutionary perspective. More precisely, evolutionary psychologists argue that cognitive instincts play a role in decision-making, as they are based on rules that develop without conscious effort and logical awareness (Cosmides & Tooby, 2006). Additionally, Kenrick (2009) states that people use domain-specific decision rules, which indicates that not only one specific rule for decision-making is utilized but rather several ones that operate according to the situation. Therefore, the environment plays an essential role in decision-making. For instance, individuals show faster and more precise behaviour regarding threatening stimuli or objects that cause fear compared to stimuli that evoke feelings of safety (Kenrick, 2009; Öhman & Mineka, 2001). Additionally, environments characterized by resource scarcity and environmental instability lead individuals to prioritize immediate consequences, such as present-based financial decisions like the consumption of status goods which hinder them from achieving distant needs, e.g., financial stability in older age (Sheehy-Skeffington, 2020).

Life history theory (LHT) has become a fundamental part of evolutionary developmental psychology. LHT can be defined as a "theory based on biological evolution that explains variations in organisms' developmental and reproductive strategies in the context of environmental pressures and available resources" (Kavanagh & Kahl, 2016). Organisms make trade-offs between current and future needs or between somatic and reproductive efforts (Griskevicius et al., 2011). Somatic efforts include the investment in growth (e.g., knowledge and skills) and reproductive efforts involve the investment in activities concerning reproduction (Griskevicius et al., 2011). Therefore, limited resources, such as energy, food, and time, must be divided between survival and reproduction (Kenrick et al., 2009). As noted by Griskevicius et al. (2011), a person has the option to choose between two types of strategies, namely fast and slow. LHT emphasizes the dependence on individuals' decision-making on the environment. More specifically, LH phenotypic strategies are preferences concerning decision patterns which adapt as a response to their environment (Griskevicius et al., 2011). Research showed that behaviours associated with fast LH strategies may be a response to environments characterized by cues of harshness (Brumbach et al., 2009; Griskevicius et al., 2013).

Harshness is a fundamental concept that influences an individual’s decision-making behaviour (Ellis et al., 2009). According to Fennemann and Frankenhuis (2020), harshness can be defined as “extrinsic mortality-morbidity; that is the rate at which external factors, which an individual cannot control, cause disability and death”. More specifically, it describes how the physical and social environment influences a person’s chance of survival and health (Fennemann & Frankenhuis, 2020). Cues indicating the harshness of an environment include exposure to crime or violence, the low life expectancy of community members and resource scarcity (Fennemann & Frankenhuis, 2020), as well as high rates of infectious diseases and injuries (Ellis et al., 2009; Frankenhuis et al., 2016). Moreover, next to harshness, unpredictability is an important factor in the development of the individual as both factors influence cognitive and behavioural processes (Frankenhuis et al., 2018; Martinez et al., 2022). If random changes of harshness occur in an environment, unpredictability is high and might lead to higher stress levels in the individual (Frankenhuis et al., 2016).

According to LHT, environmental factors like harshness, resource scarcity and unpredictability influence peoples’ preferences regarding delaying gratification (Ellis et al., 2009; Griskevicius et al., 2011; Pepper et al., 2007). Additionally, Loewenstein (1996) concluded that visceral factors like threat and fear influence a person’s behaviour directly without awareness. Thus, if the mortality risk is high or the resources low, choosing immediate rewards is more adaptive as it enables people to act fast and exploit opportunities (Griskevicius et al., 2011; Fennemann & Frankenhuis, 2020). Individuals facing these conditions do not gain much from the investment in long-term goals as that investment could easily be wiped out by external forces that are outside of their control (Griskevicius, 2011).

Furthermore, the chances of death and disability are higher, therefore individuals tend to engage in delay discounting more (Fennemann & Frankenhuis, 2020). Hence, choosing immediate rewards is not only more adaptive but preferred over delayed outcomes (Del Giudice et al., 2015). In addition, greater discounting of future suffering might be a psychological adjustment to the environment (Pepper et al., 2007). As chances of death in these environments are higher, the investment in future health is not prioritized. In harsh and unpredictable environments, people might believe they will feel less intense affect if they face negative health consequences in the future than in the present. As several studies showed, the quality of an environment predicts health and mortality (Evans & Smith, 2005; Pope et al., 2004). For example, exposure to violence has been found to be related to delay discounting and engagement with health impairing behaviours (e.g., tobacco use) (Berenson et al., 2001). Hence, if the life expectancy is low and the environment dangerous, the preference for more immediate gratifications as well as the discounting of future negative health consequences can be more adaptive (Daugherty & Brase, 2010). Furthermore, these environmental factors can lead to stress, which can lead to more impulsive actions (Fields et al., 2014) as well as higher preferences for immediate consequences (Daugherty & Brase, 2010). Empirical evidence shows that people experiencing high levels of stress show improved functioning in situations where impulsivity and risk-taking are likely to result in benefits (Lighthall et al., 2009; Van den Boset al., 2009).

Impulsivity

According to Reynolds et al. (2016) "Impulsivity is a multidimensional concept that has been defined variously as an inability to wait, a tendency to act without forethought, insensitivity to consequences and an inability to inhibit appropriate behaviours. Moreover, Barratt (1994) defined impulsivity as being related to the lack of control of thoughts and behaviour. More specifically, people with high levels of impulsivity have lower levels of self-control. High levels of self-control help people make better decisions as well as achieve their goals (Daughterty & Brase, 2010). On the contrary, low levels of self-control and thus high levels of impulsivity lead to the tendency to prefer immediate consequences over delayed ones (Daugherty & Brase, 2010; Matta et al., 2012). Impulsive individuals tend to engage in steep delay discounting, also referred to as impulsive decision-making, (de Wit et al., 2007) as they perceive the duration of delayed outcomes as longer (Wittmann & Paulus, 2008). If they would be offered 50 € directly or 500 € in 10 years, they would most likely choose the 50 € now and would therefore discount the latter value. Thus, this suggests that they perceive delayed larger rewards as less pleasurable and later negative health consequences as less severe. Additionally, low self-control is associated with a range of health-risk behaviours, including alcohol consumption, risky sexual behaviour, and drug abuse (Bickel & Marsch, 2001; Reynolds et al., 2006). Furthermore, it is linked to several heterogeneous traits and behavioural tendencies including a lack of judgement of negative consequences and devaluation of future events (de Wit & Richards, 2004). Hence, self-control is an influential component of impulsivity that has been especially linked to delay discounting (de Wit et al., 2007). Next to self-control, de Wit et al. (2007) concluded that non-planning impulsivity is positively linked to delay discounting.

Moreover, emotional distress due to environmental factors like harshness is one reason why impulsive individuals engage in delay discounting (Witmann & Paulus, 2008). Impulsive behaviour in harsh environments can be beneficial as individuals increase access to resources by acting quickly and seizing opportunities (Fennemann & Frankenhuis, 2020; Frankenhuis & Del Guidice, 2012). Concludingly, in these environments, delay discounting is more prominent and the level of impulsivity influences people's decision-making behaviour. Therefore, it can be assumed that impulsivity has a positive influence on the effect of environmental harshness on the discounting of future suffering.

The Present study

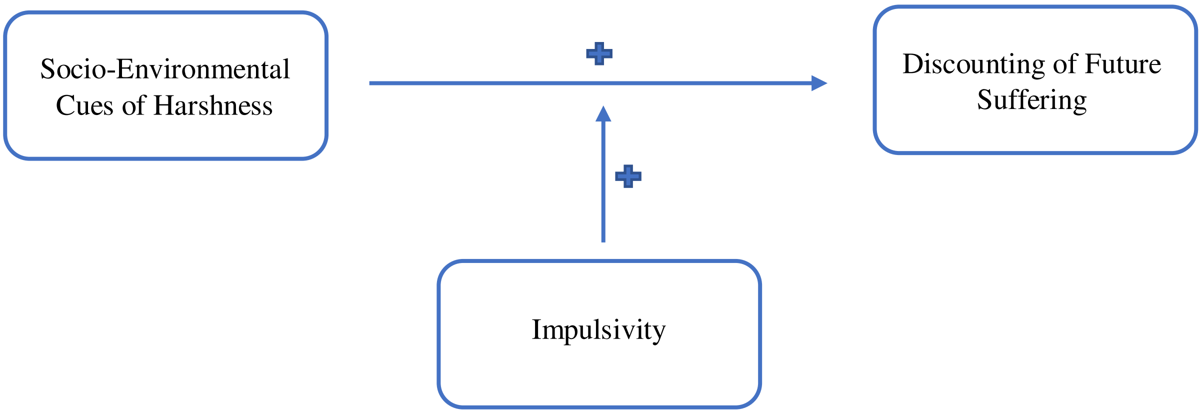
This research aims to examine whether socio-environmental cues of harshness influence the discounting of future suffering and whether this effect is moderated by impulsivity. It is assumed that impulsivity positively moderates the effect of harshness on delay discounting, however up till now, research is still sparse. Therefore, this relation should be analysed. Several studies have examined the link between delay discounting and the level of the harshness of an environment. It was found that in harsh environments, people prefer immediate consequences, which can hinder them from achieving delayed consequences (Daughtery & Brase, 2010; Sheehy-Skeffington, 2020). Impulsivity was found to be associated with both harshness and delay discounting (Daugherty & Brase, 2010; Fields et al., 2014). Kassam et al., (2008) concluded that people tend to discount their future happiness. In their study, participants indicated that they would feel less happy about a reward when it would happen in the future than about the same reward in the present. Based on this study, it is assumed that people would also discount their future suffering when being diagnosed with a life-threatening disease. Previous studies used monetary delay discounting tasks to assess discounting regarding health. Thereby, participants have a binary choice between two outcomes, a sooner smaller reward, and a later larger reward. Therefore, they suggested that people who engage in monetary discounting would also engage in discounting concerning health. Contrary to previous studies, in this study, a new tool to assess discounting is utilized that is tailored to the health aspect.

In this experiment, participants will be allocated to one of the two conditions (harsh vs. non-harsh) in Virtual Reality (VR), where they will complete two tasks. “Discounting of future suffering” will be operationalized using a delay discounting task, in which participants will be asked to indicate how miserable they would feel when being diagnosed with a life-threatening illness for six delay periods. “Impulsivity” will be operationalized using the Balloon Analogue Risk Task (BART). Thereby, the effect of “harshness” on “the discounting of future suffering” will be analysed as well as the potential moderation effect of “impulsivity” (Figure 1). This experimental study is the first one to combine the VR experience of walking around and exploring the neighbourhood in one of the two conditions with performing the two tasks. Furthermore, VR has several benefits and an added value in this study. Through a headset and motion controllers, sounds and pictures can be generated, which aim to reconstruct real engagement in those surroundings (Fox et al., 2009). Furthermore, it allows the researchers to create an easier controllable environment than the real world. In a safe environment, the use of VR can enable a ‘real-life’ perception of certain stimuli. Lastly, distracting stimuli are prevented, therefore participants can better concentrate.

Based on this theoretical framework, this study aims to answer the following two research questions: First, “What is the effect of socio-environmental cues of harshness on the discounting of future suffering?”. Second, “Is the effect of socio-environmental cues of harshness on the discounting of future suffering moderated by a person’s level of impulsivity?”. To answer these research questions, two hypotheses will be tested.

Figure 1

Illustration of both Hypotheses



Hypothesis 1: *Participants exposed to the harsh condition have higher levels of discounting of future suffering than participants exposed to the non-harsh condition.*

Hypothesis 2: *The effect of harshness on the level of discounting of future suffering is positively moderated by impulsivity.*

Methods

Design

An experimental design with two conditions (harsh vs. non-harsh) was used. The dependent variable "discounting of future suffering" was operationalized using the delay discounting task. Moreover, "impulsivity" functioned as a moderator and was measured using the BART.

Participants

Ethical approval was obtained from the Ethics Committee of BMS at the University of Twente. The 'Sona System', as well as a QR code, was used for the recruitment of participants. To reach as many participants as possible, social media platforms such as Instagram, WhatsApp, and Facebook were used. Furthermore, posters were hung up and flyers distributed around the campus of the University of Twente (Appendix A). For participation, people were either granted 1.5 Sona credits or chocolate and had the chance to win one out of five 20 € VVV-Voucher based on their performance on the BART. Convenience sampling enabled the participation of 58 people in the experiment. 51 participants were eligible for the analysis. The inclusion criteria for participating in the experiment were (a) being 18 years or older, (b) having sufficient English language skills, (c) not being pregnant, (d) not being colour-blind and (e) participation in studies that used the same VR scenes or videos of those scenes. Participants were randomly assigned to either one of the conditions, namely the harsh condition (n = 29) or the non-harsh condition (n = 22). In total, the sample consisted of 54.9% females (n =28) and 45.1% males (n = 23). The mean age of the sample was 22.7 (SD = 5.7) and varied between 19 and 59 years of age. The majority (62.7%) of the participants came from Germany (n = 32), 15.7% came from the Netherlands (n = 8) and 21.6% were distributed over several other countries. Out of the sample, 82.4% selected high school as their highest educational level, 15.7% college or university undergraduate degree and 2% college or university graduate degree.

Materials

Pre-VR Questionnaire

The online tool Qualtrics was used to compile the two questionnaires, namely the pre-VR questionnaire and the post-VR questionnaire. The pre-VR questionnaire included information about the procedure, conditions of the experiment, potential risks (Appendix B), an informed consent (Appendix C), items about demographic data (Appendix D) and information about the subsequent VR sequence (Appendix E).

VR Environments

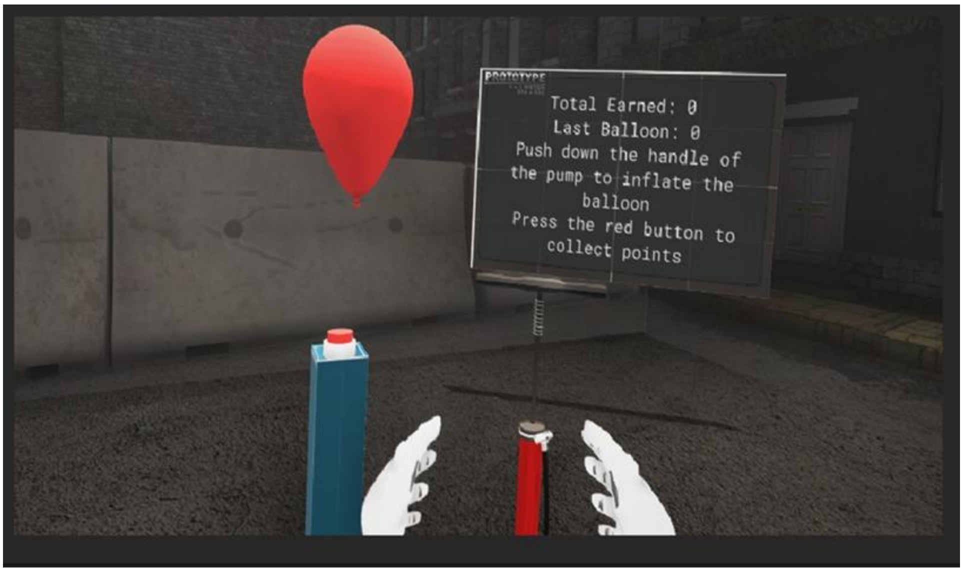
Three different VR environments, namely the practice scene, harsh condition scene and non-harsh condition scene were created using the development program 'Unity 2020.3.28f'. For the implementation in VR the 'Oculus Rift S' VR set, including the headset and controllers, was used.

Balloon Analogue Risk Task in VR. The BART was originally invented by Lejuez et al. (2002) as a tool to measure a person's risk-taking behaviour, however, some researchers argue it is also a valuable measure of impulsivity (Enticott & Ogloff, 2006; Reynolds, 2006). Moreover, it is a task "that models real-world risk behaviour through the conceptual frame of balancing the potential for reward and harm" (Lauriola et al., 2013). In this experiment, the BART was adapted and for the purpose of this study, it served as a measure of a person's level of impulsivity. The task area was surrounded by a glass box that prevented participants from leaving the area before they had completed the task. Furthermore, an orange-coloured circle marked the area where the participant should stand. Next to the circle was a pump, which was used to inflate the balloon (Figure 2). On the screen in front of the pump, the permanent points labelled 'Total earned' as well as the temporary points labelled 'Last

Balloon' were displayed. Instructions for the BART can be found in Appendix J. With each pump, the balloon was inflated, and participants earned 50 points in their temporary bank. An inflation sound was generated with the headset while the participant inflated the balloon, and a sound effect was generated when the balloon exploded. At any point, while inflating the balloon, the participant could press the red button to save points and transfer them from the temporary bank to the permanent bank. After saving the accumulated points to the permanent bank or after a balloon exploded, a new balloon appeared. In total, the task was conducted with 15 balloons (i.e., 15 trials). Through each pump, the chance of explosion was increased. Impulsivity was measured by pumps per trial. The theoretical range of scores differed between participants because a random number was drawn from the array that determined the breaking point. Therefore, participants had to decide between inflating the balloon further and earning more points or risking that the balloon would explode and hence lose the points. To calculate the scores for the BART a new variable named "mBART" was computed with the average number of pumps for each participant. This variable was based on the mean of the 15 trials the participants had in the neighbourhood scene. Only the trials during which the balloon did not explode were included because exploded balloons would not provide information on how many more pumps the participant would have committed. This restricted the variability of the absolute average values between the subjects (Lejuez et al., 2002).

Figure 2

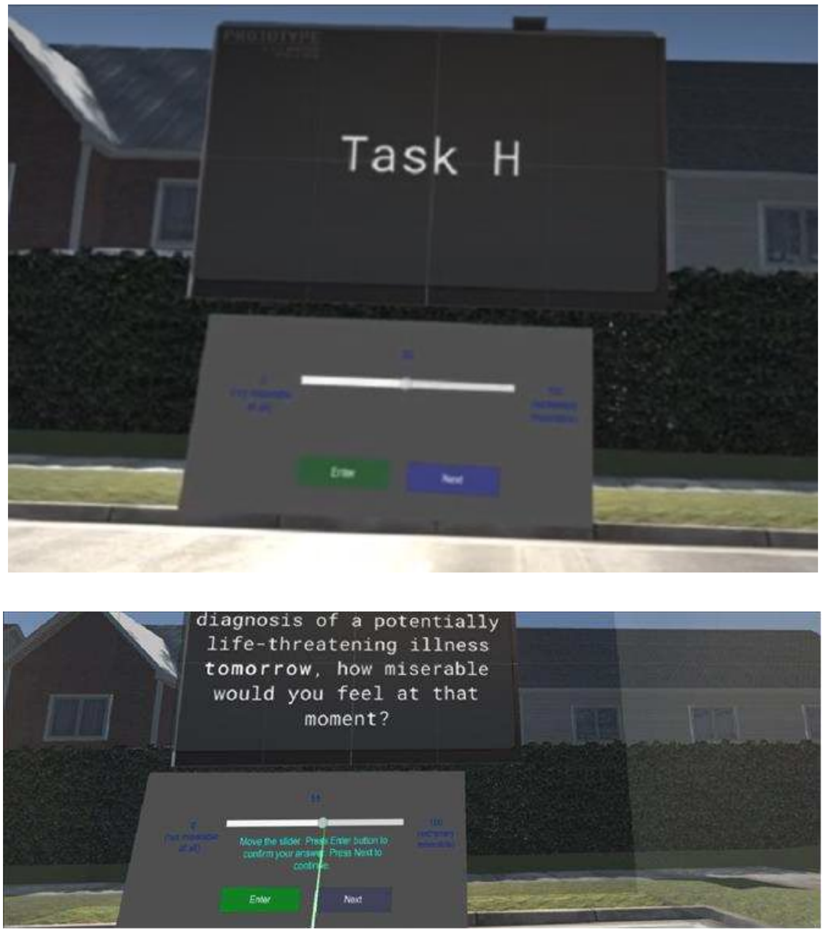
Balloon Analogue Risk Task in the Harsh Condition



Delay Discounting Task in VR. The delay discounting task was used to measure a person's decision-making behaviour concerning health. The task area was surrounded by a glass box that prevented participants from leaving the area before they had completed the task. An orange-coloured circle marked the area where the participant should stand. When entering the task zone, instructions about the delay discounting task were shown on the screen (Figure 3). Below the instructions was another screen which showed a slider from 0 (not miserable at all) to 100 (very miserable) and two buttons, namely 'enter' and 'next'. For this task, the controllers served as laser pointers with which they should click on the buttons and use the slider. Participants were asked: "If you were to receive the diagnosis of a potentially life-threatening illness tomorrow, how miserable would you feel at that moment?" (Appendix K). For each delay period (a) tomorrow, (b) in 3 months, (c) in 1 year, (d) in 3 years, (e) in 10 years and in (f) 30 years, they should indicate how miserable they would feel on the scale. The variable was computed on the six choices (i.e., six delay periods) each participant made. To calculate the area under the delay discounting curve (AUC), six different variables had to be created first. For each participant, six indifference points reflected their choices for the different delay periods (tomorrow, 3 months, 1 year, 3 years, 10 years, and 30 years). Therefore, six indifference points resulted in a total of five trapezoids. Finally, summing the areas of all five trapezoids resulted in the total area under the curve. The higher the value of the "Delay Discounting AUC", the lower the rate of discounting. For more details, see Appendix N.

Figure 3

Delay Discounting Task in the Non-Harsh Condition



Harsh Condition. The infrastructure, general design, and audio sources of both neighbourhoods resembled an English-speaking western society. For consistency reasons, the layout of the two scenes was similar. Furthermore, in the neighbourhood scenes as well as the practice scene white arrows indicated the direction in which participants should walk and the circles indicated that participants should pause for approximately ten seconds to get a good impression of their environment. Additionally, orange-coloured arrows, and circles indicated the task area.

In the centre of the harsh neighbourhood, was a basketball court with a bus stop, surrounded by streets, alleys, and houses (Figure 4). Several environmental cues indicated the harshness of the neighbourhood. First, the general atmosphere was gloomy, and the appearance of the houses and streets was dirty and grey with only one withered tree in the centre. Furthermore, many garbage bags and plastic bottles as well as broken fences lay scattered on the ground. The window of the bus stop was broken and on the ground were a sleeping bag and a mattress. These cues were supposed to indicate a lack of intact infrastructure as well as signs of poverty and violence. In addition, audio sources were implemented. Participants were exposed to the sounds of a helicopter and continuously heard the sounds of police sirens, representing a high rate of violence and criminality. Furthermore, at one point of the tour, participants could listen to two couples fighting aggressively, which represented social conflict and strained social relationships. Furthermore, an animated character was sitting in one of the alleys, where a police barrier tape was laying on the ground. All these elements represented cues of harshness. See Appendix H for the bird's eye view of the harsh condition.

Figure 4

First-person view of the harsh condition

Non-Harsh Condition. In the non-harsh neighbourhood, a park was the centre of the map, surrounded by streets with houses and trees (Figure 5). Several environmental cues indicated that the people living there were from middle to higher socio-economic classes. The sky was blue and the whole neighbourhood was clean and in good condition. Several benches, flowers and sprinklers were placed in the park and front gardens. In addition, various audio sources were implemented. Participants were exposed to the chirping of birds in the park and streets. Furthermore, close to the houses, they could listen to a family having dinner and a child practising the violin. See Appendix I for a bird's eye view of the non-harsh condition.

Figure 5

First-person view of the non-harsh condition

Practice Scene. To influence participants as little as possible, a simple environment was chosen (Appendix G). The practice scene consisted of a green field and a blue sky. Moreover, several objects (e.g., trees, basketball) were placed on the ground to familiarize participants with objects in VR. Additionally, the BART and the delay discounting task were implemented in the scene to familiarize the participants with the tasks. The BART consisted of general instructions and two trials. The delay discounting task was composed of two test questions and the slider but did not show the original instructions.

Post-VR Questionnaire

For the complete post-VR questionnaire, see Appendix L.

Manipulation Check. The post-VR questionnaire contained seven items regarding the effectivity of the different levels of harshness displayed in the VR environments. These items assessed the effectiveness of experience while being in VR. Additionally, an item concerning nausea as a result of being in VR was included. For all items, a scale from 0 (not at all) to 100 (extremely) was used. Participants were asked to indicate to what extent they (1) had a sense of being there (“immersion”), (2) had a feeling of safety (“perceived safety”), (3) experienced stress (“perceived stress”), (4) had the motivation to protect themselves from potential dangers (“motivation for self-protection”), (5) had a feeling of relaxation (“perceived relaxation”), (6) perceived the neighbourhood as dangerous and (“perceived danger”) (7) perceived the residents in the neighbourhood as trustworthy (“trustworthiness of residents”). Moreover, to see whether there is an influence of early childhood, questions about perceived environmental unpredictability and perceived neighbourhood quality were for example used. However, the analysis of these items was beyond the scope of the current study.

Naivety Check. The naivety check included one item regarding the purpose of the study. Participants were required to indicate whether they had an assumption about this study, e.g., about the overall purpose or certain questions.

Procedure

First, participants were invited to sit at a table with a computer screen and start with the pre-VR questionnaire. After they filled out the questionnaire and muted their phone, they were asked to sit on another chair for the VR scene. The researchers gave the participants a hygiene mask to wear underneath the VR headset. Once the participant was introduced to the VR equipment, the researcher started the practice scene. With the use of a verbal protocol (Appendix F), the researcher explained that the participant was supposed to follow the white arrows and rest in the white circles for around ten seconds to get a good and thorough impression of their environment. After they followed all the white arrows, they were supposed to follow the orange arrow to approach the first task, which was marked by an orange circle. The BART was the first task participants should perform. No information about the breaking point of the balloon was given to the participants. They were told that at some point the balloon would explode, which could either be at the first pump or after infinite pumps. When the balloon exploded, the collected points from the temporary bank were lost. After the participant completed the BART, they were supposed to follow the next arrows to get to the second task. For the second task, participants were supposed to complete the delay discounting task. After they had finished that task, they were told to ask any remaining questions they had now because the researcher was not allowed to interact with the participant after the neighbourhood scene had started. At the end of the practice scene, the researcher explained that the neighbourhood scene would follow. Participants were supposed to do the same as in the practice scene.

After completing the practice scene, participants were allocated to either the non-harsh neighbourhood or the harsh neighbourhood scene in VR. In addition, the order of the two tasks (BART and Delay Discounting Task) was changed after half of the sample. Participants spend approximately seven minutes in one of the neighbourhood scenes. During that time, the researcher had no interaction with the participant.

After they finished the VR scenes, participants were asked to fill out the post-VR questionnaire. There was little interaction between researcher and participant in order not to distort the results. While participants filled out the post-VR questionnaire and read the debriefing about the purpose of the study (Appendix M), the researcher waited outside to guarantee privacy. In the debriefing, they were told that the five best-performing participants each had the chance to win a 20€ VVV-Voucher in the end. See figure 6 for a graphic display of the procedure.

Figure 6

Graphic display of the procedure of the experiment

Data Analysis

All analyses were performed with the statistical programme SPSS (version 26). First, the data was filtered. Due to technical problems that caused missing data during the writing of log files, three log files were omitted. Additionally, due to a mistake made by the researchers, the explosion probability for four cases was different, hence they had to be excluded. Therefore, out of 58 participants who completed the study, 51 remained for the analysis. Furthermore, it was checked for outliers. More precisely, whether people performing either the delay discounting task or on the BART had atypical responses. Based on this, no data were excluded.

Moreover, data were prepared for analysis. To test the first hypothesis, the assumptions for conducting the independent sample t-test were checked. The Kolmogorov-Smirnov test ($p < .001$), as well as the Shapiro Wilk test ($p < .001$), indicated that the residuals of the dependent variable were not normally distributed. Furthermore, the data showed a Skewness of -.168 and a Kurtosis of 3.47 (Appendix O). Because the assumption of normality was not met, an independent t-test could not be performed. Instead, the corresponding non-parametric Mann-Whitney U Test was utilized. This test enabled comparing the mean rank for participants in the two conditions (harsh vs. non-harsh).

To test the second hypothesis, the normality of the data from the BART was checked first. The average number of pumps was approximately normally distributed and showed a Skewness of .743 and a Kurtosis of 1.77. Likewise, the Kolmogorov-Smirnov test ($p = .2$), as well as the Shapiro Wilk test ($p = .117$), supported this assumption (Appendix P). In order to perform a multiple linear regression analysis, the interaction effect had to be calculated. Therefore, the values for the condition were multiplied by the values for the BART. The relevant syntaxes for the analysis can be found in Appendix Q.

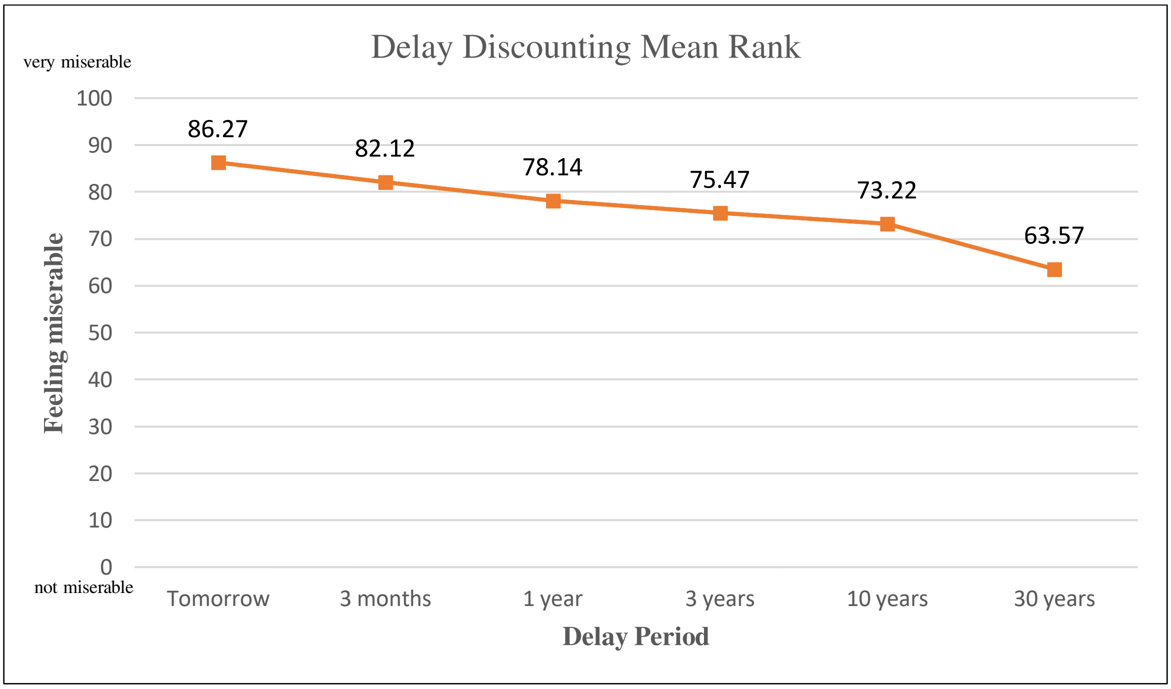
Results

Descriptive Statistics

The average value regarding the responses to the question "If you were to receive the diagnosis of a potentially life-threatening illness tomorrow, how miserable would you feel at that moment?" can be found in Figure 7. On average participants had lower scores of feeling miserable on delay periods further in the future. The mean of the overall sample regarding the "Delay Discounting AUC" was 383.86. Participants exposed to the harsh condition had on average higher "Delay Discounting AUC" values than people exposed to the non-harsh condition. Higher levels of "Delay Discounting AUC" indicated lower levels of delay discounting. Furthermore, the average number of pumps on the BART was 3.56. Participants performing the BART in the non-harsh condition had on average higher values than participants performing the BART in the harsh condition. Higher "mBART" values (greater number of pumps) implied higher levels of impulsivity (Table 1).

Figure 7

The Average Subjective Value of Feeling Miserable Plotted as a Function of Time (n = 51)



Note. Displaying average values regarding the question "If you were to receive the diagnosis of a potentially life-threatening illness tomorrow, how miserable would you feel at that moment?".

Table 1

Descriptive Statistics of "Delay Discounting AUC" Values and "mBART" Values

	Non-Harsh (N = 22)	Harsh (N = 29)	Total (N = 51)
Delay Discounting AUC[a]			
Mean (SD)	391.93 (63.4)	377.74 (117.05)	383.86 (97.01)
Median (Min, Max)	399 (203.5, 492)	395 (42, 500)	396 (42, 500)
mBART[b]			
Mean (SD)	3.6 (0.76)	3.53 (1.34)	3.56 (1.12)
Median (Min, Max)	3.5 (2.2, 5)	3.4 (1.13, 7.33)	3.47 (1.13,7.33)

Note. [a] Higher levels indicate lower levels of discounting. [b] Higher levels indicate higher levels of impulsivity

Manipulation Check

In order to check the effectivity of the manipulation, an analysis of seven items was executed. Only the variable "immersion" fulfilled the normality assumption. An independent sample t-test was conducted t (49) = 1.05, p = 3. For both conditions, participants indicated to have a sense of being there. For the other variables of the manipulation check, a Mann-Whitney U test was conducted. A significant result was obtained for "perceived safety" U (59) = 569, $p < .01$. This indicated that participants felt less safe in the harsh condition than in the non-harsh condition. For the variable "perceived stress", a significant result was found U (51) = 136,000, $p < .01$. Hence, participants felt more stressed in the harsh condition. For "motivation for self-protection" a significant result was obtained U (51) = 725,000, $p < .01$. Participants exposed to the harsh condition felt a higher motivation to protect themselves from potential dangers. A significant result was found for "perceived relaxation", U (51) = 542,500, $p < .01$. Participants felt less relaxed in the harsh condition. For "perceived danger" a significant result was obtained, U (51) = 100, 500, $p < .01$. Participants perceived the harsh condition as more dangerous. Lastly, for "trustworthiness of residents" a significant result was found, U (51) = 620,000, $p < .01$. Hence, participants perceived the residents in the harsh condition as less trustworthy. Therefore, it can be concluded that the manipulation check was effective.

Inferential Statistics

Hypothesis 1

To test the first hypothesis '*Participants exposed to the harsh condition have higher levels of discounting of future suffering than people exposed to the non-harsh condition,* the effect of the independent variable "harshness" on the dependent variable "discounting of future suffering" was analysed. The Mann-Whitney U test revealed no significant difference between the conditions (harsh vs. non-harsh) on the discounting of future suffering (U = 307, Z = -.228, p = .819). Therefore, the first hypothesis could be rejected.

Hypothesis 2

To test the second hypothesis '*The effect of a condition on the level of discounting of future suffering is positively moderated by a participant's levels of impulsivity'*, the influence of impulsivity on the effect of the independent on the dependent variable was investigated. To test the possible moderation effect of "impulsivity" (measured with the BART) on the effect of "harshness" on the "discounting of future suffering", a multiple linear regression was conducted (Figure 8). R^2 = .021 showed that the predictors explained 2.1% of the variance of the dependent variable The overall regression showed no statistical significance for the moderation effect of "impulsivity" on the effect of "harshness" on "discounting of future suffering" (R^2 = .021, F (3, 47) = .335, p = .8). It was found that "impulsivity" did not significantly predict the effect (β = .467, p = .48). Thus, the second hypothesis had to be rejected (Table 2).

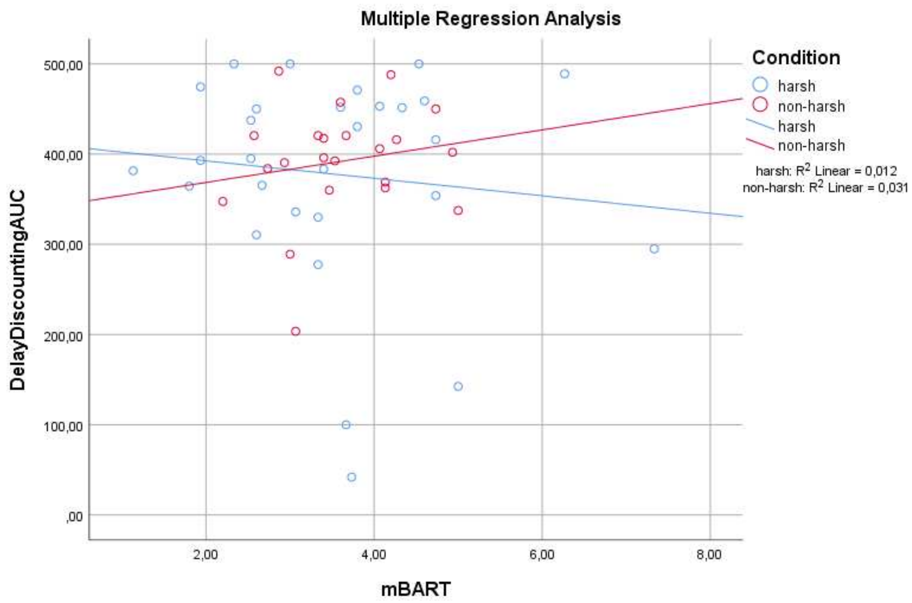
Table 2

*Moderation analysis: DelayDiscountingAUC, Condition, mBART and mBART*Condition in a Multiple Regression Analysis*

	Unstandardized coefficient		Standardized coefficients			Correlations		
Model	B	SD	Beta	t	Sig.	Zero-order	Partial	Part
Intercept	411.93	52.46		7.85	.000			
Condition	-72.44	116.76	-.373	-.62	.54	.07	-.09	-.09
mBART	-9.68	13.92	-.112	-.7	.49	-.06	-.1	-.1
mBART*Condition	24.24	31.59	.467	.767	.48	.09	.11	.11

Figure 8

Moderation Analysis: Scatterplot for Multiple Linear Regression Analysis



Discussion

In this study, the effect of socio-environmental cues of harshness on the discounting of future suffering was investigated using VR. Furthermore, the role of impulsivity as a moderator was examined. Therefore, two hypotheses were tested. First, it was hypothesized that participants exposed to the harsh condition have higher levels of discounting of future suffering than people exposed to the non-harsh condition. Second, it was anticipated that the effect of harshness on the level of discounting of future suffering is moderated by impulsivity. Contradictory to the expectations, there was neither a significant difference in discounting of future suffering between the harsh and non-harsh conditions, nor did impulsivity moderate this effect.

The results of the present study are inconsistent with most previous research on this topic. The evolutionary framework of LHT postulates that individuals exposed to cues of harshness are more likely to engage in delay discounting and that discounting immediate consequences is more beneficial in these circumstances (Fennemann & Frankenhuis, 2020). Furthermore, the finding is non in line with Griskevicius et al. (2011) who found support for LHT while also considering childhood adversity. However, the replication study by Pepper et al. (2017) could not find an effect of situational cues of harshness on delay discounting. The analysis for the manipulation check items yielded significant results, indicating that the manipulation of the independent variable harshness worked, and participants perceived the harsh condition as more dangerous and stressful. However, this has not affected the results, as there was no difference between the conditions. The current research was based on the study of Kassam et al. (2008) and to some extent, the results are concordant. The findings of their study showed that people tend to discount their future happiness. Kassam et al. (2008) concluded that people tend to value their hedonic experience as less intense in the future than in the present. A new item was used in this study, concludingly, no research has used this exact paradigm before. However, based on the discussed theory and evidence it was assumed that people exposed to harsh environments would discount their future negative health consequences. In the present study, participants discounted their future suffering regardless of the harshness of the condition. More specifically, results showed that when asked to imagine receiving a life-threatening diagnosis, participants indicated feeling less miserable in the far future (e.g., 30 years) than in the present.

A potential explanation for why the results deviate is that only situational cues of harshness were taken into account. More specifically, participants' upbringing, as well as current life situations, were not considered in the extent of this research. This could explain the effect of this study's rather homogeneous sample (students). Various studies (e.g., Griskevicius, 2011) controlled for childhood adversity and found a significant effect. Many cognitions and behaviours are formed (not fixed) in childhood and therefore individuals who had experienced childhood adversity might perceive cues of harshness differently. The study by Griskevicius (2011) found that people who grew up in an environment characterized by more cues of harshness might more likely engage in delay discounting. Furthermore, in the study of Kassam et al. (2008), they investigated the discounting of future happiness with a monetary delay discounting task. The discounting of future negative health consequences in this study however does not entail choosing between an immediate and a delayed reward, but rather indicating misery in response to a diagnosis of a life-threatening disease on different delay periods. It is still a relatively new concept in psychological research and therefore research is sparse. Noticeable however is that the study of Griskevicius et al. (2011), Pepper et al. (2013) and the current study have similar characteristics, including students with comparable mean age, origin, and reward for participating. Lastly, even though the manipulation check worked, e.g., on average participants indicated higher levels of stress in the harsh environment, they were aware of being in a simulation. Furthermore, research has shown that interaction with avatars in VR resembles real-life interaction (Fox et al., 2009), however, in this research, no interaction was enabled.

Moreover, the present study was inconsistent with research that concluded that impulsivity is more common as well as more adaptive in environments characterized by harshness and leads individuals to engage in delay discounting (Fennemann & Frankenhuis, 2020). The present results indicated no moderation effect of impulsivity on the effect of socio-environmental cues of harshness on the discounting of future suffering. Furthermore, in most research, impulsivity was measured using for example the Barratt Impulsiveness Scale, which is a self-report measurement. In this research, the BART was used as a behavioural measure to assess impulsivity. Contrary to the Barratt Impulsiveness Scale, the BART measures only the behavioural risk-taking part of impulsivity and does not consider concepts like self-control and non-planning impulsivity which have been closely linked to delay discounting (de Wit et al., 2007). As aforementioned, childhood adversity is a variable that has been found to be related to delay discounting. Lewitt et al. (2021) have also connected adverse life experiences and impulsivity. This could be another reason for the deviating results.

This present study gives additional information that several cues of harshness are important to examine this effect in real-life. Moreover, as the hypotheses formulated were based on an evolutionary developmental framework, it leads to reconsidering LHT as a theoretical perspective for explaining delay discounting and impulsivity. The (un-)conscious processes behind decision-making and the role of impulsivity might be too complex to be solely understood from an evolutionary perspective. Moreover, according to LHT, the main goal of human behaviour is reproduction (Kavanagh & Kahl, 2016). Compared to hunters and gatherers, humans have relatively good conditions for reproduction. However, statistics show that the general birth rate is declining (BBC, 2021). Therefore, it can be suggested that nowadays reproduction is not the main goal behind human decision-making processes. Therefore, to understand behaviours and cognitions more clearly, factors like intelligence, culture, SES, personality etc. should be taken into account.

Strengths

Using VR to examine the effect of harshness on a participant's discounting of future suffering has an added value. The use of a headset and controllers creates a real-life perception of the environment (Fox et al., 2009). Furthermore, it is a safer, more controlled option than experimenting in a real environment. Due to the elimination of external variables, high internal validity is guaranteed. To the researcher's knowledge, this study was the first to ever use VR to expose participants to cues of harshness as well as for the execution of both tasks, namely the delay discounting task and the BART. More specifically, participants did a walking tour in one of the conditions (harsh vs. non-harsh) in VR for approximately seven minutes and afterwards completed the two tasks while still being in the same VR environment. In a pilot study with the BART, participants were exposed to VR and afterwards had to complete the task on a computer. Hence, an interruption was created, and participants were not exposed to the cues of harshness during the performance of the task. The beneficial aspect of this study is that because there was no interruption, a more impactful result could be generated.

Additionally, this experiment was a collaboration of a multidisciplinary team of psychologists, developers, and engineers. The VR scenes were designed for specifically this experiment. This could be ensured through the collaboration of researchers from different domains.

Limitations

Regarding the limitations of the study, one aspect that should be considered is the sample. Many of the studies that revealed different results had a bigger sample size. This sample consisted of 51 respondents which consequently left less than 30 participants per group. A small sample hence cannot be generalized to a population, and it can affect the internal and external validity of the study. Furthermore, the sample of the study was WEIRD, which implies that most of the participants were from Western, educated, industrialized, rich and democratic nations (Muthukrishna et al., 2020). In the field of psychology, 96% of findings from the research are based on studies conducted with WEIRD samples (Arnett, 2009). Hence, conclusions are made about humankind by generalize findings about only a small percentage of the world's population. However, cultural differences go in hand with psychological differences, including different norms and attitudes. Moreover, the mean age of the sample was 22.7. Literature has indicated the importance of mental representations of events in understanding time discounting (Berns et al., 2007; Kassam et al., 2008). Participants might have had difficulties imagining their life in 10 or even 30 years and hence, might expect to receive a life-threatening diagnosis at their young age as more severe than in older age. Additionally, most of the participants were students from the University of Twente, hence the sample has a limited range of participants' current SES. Various literature has determined a link between SES and decision-making. More precisely, it has been found that lower SES, resource scarcity and environmental instability trigger individuals to choose immediate rewards (Sheehy-Skeffington, 2020). Harshness can be an indicator of the SES of the people living in harsh neighbourhoods. Hence, this restriction might have reduced the power to find a significant effect of cues of harshness on the discounting of future suffering. Moreover, various literature has identified that exposure to environmental instability and resource scarcity influences individual behaviour in the long term (Zeynel & Uzer, 2020). Individuals growing up in environments characterized by harshness might have responded to the cues stronger. Hence, it could be suggested that childhood adversity would moderate the effect of harshness on delay discounting. Concludingly, the sample was not representative, therefore, using a bigger more diverse sample could significantly affect the result.

Furthermore, participants might have perceived the instructions for the two tasks as too long. It was noticeable during the experiment that some participants did not read the instructions of the BART carefully enough and therefore skipped some balloons. To reduce the amount of missing data, shortening the instructions could be beneficial.

Lastly, a limitation is that impulsivity was measured with the BART only. Some researchers argued that the BART can be used as a measure of impulsivity (Lejuez et al., 2002; Reynolds, 2006). However, the BART only assesses the risk-taking part of impulsivity. Including self-report measurements like the Barratt Impulsiveness Scale (Barratt, 1996). could add other factors of impulsivity. The concept of self-control, for example, would have been interesting to investigate as it was found to be closely linked to delay discounting. Furthermore, the BART is only a behavioural measure for impulsivity. This makes it difficult to investigate the dimensions from a broader perspective. Concludingly, using a self-report as well as a behavioural measure could enable a more valid and reliable measure of the construct impulsiveness.

Conclusion and Directions for Future Research

Although some research on this topic already exists, there is a need for more research to establish a better understanding of the influence of socio-environmental cues of harshness on the discounting of future negative health consequences as well as the influence of impulsiveness. Despite the study’s limitations, it was the first ever to use VR to expose participants to cues of harshness throughout the tour in the neighbourhoods and the two tasks. Furthermore, this study considered the influence of harshness in the experimental condition and hence, sheds light on the spare research on situational cues of harshness on decision making.

For future research, these limitations and strengths of the study should be considered. Researchers should try to make their sample more diverse, including participants from different life stages, cultures, neighbourhoods, SES etc. to prevent using a WEIRD sample. This can enable more reliable and valid results, as people from environments characterized by more cues of harshness might for example show higher levels of delay discounting and impulsivity. VR is a beneficial tool that is widely used in psychology and other social sciences. To have a broader perspective on the multidimensional concept of impulsivity, not only the BART as a behavioural measure should be used but rather an additional measure should be incorporated. Lastly, as various literature has found an association between childhood adversity and delay discounting, this should be taken into account for future research.

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Appendix A. Recruitment Poster

Appendix B. Pre-VR Questionnaire

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Welcome!

You are invited to take part in a study investigating how people experience a Virtual Reality neighbourhood.

The project is conducted by Erik Janus and Paula König (BSc Psychology students, University of Twente) and supervised by Jeanette Hadaschik, MSc (Department of Psychology of Conflict, Risk and Safety, University of Twente; Work and Social Psychology, Maastricht University) and Dr. Marielle Stel (Department of Psychology of Conflict, Risk and Safety, University of Twente) as well as Dr. Karlijn Massar and Prof. Dr. Rob Ruiter (Maastricht University). The study is approved by the Ethics Committee of the Faculty of Behavioural, Management and Social Sciences at the University of Twente (request number 210124).

Please take time to **read** the following information **carefully** before you decide whether or not to take part, it is important for you to understand what participation in the study will involve.

Who can take part?

- We are looking for participants aged 18 years and older.
- Your English language skills need to be sufficient in order to understand instructions and answer the questionnaires.
- Participation is completely voluntary and anonymous.

What is involved?

If you decide to take part, your session will consist of the following parts:

1. You fill in a short questionnaire.
2. You experience Virtual Reality for about 10 minutes. You will receive instructions on how to put on the

headset and how to move in the virtual world.

3. In the virtual world you will go for a walk and complete two tasks.

4. Right after experiencing the virtual world, you are asked to fill in a questionnaire.

One session takes about **45 minutes**.

Will I get paid?

- For participation in SONA, you will receive 1.5 credits
- Additionally, the top 5 performing participants will each receive a 20€ VVV-voucher
- The winners will be announced once the data collection is finished. If you'd like to be notified in case you win one of the prizes, you need to provide your email address at the end of the study.

Are there any risks?

- Some people get nauseous during or after experiencing Virtual Reality. This usually goes away after a brief period of rest.
- The questionnaire includes questions about positive and negative childhood experiences (which some people might find uncomfortable).

What about Covid-19 prevention?

- Our team will adhere to a safety protocol including thorough disinfection of equipment after every participant and ventilation of the room.
- You can participate only if you are free of relevant symptoms.

What happens with the data?

- All data collected during the study will be kept strictly confidential and anonymous.
- **Your response cannot and will not be traced to you personally** and no identifying information will appear in any documents or in the final report.

- A unique, random identifier code will be sent to you via email after completing the study. You can use it in case you would like to withdraw your consent after taking part. - Please answer as honestly as possible.

Do you have any general questions?

If yes, please ask the researcher now.

Click 'next' to proceed.

Appendix C. Informed Consent

Informed Consent

By clicking **YES** below, I agree to the following:

I understand that my participation is voluntary. I also understand that I have the right to withdraw my consent at any time without needing to give a reason, if I experience any discomfort or distress.

Furthermore, the following points are clear to me:
- All data that are collected by the researcher are treated completely anonymously and cannot and will not be traced back to me personally.
- I understand that I have to provide my email address if I want to be notified in case I win a prize. If I provide my email address, it will also be used to send me a copy of the debriefing information including my response identifier code (which is needed to request deletion of the data).
- I understand and agree that the purpose and hypotheses of the current study cannot be revealed to me because it could bias my answers. However, after completion of the study I will receive a full debriefing.
- I agree to keep the procedures and explanation of this study to myself and will not pass this information on to others because this might negatively influence the study results.

I agree to participate in the study:

○ YES, I fully understand the contents of this consent form and agree to participate in this study. I also agree not to disclose the details of the study to other parties.

○ NO (you will be directed to the end of the study)

Appendix D. Demographic Data

In this section, we ask you to provide some general information.

With which gender do you identify most?

- ◯ Male
- ◯ Female
- ◯ Diverse
- ◯ Transgender
- ◯ Non-binary
- ◯ Other
- ◯ Prefer not to say

Please choose **the country you lived in until you were about five years old**. If you lived in more than one country, indicate the one that most influenced your early childhood.

Would you like to receive SONA credits for completing this questionaire? (Only relevant for students of Dutch universities)

- ◯ Yes
- ◯ No

What is the highest educational level you have achieved?

- ◯ Elementary school
- ◯ High school
- ◯ College/University - Undergraduate degree (e.g. Bachelor of Science, Bachelor of Arts or equivalent)
- ◯ College/University - Graduate degree (e.g. Master of Science/Arts or equivalent)
- ◯ Doctoral degree/PhD
- ◯ Other

How old are you? (Please enter only the number)

What is your nationality?

Appendix E. Information about the VR Procedure

In the next part of your session, you will experience Virtual Reality.

You will walk around a **virtual neighbourhood** that is modelled based on examples of real neighbourhoods in the United Kingdom and USA. **Please imagine that you are walking around this neighbourhood in reality**. Arrows are painted on the ground to guide you. Please follow them to do a small tour of the neighbourhood. Take your time. When you see a circle painted on the ground, please stop walking, have a break, look around and get a good impression of your environment and your surroundings. When you feel ready, continue to follow the next arrow. When you have completed your tour, you can continue walking around and exploring other areas and corners until your time is over. Your stay in the neighbourhood takes 7 minutes.

Before you enter the virtual neighbourhood, you will enter a 'practice' world where you will learn to use the controllers, try to orient yourself and become familiar with how to move. If you have any questions, please make sure to ask the researcher **while you are still in the practice world**, that means **before you enter the virtual neighbourhood**. The researcher will let you know when you are about to leave the practice world.

Once you are in the virtual neighbourhood, we would like you to fully focus on the experience and not be distracted. Therefore, it's important that you ask any questions before. Of course, in case you would like to withdraw from the experiment or in case you feel nauseous, you can always stop without giving a reason.

○ Ok, I understand

Appendix F. Verbal Instruction Protocol

Procedure: Verbal explanations & communication with participants

Preparation before each p. arrives:

- *disinfect controllers and headset (especially "nose area")*
- *prepare new eye mask for each p.*
- *close windows and ventilation openings to control noises from outside*
- *calibrate headset & controllers (Oculus Device setup and Guardian setup)*
- *open preVR questionnaire*

General:

1. *Open MS teams and OneDrive folder.*
2. *Open participant log sheet (excel)*
   - ➔ *later enter data regarding participant, researcher, the condition, and noteworthy information there*
3. *After each day in the lab, secure the gathered data by uploading log to the OneDrive folder and drag and drop it on the hard drive*

Questionnaire setup:

1. *Open Qualtrics on a different PC than VR and open both Pre and Post VR questionnaire*
2. *Navigate to "Distributions" and create anonymous (reusable) link:*

pre: https://utwentebs.eu.qualtrics.com/jfe/form/SV_0q8Q9WesGIh8WCW

post: https://utwentebs.eu.qualtrics.com/jfe/form/SV_0fadKAdrEee9ZZk

-> Delete cookies if you get a message by Qualtrics that you have already taken the survey

VR setup:

1. *Oculus guardian setup (and Device setup after Oculus app was closed)*
2. *Start unity, open both Good Neighbourhood (always for practice scene) and Deprived Neighbourhood (optional, if: condition). Load practice scene*
3. *Set audio output to Oculus*
4. *Equipment disinfection; open oculus wheel & strap. Attach mask to headset.*
5. *Mute all personal devices, also applies to participants (phone, laptop, tablet)*

1.PreVR survey

[Open PreVR survey, enter ID and condition]

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Welcome: **"your session today consists of three parts: first a short questionnaire, then VR in which you will complete two tasks and finally a questionnaire"**

2. Putting on headset & holding controllers

Name practice output file: *file name=practice; ID=1,2,3. etc]*

[FIRST, START PLAY MODE OF PRACTICE *SCENE; adjust camera offset position "Y" to 0.25]*

"Hold the controllers with the rings facing towards you and place your thumbs on the small thumb sticks." *[they try it, then put them on the table in front of them to focus on the headset]*

"The headset has a wheel at the back to loosen and fasten how tight it fits. After you put it on, secure it with the wheel and use the strap at the top to fasten the fit. It should fit tightly but comfortably so that your visual field is clear. You might have to readjust the eye mask."

[when p. puts on headset, check if Unity play mode is working, you should see head movement on screen. If not, exit and restart play mode]

[they have finished adjusting the headset]

3. Practice scene

[p. wears the headset and holds both controllers in their hands; the practice scene is in play mode]

Adjust height to 0.25 (ask p to close eyes to prevent cybersickness)

"You are now in the practice world. Like in real life, you can move your head up and down and left to right to look around *[let them try].* **You can also turn in your chair to look around** *[let them try].*

Also, holding your controllers and moving your hands in real life causes your virtual hands to move. Please use your left thumb to push the thumb stick away from you to move forwards. Pull it towards you to move backwards. You can also move diagonally. You can try it out now *[let them try it, answer questions if they have any*]. **With your right thumb, you can move the thumb stick to change perspective** [let them try]. **By using your**

index fingers, you can use the triggers on the back of your controllers to interact with certain objects in VR. You will have a chance to practice in this
scene. On the ground, you can see white arrows and circles. This will look similar in the virtual neighbourhood. Please follow the white arrows to do a tour of the neighbourhood. When you get to a circle, this is a sign for you to stop walking, look around and get a good and thorough impression of your environment and your surroundings. Taking a little break from walking can also
help to reduce cyber sickness. Stay in or around the circle for about 10 seconds. When you feel ready, continue walking in the direction of the next arrow. Please try it now.
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[let them walk around; while they do so check if headset cable is inhibiting their movements; check if
audio output is set to Oculus].
At the end of your tour you will see an orange-coloured arrow. Follow the orange arrows to the first task. Approach the task area and stand in the orange-coloured circle. The screen will show instructions.
[When p. is practicing how the tasks work]

Task B:
Please take your time to read the instructions thoroughly. The task will not work as intended if you don't follow the instructions. Each time you press the button, look at the screen to read the instructions. You won't be able to leave the task area until you have finished the task.
[only read the rest of this text if the participant is struggling. Make sure to check they understand that
they always need to press the red button to move on to the next balloon]
(Using your virtual hands, you can interact with the red button by pressing it. Similarly, you can use the pump by pressing down the lever using your virtual hands, please don't use your index finger. Please read the instructions carefully and monitor if the instructions shown on the screen change after you performed an action. The red button can sometimes stuck; if you don't hear a sound while pressing it, try again)
[p. Has finished 1st task]
After you have completed the first task, follow the next orange arrow to the second task. When you are there, enter the orange circle and read the instructions on the screen.

[p. Has arrived at 2nd task]

Task H:

Please take your time to read the instructions thoroughly. The task will not work as intended if you don't follow the instructions. Each time you press the Next button, look at the screen to read the instructions. *[only read the rest of this text if the participant is struggling. Make sure to check they*
understand that they always need to press Enter and Next to move on to the next question]
[By pointing the rays/laser emerging from your hands, you can interact with the screen in front of you. Direct the ray to the buttons and pull the trigger using your index finger to press it. Similarly, direct the ray to the slider and pull the trigger while moving your hands to adjust the slider to your liking. Please read the instructions carefully and monitor if the instructions shown on the screen change after you performed an action.]
The light ray might look a bit different in the virtual neighbourhood but it will work the same way.

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…

[they have completed the practice tour and both tasks]

"Do you have any questions? If yes, please make sure to ask them now. Once you are in the neighbourhood, we cannot interact with you to not distract you from your experience". [give them time to ask].

Next, the experiment will begin. I will stop the practice scene and start the neighbourhood scene. Please explore the neighbourhood using the white arrows as a guide. Walk in the direction of the first white arrow, until you see the next white arrow. As in the practice scene you will do two tasks in the neighbourhood. Those tasks will be very similar to the ones you have just completed but there will be some differences. It is therefore important that you read the instructions carefully.

After you have followed all the white arrows, follow the orange arrows to the first task. After you have completed the first task, follow the next orange arrow to the second task. After you have completed the second task, you have finished the experiment. Try to refrain from asking any questions while being in the virtual environment".

[before changing the scene]

"Please close your eyes so I can change the scene. I will tell you when you can open them again."

- adjust height to 0.25 (Cameraoffset)

- enter condition (N/D-B/H-B/H) in output along with participant ID (1,2,…)

File name: D_BH/N_BH/D_HB/N_HB

4. D/N scene

[D/N scene is in play mode]

"Can you see the neighbourhood?" [if yes] -> **"Ok, I will let you do the tour and the tasks"**

[if no -> exit and restart play mode]

[set timer to measure the time that the participant spends on the tour in VR]

"Ok, your time in the neighbourhood is over now. You can hand the controllers to me and take off the headset by loosening the strap and the wheel."

[ONLY AFTER THEY TOOK OFF HEADSET: EXIT PLAY MODE]

5. PostVR survey

"Are you ready to continue with the next part? Please fill in this questionnaire"

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"I will leave the room now and wait outside until you are finished"

Open survey about VR experience and childhood adversity

"I will leave the room now and wait outside until you are finished"?

6. End

[p. indicates they are finished]

[ask them if they feel ok and if they have any questions; offer sweets]

[approve SONA credits]

Appendix G. Practice Scene

Figure 9

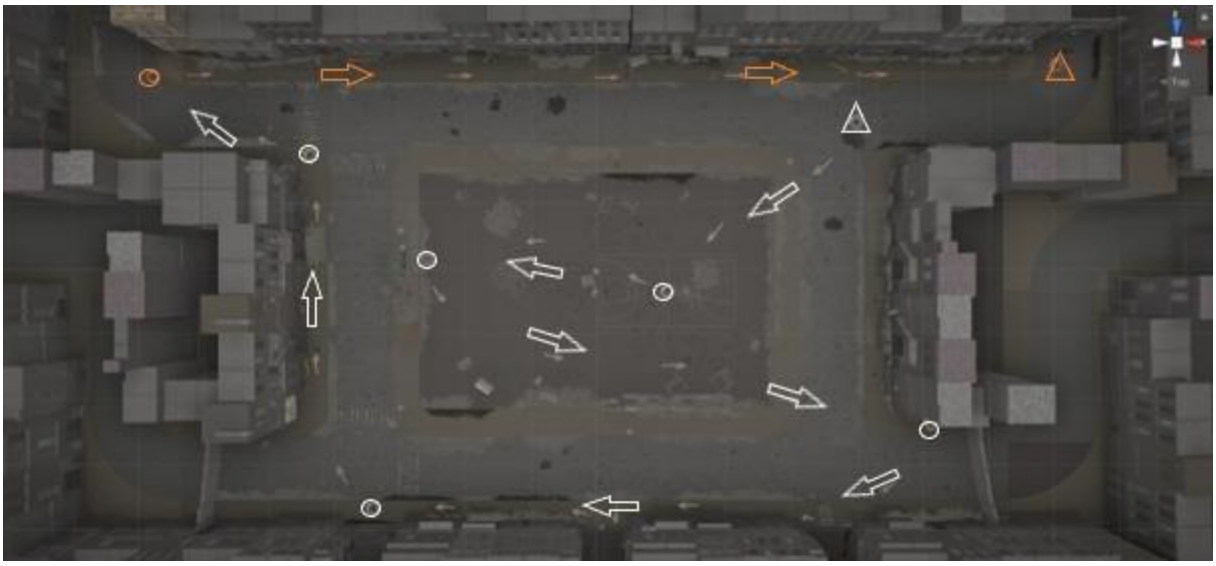
Tour of the Practice Scene

Note. The white triangle indicates the start point**.** White arrows indicate the tour of the neighbourhood. White circles indicate a point where the participant should pause. Orange arrows indicate the way to the task. Orange circles indicate the task area. The orange triangle indicates the end point.

Appendix H. Harsh Neighbourhood

Figure 10

Tour of the Harsh Neighbourhood



Note. The white triangle indicates the start point**.** White arrows indicate the tour of the neighbourhood. White circles indicate a point where the participant should pause. Orange arrows indicate the way to the task. Orange circles indicate the task area. The orange triangle indicates the end point.

Appendix I. Non-Harsh Neighbourhood

Figure 11

Tour of the Non-Harsh Neighbourhood

Note. The white triangle indicates the start point**.** White arrows indicate the tour of the neighbourhood. White circles indicate a point where the participant should pause. Orange arrows indicate the way to the task. Orange circles indicate the task area. The orange triangle indicates the end point.

Appendix J. Instructions Balloon Analog Risk Task

Welcome to Task B! In this task, you will be presented with 15 balloons, one at a time. For each balloon, you need to push down the handle of the pump to increase the size of the balloon. For each pump, you will gain 50 points in a temporary bank. You will not be shown the amount you have accumulated in your temporary bank. At any point, you can stop pumping up the balloon and press the red button to collect your points. Pressing this button will start you on the next balloon and will transfer the accumulated points from your temporary bank to your permanent bank labelled "Total Earned." The amount you earned on the previous balloon is labelled "Last Balloon." Press the red button to continue.

It is your choice to determine how much to pump up the balloon, but at some point, the balloon will explode! The explosion point varies across balloons, ranging from the first pump to enough pumps to make the balloon big. If the balloon explodes before you press the red button then all points in your temporary bank are lost and you move on to the next balloon. Press the red button to continue.

Exploded balloons do not affect the points accumulated in your permanent bank. The participants with the highest number of points will each win a voucher! Press the red button to continue.

The next 15 balloons will count towards your total points and your chance to win a voucher. Press the red button to start the first balloon.

You have finished this task. Press the red button to leave this game area. Follow the orange arrows to the next task!

Appendix K. Instructions Delay Discounting Task

[1st element:]

Welcome to task H. Please imagine the following scenario: At a doctor's appointment, you are told that you have a serious illness.

Medical treatment is available but there is a chance that you will not recover, and you might die within the next year. It is very likely that you will suffer a lot.

The following questions ask you to imagine how miserable you would feel in that scenario (mentally, not physically). Press 'Next 'to continue.

[2nd element:]

You will be asked to answer each question on a scale from 0 to 100, where 0 represents "not miserable at all" and 100 represents "extremely miserable".

Please use your index finger of your left or right controller to press the trigger and move the slider.

Please read each question carefully. Press 'Next' to continue.

[Instructions below slider:]

Move the slider. Press 'Enter' to confirm your answer.

Press 'Next' to continue.

[3rd element:]

"If you were to receive the diagnosis of a life-threatening illness tomorrow, how miserable would you feel?"

Appendix L. Post-VR Questionnaire, Manipulation Check and Naivety Check

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Some people experience nausea when being in VR. Did you become sick or nauseous as a result of experiencing VR?

Please answer on a scale of 0 to 100
where 100 represents extremely sick (e.g. having to vomit) and 0 represents not sick at all.

0 10 20 30 40 50 60 70 80 90 100

nausea/sickness

While being in the virtual neighbourhood, did you have a **sensation of 'being there'** (in the virtual environment)?

Please rate your sensation of being in the virtual environment, on the following scale from 0 to 100, where **100 represents your normal experience of being in a place**.

0 10 20 30 40 50 60 70 80 90 100

I had a sense of "being there"...

Please rate how **safe** you felt while being in the virtual neighbourhood,

where **100 represents the strongest possible feeling of safety** and **0 represents feeling not safe at all.**

0 10 20 30 40 50 60 70 80 90 100

My feeling of safety was...

Please rate how **stressed** you felt being in the virtual neighbourhood,

where **100 represents highest stress possible** and **0 represents not feeling stressed at all.**

0 10 20 30 40 50 60 70 80 90 100

My feeling of stress was...

Please rate how **motivated you felt to protect yourself from potential dangers** while being in the virtual neighbourhood,

where **100 represents the highest possible motivation for self-protection** and **0 represents not feeling motivated to protect youself at all.**

0 10 20 30 40 50 60 70 80 90 100

My motivation for self-protection was...

Please rate how **relaxed** you felt in the virtual neighbourhood,

where **100 represents highest relaxation possible** and **0 represents not feeling relaxed at all.**

	0	10	20	30	40	50	60	70	80	90	100
My relaxation was...											

Please rate how **dangerous** you perceived the virtual neighbourhood to be,

where **100 represents most dangerous possible** and **0 represents not dangerous at all.**

	0	10	20	30	40	50	60	70	80	90	100
How dangerous did the neighbourhood seem to you?											

Please rate your perception of the trustworthiness of the residents in the virtual neighbourhood,

where **100 represents most trustworthy** and **0 represents not trustworthy at all.**

	0	10	20	30	40	50	60	70	80	90	100
How trustworthy did the residents seem to you?											

What three things did you pay **most attention** to while you were in the virtual neighbourhood? These could be visual features of the environment, sounds or your own feelings. Please describe them briefly below.

1.
2.
3.

Did you experience any technical issues while being in the virtual neighbourhood? For example, graphic distortions (e.g. zig zag lines, black patches) in your visual field, non-responsive controllers, problems with the audio, etc.

- ○ No issues at all
- ○ Minor issues but they didn't distract or confuse me
- ○ Some issues that were moderately distracting/confusing
- ○ Major issues that were very distracting/confusing

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When people participate in research, they might have their own associations, ideas or suspicions about the purpose of a study. Especially after having participated in multiple studies, people might notice similarities or differences that can lead to assumptions about a study. These assumptions can then bias the way how people respond. This is not a mistake but part of how the human mind works.

By indicating whether you have any assumptions, you're helping us to better understand the data.

Do you have any assumptions about this study, e.g. about the overall purpose or about certain questions?

- ○ No, I don't have any assumptions beyond the information that was provided in the study
- ○ Yes, I have an assumption

Appendix M. Debriefing

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THANK YOU!
You have reached the end of this questionnaire. We very much appreciate your contribution to our research.

DEBRIEFING: This study's aim is to investigate whether there is a relationship between the environment that participants experience in Virtual Reality and their behaviour in decision-making games. In addition, our early experiences in family and neighbourhood might also have an influence on our decision-making and what effect an environment has on us. We are not interested in individual responses but rather in comparing trends across different VR environments.

Results from this study might help us to further understand how different environments influence our decision-making. Not much is known about this topic and our research ultimately aims to support intervention development that helps people make decisions that increase their well-being. If you have concerns about your participation or would like to withdraw from the study, you can contact the researchers and provide your identifier code.

Please don't share this information with others as it might influence how future participants behave during the experiment.

Based on the number of points that you won during the square and the balloon game you can win one of five 20 Euro VVV vouchers. The winners will be notified via email after data collection has ended. Due to the pandemic, data collection is expected to take longer than usual, therefore it can take a while until we can announce the winners.

Appendix N. Calculation of AUC

The variable “Discounting of future suffering” was measured with the Delay Discounting Task. In order to use this in the analysis, several steps had to be performed. The goal was to compute a new variable “Delay Discounting AUC” in SPSS based on the six choices each participant has made. Five different trapezoids were calculated and summed up in the end to calculate the new variable “Delay Discounting AUC”. The higher the value of the “Delay Discounting AUC”, the lower the discounting.

<u>The area of a trapezoid is:</u>

(a+b)/2 * c, with c=1. (Borges et al, 2016)

- a = indifference point on the left side of the trapezoid
- b = indifference point on the right side of the trapezoid
- c = 1 the distances between the indifference points should be normed to 1. Otherwise, indifference points that are further in the future will have a higher weight, but all indifference points should have an equal influence on the overall “Delay Discounting AUC”.

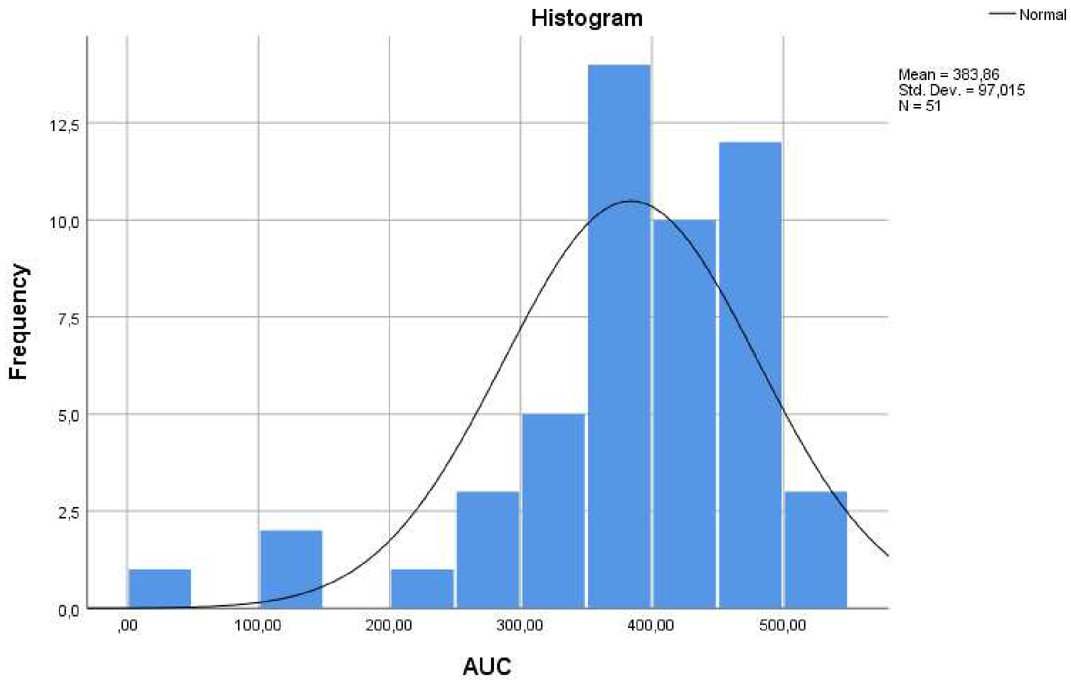
Steps:

1. new variable "trap1" (trapezoid1, based on the variables choice_tomorrow and choice_3months)
2. new variable "trap2" (trapezoid2, based on the variables choice_3months and choice_1year)
3. new variable "trap3" (trapezoid3, based on the variables choice_1year and choice_3years)
4. new variable "trap4" (trapezoid4, based on the variables choice_3years and choice_10years)
5. new variable "trap5" (trapezoid4, based on the variables choice_10years and choice_30years)
6. new variable "Delay Discounting AUC" (sum of trap1+trap2+trap3+trap4+trap5)

Appendix O. Test of Normality Delay Discounting AUC

Figure 12

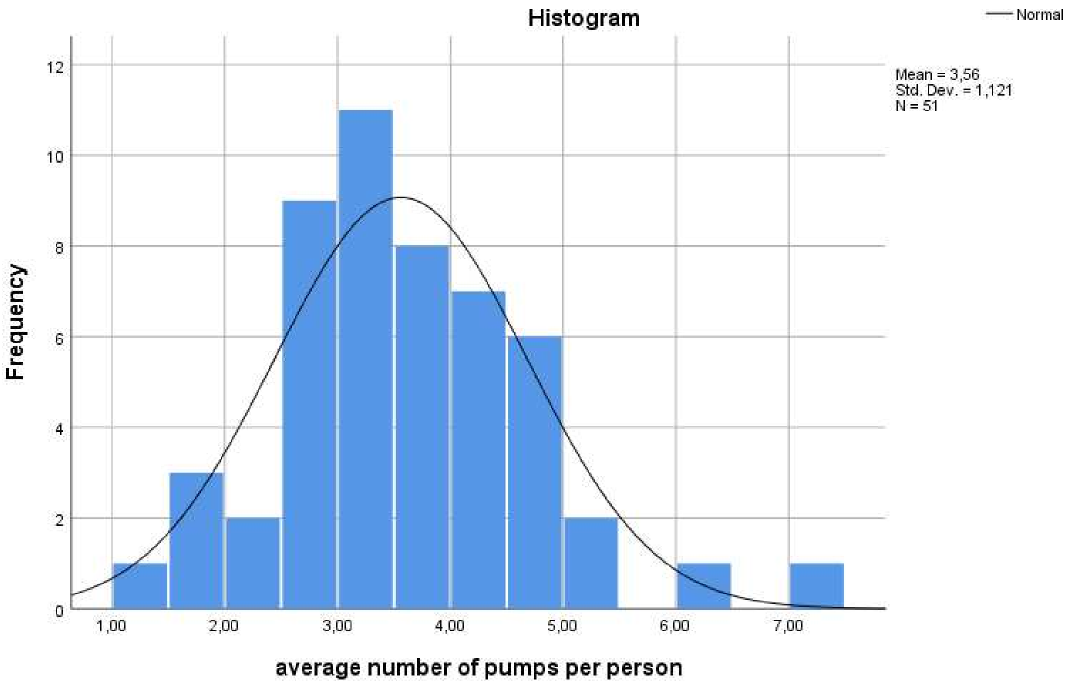
Distribution of the values of the delay discounting task (Delay Discounting AUC)



Appendix P. Test of Normality BART

Figure 13

Distribution of the values of the average number of pumps per person on the BART



Appendix Q. SPSS Syntax

#computing the variable ‘mBART’, by taking the average number of pumps per person on the 15 different trials

COMPUTE
mBART=MEAN(log_count_inflate_exp_1,log_count_inflate_exp_2,log_count_inflate_exp_,
log_count_inflate_exp_4,log_count_inflate_exp_5,log_count_inflate_exp_6,log_count_inflate
_exp_7,log_count_inflate_exp_8,log_count_inflate_exp_9,log_count_inflate_exp_10,log_cou
nt_inflate_exp_11,log_count_inflate_exp_12,log_count_inflate_exp_13,log_count_inflate_ex
p_14,log_count_inflate_exp_15).
EXECUTE.

#computing the variables Trap1, Trap2, Trap3, Trap4, Trap5
COMPUTE
Trap1 = (tomorrow + 3months) / 2 * 1
Trap2 = (3months + 1year) / 2 * 1
Trap3 = (1year + 3years) / 2 * 1
Trap4 = (3years + 10years) / 2 * 1
Trap5 = (10years + 30years) / 2 * 1
EXECUTE.

#computing the variable DelayDiscountingAUC to have the area under the curve for the delay discounting variable
COMPUTE
DelayDiscountingAUC = (Trap1 + Trap2 + Trap3 + Trap4 + Trap5)
EXECUTE.

#independent sample t-test to compare means of control and experimental condition with regard to the average value on delay discounting
T-TEST GROUPS=Condition_new(0 1)
  /MISSING=ANALYSIS
  /VARIABLES=DelayDiscountingAUC
  /CRITERIA=CI(.95).

#conducting a test of normality to check the assumption for a parametric test
EXAMINE VARIABLES=DelayDiscountingAUC BY Condition_new
  /PLOT HISTOGRAM NPPLOT
  /STATISTICS NONE
  /CINTERVAL 95
  /MISSING LISTWISE
  /NOTOTAL.

#conducting the non-parametric Mann-Whitney U test to compare means of control and experimental condition about the average value on delay discounting

```
NPAR TESTS
  /M-W= DelayDiscountingAUC BY Condition_new(0 1)
  /STATISTICS=DESCRIPTIVES QUARTILES
  /MISSING ANALYSIS.
```

#conducting a moderated multiple regression to test whether there is a moderation effect of impulsivity on the relation between socio-environmental cues of harshness and the discounting of future suffering

```
REGRESSION
  /DESCRIPTIVES MEAN STDDEV CORR SIG N
  /MISSING LISTWISE
  /STATISTICS COEFF OUTS R ANOVA CHANGE ZPP
  /CRITERIA=PIN(.05) POUT(.10)
  /NOORIGIN
  /DEPENDENT DelayDiscountingAUC
  /METHOD=ENTER condition_new mBART BART_Condition
  /SCATTERPLOT=(*ZRESID ,*ZPRED)
  /RESIDUALS NORMPROB(ZRESID)
  /CASEWISE PLOT(ZRESID) OUTLIERS(3)
  /SAVE COOK.
```