Investigating the Impact of Cues of Harshness on Reflection Impulsivity Using Virtual Reality

Salomé Hackenfort

Department of Conflict, Risk and Safety, University of Twente

202000377 Bachelor Thesis CRS

1st Supervisor Jeanette Hadaschik, MSc.

2nd Supervisor Dr. Mariëlle Stel

8 July 2021

Abstract

Our environments shape and influence our cognition and behaviour and might even cause individuals to behave in ways that some may consider irrational. The present research aimed to gain further insight into this relationship between environment and cognition. Specifically, it was investigated how environments scoring high on the harshness dimension influence impulsive behaviour, compared to environments low in harshness. For this, an experiment was conducted in which participants were exposed to either a Virtual Reality (VR) scene that displayed a high number of cues of harshness or a VR scene with no cues of harshness. Afterwards, their tendency to make impulsive decisions without reflecting was measured using the Information Sampling Task (IST). A Mann-Whitney *U* test revealed no significant effect of the experimental condition on reflection impulsivity as measured by the IST. Therefore, the null-hypothesis, that there is no effect of the number of harshness cues on impulsive behaviour, had to be retained. Despite this, the present research can be considered an impulse to further investigate this relation between environmental harshness and impulsivity, for example by testing on a sample with a high diversity regarding participants' background.

Investigating the Impact of Cues of Harshness on Reflection Impulsivity Using Virtual Reality

Although humans are able to plan ahead and consider future factors when making decisions, they often still choose not to do so. Instead, it frequently happens that individuals act impulsively, without reflecting on their decision and with disregard for the future. But what is this behaviour caused by? To be able to get an insight into this, this study aims to investigate one possible cause of impulsive decision making. The introduction starts by outlining general decision-making processes and what they are most influenced by, to introduce the subordinate concepts of risk-taking and impulsivity. Following this, possible explanations for the occurrence of impulsive behaviour will be taken into account, while considering the perspective of evolutionary psychology theory as opposed to the developmental psychopathology model. According to the former, impulsive behaviour may be adaptive in response to environmental influences and cues. These environmental cues will be investigated further, especially with regard to environmental harshness. Therefore, the aim is to uncover whether environmental harshness might be a cause of impulsive decision making. Lastly, the specifics of the current study and the role of Virtual Reality in this context are outlined.

Decision Making and Reflective Impulsivity

Decision making and its processes have been widely studied. It can be defined as the interaction between a problem that needs to be solved and the individual who aims to solve the problem within a specific environment (Narayan & Corcoran-Perry, 1997). The entire process of trying to come to a decision seems to be affected by several personal as well as environmental factors (Halpern, 1997). Previous research found that those factors include for example age, sex, uncertainty about the alternatives, possible consequences, emotions, experience, but also social influences and work demands among many others (Cannon-Bowers et al., 1996). Furthermore, research is available indicating that especially external stressors have an immediate effect on decision making. For example, inducing stress in participants by having them put their hand into ice-cold water before asking them to make financial decisions strongly affected their decision-making process in a study conducted by Porcelli and Delgado (2009). Similarly, Johnson et al. (2012) found that adolescents exposed to a cognitive stressor, in this case a social evaluation, showed increased behavioural risk-taking compared to those not exposed to the stressor. Moreover, they also found that the participants acted in a more impulsive way. These findings show that being exposed to different environmental factors and external stressors indeed has direct effects on the decision-making process and may also predict impulsive and risky behaviour.

Because it can be considered a type of decision making, risk taking is also influenced by characteristics of the situation, the decision maker, and interactions between the situation and decision maker (Figner & Weber, 2011). Zinn (2015) describes that decision makers are often not unaware of certain risks they are taking, but instead know that there is the possibility of making a decision that has an adverse outcome. Findings like these seem contradictory to the notion of human beings as generally risk-averse, who prefer to invest in activities with relatively low risk (Winterhalder, 2007). It seems that under some conditions, individuals make decisions in ways that may be considered risky or even irrational. One factor influencing this seems to be the socio-economic status and environmental conditions one grew up in. Individuals who experienced living with a lack of resources and a high amount of mortality cues in their environment tend to take more risks, for example when it comes to financial decision making (Griskevicius et al., 2011; Griskevicius et al., 2013). Support for this is offered by Fenneman and Frankenhuis (2020), who explain that risky or impulsive behaviour can be considered reflective of behavioural adaptations to harsh and unpredictable environments. In such environments, individuals may display impulsivity with regard to their decision making, defined as choice impulsivity. Choice impulsivity includes the concept of information impulsivity, defined as the tendency to act without gathering or considering information about potential consequences of decision making or actions (Fenneman & Frankenhuis, 2020). This definition is in line with Kagan's (1966) idea of reflection impulsivity, which refers to the tendency to gather and evaluate information before making a decision. Similarly, Clark et al. (2006) define impulsivity as carrying out actions with inadequate or little forethought. Here, the extent of information that is being sampled and the accuracy of the following decision are thought to be highly correlated.

Similar to patterns of behavioural risk taking, the socio-economic status experienced while growing up also seems to predict impulsive behaviour. In two experiments, Griskevicius et al. (2013) showed that those individuals who grew up with a lower socio-economic status approached temptations faster compared to those growing up with a higher socio-economic status. For example, when exposed to cues of recession, individuals with a background of low childhood socio-economic status chose to spend money on immediate rewards instead of saving it for the future. Furthermore, these impulsive behavioural tendencies that are rooted in early-life experiences only seemed to emerge when individuals were directly confronted with conditions of economic uncertainty, and otherwise might be dormant (Griskevicius et al., 2013).

Such conditions of economic uncertainty could be, for example, resource scarcity or a recession. These findings suggest that cues of low socio-economic status that individuals experience during childhood significantly affect and predict the tendency to behave impulsively and make decisions without much forethought. Therefore, environmental cues and conditions seem to be partly responsible for the way individuals make decisions, which will be further investigated in the following section.

Environmental Influences on Impulsivity

Impacts of Environmental Conditions on Behaviour and Cognition

The effects of environmental conditions on human behaviour and health have been widely researched. It has been shown, for example by Benita and Tuncer (2019), that urban environmental conditions, for example built-up areas, temperature, humidity, or noise, have a strong effect on the body and its reactions, in that being exposed to these conditions is reflected in physiological indicators of stress. Apart from urban environmental conditions, the socio-economic conditions one experiences also affect behaviour and cognition of an individual. Paal et al. (2015), for example, studied a sample of individuals who experienced living with a low socio-economic status at age 16. They measured behavioural disinhibition using the stop-signal task and concluded that growing up in a more deprived environment predicted impulsive behaviour and increased behavioural disinhibition. Furthermore, growing up in stressful environments like these may enhance cognition with regard to problem solving, i.e., improved detection, learning, and solving of memory tasks that involve cues which are ecologically relevant (Frankenhuis & de Weerth, 2013). This enhanced cognition can be considered a developmental adaptation to the immediate environment as a way to cope within the environment. Therefore, these findings from previously conducted research indicate that humans behaviourally and cognitively adapt to their environment, and thus, behave differently depending on the environment they grew up in.

For example, as Frankenhuis et al. (2016) theorise, people may behave more impulsively and vigilant in environments that are being experienced as harsh and unpredictable. In doing so, information about the current environment could be provided by previous experiences and early stressors. More concretely, it is hypothesized that harshness and unpredictability are environmental dimensions that have a significant effect on individual development and cognition. Harshness refers to the rates of mortality and morbidity, caused by uncontrollable factors in the environment such as diseases or infections and other dangers to health and survival. Thus, harshness results in a shorter reproductive life span of those living in these environments. Furthermore, Frankenhuis et al. (2016) define unpredictability as, on one hand, the range of possible outcomes with regard to the mean level of harshness, and on the other hand the variation in the mean level of harshness over time. It has been found that experiencing environments high in harshness and unpredictability may psychologically manifest in behaviours and reactions that are impulsive (Griskevicius et al., 2011), meaning that socio-environmental cues affect behaviour and decision making even later in life. In the present study, the focus will be on the effects of harshness only.

Evolutionary Psychology Perspective on Decision Making Processes

One approach to explaining this phenomenon of adapting to the current environment is to look at this type of behaviour from an evolutionary perspective. According to this perspective, the human mind consists of several sets of "computational machines" that aim to solve problems of adaptation and increase one's fitness (Cosmides & Tooby, 2006). Fitness in this context means the probability that an organism's genetic line will not become extinct by reproducing (Murphy & Elston, 1978). Thus, the ultimate function of psychological mechanisms and behaviour is to increase chances of reproduction (Neuberg et al., 2010). This way, over time, certain behavioural and cognitive traits are naturally selected for. This does not mean that reproduction is a conscious goal, but instead may also be present indirectly, for example by protecting oneself or acquiring resources (Neuberg et al., 2010). Furthermore, the evolutionary perspective does not consider the direct consequences of behaviour and psychological processes, but rather their implications for reproductive fitness. Therefore, it can be said that even seemingly impulsive and risky behaviour, despite potential harm to health and wellbeing, may be reflective of a present orientation produced by biological adaptations (Frankenhuis et al., 2016). For individuals living in harsh and unpredictable environments, for example, this may manifest in a preference for immediate rewards, since delayed rewards might be more difficult to attain. This view is strongly contrasting the view of the developmental psychopathology model, according to which decision-making can only be considered "functional" as long as it maximizes health, safety, and well-being (Cicchetti & Rogosch, 2002). Therefore, the developmental psychopathology model considers impulsive behaviour to be dysfunctional and an indicator of low self-control. Although it might be the case that behaving impulsively may indeed have adverse outcomes, the evolutionary perspective can be used to try to further explain why individuals come to behave in an impulsive manner in the first place. Therefore, evolutionary theory can account for the here described findings of how the environment affects behaviour.

Further, evolutionary theory accounts for decision making processes in a similar way, in that it presumes that the human brain consists of a number of different systems for decision-making. Depending on adaptively relevant features of the environment, different systems will be active (Kenrick et al., 2009). This means that also the choices that individuals make are driven by a mechanism designed to maximize fitness based on cues from the immediate environment. What decision serves an individual's fitness most depends on biologically relevant factors. Kenrick et al. (2009) further describe that because of this, human decision-making contains a "deep rationality", meaning that the aim of decision-making is to solve recurring adaptive problems throughout different areas of life. It can be theorized that for individuals growing up in harsh environments, this may mean that they have a stronger preference for immediate compared to delayed rewards (Frankenhuis et al., 2016). From the perspective of evolutionary theory, this may be because individuals developed enhanced cognition for dealing with threats in a rapidly changing environment, which manifested in impulsive reactions with little deliberation (Frankenhuis et al., 2016). Dickman (1990) calls this "functional impulsivity" to refer to this tendency of acting with little amount of forethought when such a style of decision making is optimal.

Ellis et al. (2009) theorize similarly in their article on Life History (LH) strategies. They put forward that, through evolution and development, LH strategies of individuals become adaptive to the environment they live in. However, this process does not unfold over generations, but instead, individuals match LH strategies to environmental conditions they experience in their own lifetime. For example, individuals living in environments high on extrinsic morbidity and mortality tend to reproduce earlier in life than those in environments that score low on these concepts, which could be theorized to be one such LH strategy (Ellis et al., 2009). Furthermore, with increases in population density, intra-specific competition among individuals increases as well. To cope with this competition, individuals might then seek to access and exploit resources as quickly as possible (Ellis et al., 2009). Research conducted by Fenneman and Frankenhuis (2020) revealed results that match this theory. They developed a mathematical model to explore how harshness and unpredictability affect impulsivity at an optimal level. With this, they refer to a level of impulsivity that is optimal in the sense that it is adaptive and ensures survival, reproduction, and allocation of resources. Their conclusions on the effects of harsh and unpredictable environments entail that being exposed to situations in which resource encounters are likely to be interrupted by others should lead to more impulsive decision making (Fenneman & Frankenhuis, 2020). Therefore, the findings from this paper present one example of how external stressors within the environment may lead individuals to display higher levels of impulsivity compared to situations in which such stressors are absent.

In conclusion, previous findings from research informed by evolutionary theory and studies on environmental factors and their effect on behaviour and decision making suggest that the environment influences decision-making in a way that is evolutionary adaptive. Furthermore, it outlines how especially impulsive behaviour seems to be affected by harsh conditions.

Current Study

Although quite some research is available that explores the effect of different environmental conditions on individuals, the present study aims to take a slightly different approach. Previous research indicates that such environments have long term effects on individuals and alter decision-making processes even until later in life. So far, not a lot of research has been conducted on how immediate environmental conditions affect impulsive decision making in real time. Therefore, the present research aims to fill this gap by taking a closer look at how different environments influence decision-making behaviour and impulsivity of individuals. This also means that unpredictability, as it includes an account of different time points, will not be considered for this research. This study on the other hand seeks to uncover if environmental cues also have immediate effects on decision-making, and whether they increase the tendency to behave impulsively or not. More concretely, the goal is to investigate and uncover the effects of an environment that is high on harshness, compared to one that scores low on this dimension, and how this influences reflective impulsivity. Reflection impulsivity will be measured using the Information Sampling Task (IST), which was developed as an index of the tendency to evaluate information before making a decision (Clark et al., 2006). To do this, an experiment was carried out in which participants were exposed to a Virtual Reality (VR) environment of either a neighbourhood containing a high or one containing a low number of cues of harshness. VR was used because, compared to other experimental stimuli that could have provided cues of harshness (for example pictures), VR increases the feeling of presence and immersion of participants in the virtual environment (Yao & Kim, 2019). This makes it possible to have more control over inter-individual variation caused by participants' own imagination of the environment and increases comparability. Furthermore, it might also increase the effect of the experimental manipulation.

Research Question and Hypothesis

The main research question this study aimed to investigate was "What is the impact of immediate environmental cues of harshness on reflection impulsivity?". As outlined before, environmental harshness experienced during childhood predicts an increase in impulsive behaviour. Additionally, certain environmental conditions can lead to immediate physiological reactions and stress. Because of this, it was hypothesized in this study that the environmental condition displaying cues of harshness would cause participants to display higher levels of reflection impulsivity as an immediate reaction to the environment. Two measures of reflection impulsivity from the IST were used: the total IST score, as well as an additional measure, namely the tendency to sample information. This was done because the average number of boxes opened, indexed by the total IST score, provides a limited amount of information under some circumstances (Clark et al., 2006). The measure of the tendency to sample information was based on the number of boxes opened, divided by the total number of boxes in the grid (25). It was measured from 0 to 1, where 1 indicates a high tendency to sample information and 0 a low tendency. Thus, including the tendency to sample information quantified the amount of information revealed by participants during the task. Obtaining this score between 0 and 1 allows for comparability with research in which the 5x5 grid for the IST is not used, or research that includes a different design to measure reflection impulsivity.

Therefore, the following hypotheses were tested:

1. The environmental condition displaying cues of harshness leads participants to display higher levels of reflection impulsivity than those in the control condition.
    a. Total IST score of participants exposed to harshness cues is higher than those of participants in the control condition.
    b. Participants exposed to harshness cues display a lower tendency to sample information than those in the control condition.

Method

Design

The study made use of a between-subjects experimental design conducted in a lab that aimed to test the above stated hypotheses. The independent variable "situational harshness" was operationalized using two conditions, one displaying a high amount of harshness cues and the other displaying no cues of harshness. The aim was to test the effect of this independent variable on the dependent variable, namely "reflection impulsivity", which was measured by the score on the IST and the tendency to sample information.

Participants

Participants were recruited via the Twente Student Research Participation System (SONA). Therefore, most participants were students at University of Twente (UT). Convenience sampling was used, especially recruitment options via social media. The link to the information sheet of the study was shared in WhatsApp groups of psychology students and other student group chats at UT, and in Facebook groups. Furthermore, posters (see Appendix

A) were hung up on campus and in buildings close to the university, with QR-codes automatically opening a pre-written email to facilitate participant sign-up. For participating, all participants indicating that they wanted to received a 5€ VVV-voucher or BoL-voucher. Additionally, 5x20€ BoL-vouchers were distributed among all participants based on their performance on the games.

In total, 38 participants (18 male, 19 female, 1 diverse) were recruited. The sample had a mean age of 21.42 (*SD* = 1.88). With regard to nationality, 28 (73.68%) participants were from Germany, 6 (15.79%) participants were Dutch, and 4 (10.53%) participants were from another country. Due to technical difficulties with the control condition, it was not possible to randomly assign participants to either the condition with cues indicating a high amount of harshness or the control condition with no harshness cues. Because of this, the first 20 participants that took part in the experiment were in the deprived-neighbourhood condition, and the last 18 participants were in the normal-neighbourhood condition.

Procedure and Materials

Participants and researchers made sure to follow Covid-19 measures in place at the time. For example, before the participant arrived, everything they could possibly touch was cleaned and disinfected. At first, participants were briefed about the procedure of the experimental session. Next, they were seated at a table in front of the same computer screen they would later play the IST on.

First Questionnaire

Two questionnaires were created, one to be answered before the experiment and one at the end of the experiment. To create the questionnaires, Qualtrics software version 2021 was used. Participants started by answering a questionnaire used to brief them, receive their consent (see Appendix B), and collect information about their demographics, i.e. their gender, highest achieved educational level, age, and nationality. Furthermore, they were also asked what country they lived in until the age of five. After that, participants were requested in the questionnaire to put their mobile phone on silent before being provided with an introductory text informing them about the main steps of the VR-part of the study.

Exposure to the Virtual Reality Scenes

Because of the difficulty to expose participants to different levels of harshness in real life, VR-simulations of such environments were programmed and designed using the game engine Unity version 2020 (2.3). Furthermore, VR-equipment by the brand Oculus was used, specifically the Oculus Rift S headset with Touch Controllers.

This second part of the experiment-session started with giving participants verbal instructions about the VR-part of the study. It was explained to participants that their main task was to simply explore the virtual neighbourhood and experience their surroundings. Furthermore, it was also explained how to put on the VR-headset and adjust it and how to use the controllers (one in each hand) to move around in the VR-environment. In addition to using the controllers, participants could also move in the office chair they were sitting in to adjust their perspective, but otherwise had to stay seated. Before starting the VR-scenes, participants were asked to put on a mask for the VR-glasses and a hair/ head-cover due to Covid-19 safety measures. Before participants put on the headset, a practice scene was started, to make sure that this would be the first thing that participants see in VR so that other possible influential cues could be eliminated (e.g., home screen of VR-program). In the practice scene, participants had the opportunity to get used to moving in the VR-environment and ask questions about it. This scene was designed as simple as possible, with grass, a blue sky, and various shapes and forms placed in the scene (see Appendix C). Furthermore, in this practice scene as well as in the experimental scenes, arrows and circles on the ground indicated a tour that participants were instructed to follow while being in the practice scene as well as later on in the virtual neighbourhoods. It was explained to participants that they could use the circles to stand on for a short while, as an incentive for them to look at their environment, but also to help avoid getting dizzy or nauseous.

Participants were also told that it would be best to ask questions while still in the practice scene, to avoid interacting with them while in one of the virtual neighbourhoods to enhance immersion. Furthermore, it was explained to participants that they would stay in the virtual neighbourhood for around 7 to 8 minutes, and even if they were done with the tour, they could roam around some more until the researchers would tell them that their time was up. Participants were also made aware that if they felt unwell or uncomfortable, they could always ask to end the VR session sooner than that. When participants indicated that they had no more questions and were ready to continue with the virtual neighbourhood scene, one of the two experimental conditions was started. For the switch from the practice scene to the virtual neighbourhood scene participants were asked to close their eyes.

Description of the two VR-scenes. Two different VR-scenes of neighbourhoods were created using Unity. Both were based on the same basic layout, with a basketball court in the centre, a street surrounding it, and buildings on the side of the street, separated by alleyways. Participants were exposed to one of these two scenes for around 7 minutes.

The first 20 participants were assigned to the experimental condition, referred to as the "deprived neighbourhood" (DN), which displayed a high number of harshness cues. This was done by designing this scene so that it displayed indicators of a lack of intact infrastructure and public services, household conflicts and generally poor living circumstances (see Appendix D for screenshot of DN condition). The lack of intact infrastructure was represented by generally insufficient maintenance in this neighbourhood, meaning that trash was placed on the streets and sidewalks, as well as barrier tape, puddles and dirty patches, and barrels on the ground. Furthermore, the bus stop that could be found in this environment had a broken glass window and appeared dirty. Car noises from a much-frequented street as well as sirens could be heard in close distance. As an indicator for the conflict loaded households in this neighbourhood, participants could also hear yelling from a fight between a man and a woman coming out of one of the buildings. Additionally, the poor living circumstances of this neighbourhood were indicated by broken windows of the apartment buildings, to further emphasise that maintenance of private property was also low. One simulation of a character was placed in an alleyway in the neighbourhood, who appeared to be a young man wearing a hoodie and loose pants. To further enhance the general mood of this environment, the weather was designed to appear cloudy and grey.

The other neighbourhood, which the last 18 participants were assigned to, was designed to be the contrary to the DN condition, in that it displayed no cues of harshness. This "non-deprived neighbourhood" (NN) condition was used to be the control condition. Here, infrastructure and public services appeared to be intact, meaning that the streets were clean, and trees and bushes were placed in an orderly distance next to the sidewalk. The outside of the buildings appeared to be upper-middle class housing with well-maintained front yards facing the street, indicating average to high living circumstances. Two virtual characters could be found in this neighbourhood in an alleyway, a man and a woman, who were having a conversation about going on a camping trip together. This was done to display a neighbourhood with better social cohesion than in the DN condition. Furthermore, in this virtual neighbourhood, participants could see a blue sky and hear birds chirping, and no car- or other noises. For screenshots of this virtual neighbourhood see Appendix E.

To make sure that all participants were exposed to the virtual neighbourhood scenes for approximately the same amount of time, the time of exposure was measured. However, this does not mean that all participants stayed in the VR-scene for the exact same amount of time, since participants were told that their time was up only when it became clear that they had explored most of the virtual neighbourhood. This was done by watching what participants were seeing on screen. More specifically, when 7 minutes were over and participants only seemed to stand somewhere and were not actively exploring anymore, the VR-part was ended. The researchers told participants that they could now take off the VR-headset, before asking them if they felt ready to continue with the next part of the experimental session.

Playing the Information Sampling Task (IST)

During the third part of the experiment, participants played the IST. This game was developed by Clark et al. (2006) and used to measure the dependent variable reflection impulsivity. In the context of Clark et al.'s (2006) research, high internal consistency of the IST was measured. Furthermore, regarding reliability and validity, they found that response accuracy was indeed a function of the extent of information analysis, which, as explained before, is a characteristic of reflection impulsivity. Therefore, the IST is able to indicate the tendency to sample information before making a decision, which is why it was used in this study to measure reflection impulsivity.

The game was played on a 24'' computer screen using mouse-click. In addition, participants were asked to leave on their head cover and put on headphones to be able to hear sounds coming from two other games that they had to play next to the IST. These two other games were used to assess decision-making in other ways, as one game measured risk taking and the other one delay discounting. However, these two other games were not considered for analysis as they were not relevant with regard to the focus of this study. The order in which participants played the first two games was randomized, however, the last game was always the same because it took the longest to play. This means that participant played the IST either first or second in order. Although these two games were also part of the experiment, they were not considered for analysis in this paper.

The screen was only turned on after the game had loaded and started, to again avoid interference of other cues with the potential effect of the virtual neighbourhood. Then, all researchers left the room so that participants would not feel observed while playing the games and completing the second questionnaire. Participants received instructions on how to play the IST on screen (see Appendix F).

Playing the IST involved one practice trial before starting with five trials of the main task. Participants were presented with a 5x5 grid of greyed-out boxes, with two larger coloured boxes at the bottom of the screen, one yellow and the other one blue. Clicking on a grey box in the grid caused the box to reveal one of those two colours and remain open for the duration of the trial (see Appendix G for example trial). The task was to decide whether there were more yellow-coloured boxes or blue-coloured boxes on the grid. Participants were able to open the boxes at their own rate and could open as many boxes as they wanted before making their decision. However, with each opened box, the available win decreased from initially 250 points for each new trial by 10 points for each opened box. When clicking on one of the two coloured boxes at the bottom to indicate the decision, a new screen appeared with feedback, reading either "Correct! You have won [X] points" or "Wrong! You have lost 100 points". Therefore, making an incorrect decision always led to a loss of 100 points, regardless of the number of boxes opened. Overall performance on the IST depended on the average number of boxes opened before making a decision. The tendency to sample information was then measured based on the number of boxes opened divided by 25 (total number of boxes in the grid).

Second Questionnaire

After finishing playing the game, participants were automatically directed to a Qualtrics questionnaire, considered the fourth part of the session. This questionnaire was used to ask them about their experience in the VR-environment and debrief them. More specifically, participants were asked about their immersion into the VR-environment as a manipulation check. After that, they were asked questions about their childhood experiences to be able to account for possible influences from this direction, although this was not included in inferential analysis. Lastly, participants had to indicate during the questionnaire whether they had any assumptions about the purpose of the study.

Once they were finished, participants came to the door and informed the researchers. Finally, participants were thanked for their participation and offered sweets.

Results

Data Analysis

All statistical analyses were conducted using IBM SPSS Statistics 27 for MacOS. Participant data was screened for exclusion criteria with regard to their age, as they had to be over 18 years old, and whether or not they were able to complete the Virtual Reality part. No data was omitted and thus, 38 data points remained for analysis.

The statistical analysis that was conducted aimed to test the effect of the experimental condition (DN vs NN) on reflection impulsivity. Analysis was performed on two measures of the dependent variable, namely the total IST score (tIST, based on the average number of boxes opened before making a decision) and the tendency of participants to sample information (IS). The latter was based on the number of boxes opened, divided by the total number of boxes in the grid (25), and measured from 0 to 1, where 1 indicates a high tendency to sample information and 0 a low tendency. The tendency to sample information was recorded for each trial of the game individually, and therefore, the IS variable was computed based on the mean of all five trials. For more information and the SPSS syntax see Appendix H.

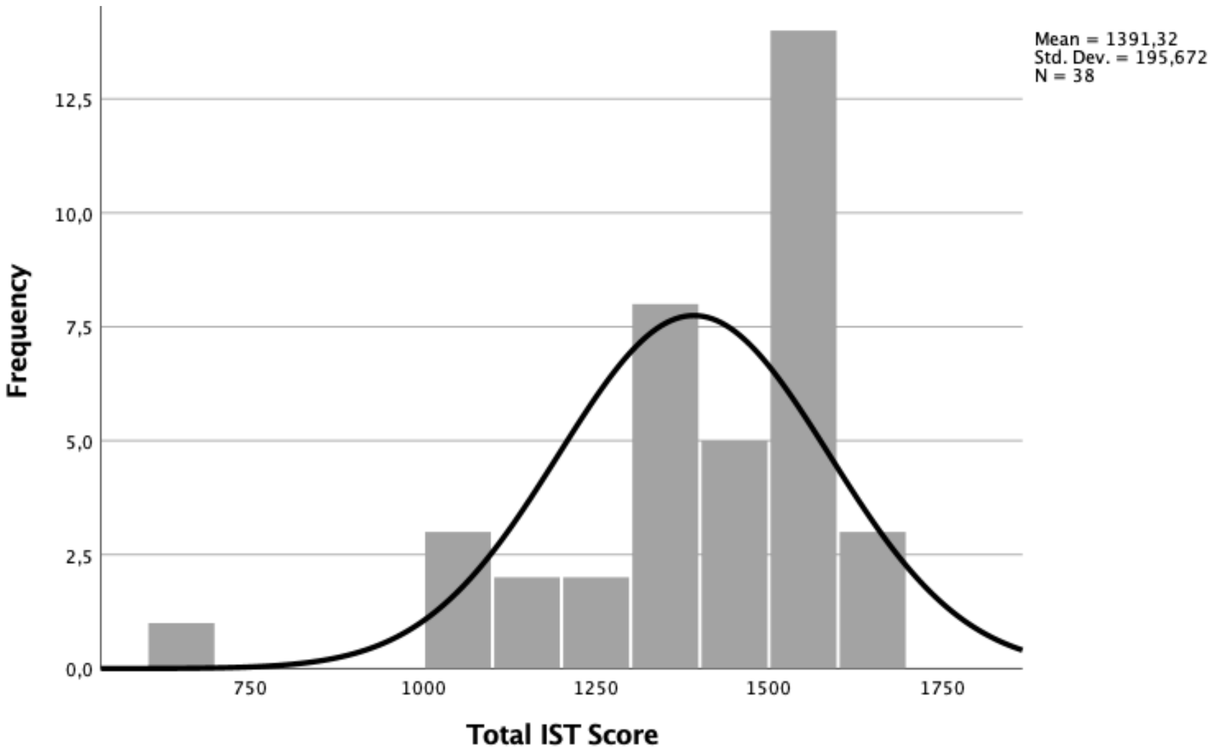
An alpha level of .05 was used for all statistical tests. The aim was to analyse the collected data using an Independent Samples *t*-Test. First, the mean, descriptive statistics, and frequencies were computed. Then, the data was assessed to see whether it met the assumptions to be able to carry out the Independent *t*-Test.

Descriptive Statistics

With regard to total IST score, the lowest number of points scored was 690, the highest 1620, with a sample mean of 1391.32 (*SD* = 195.67). Figure 1 reports the total number of points to indicate overall IST performance.

Figure 1

Distribution of Total IST Score



The lowest score on tendency to sample information was .00, the highest .85, and the sample had an overall mean of .19 (*SD* = 0.14). Table 1 reports a summary of those measures. Higher tIST scores indicate higher impulsivity, whereas higher IS indicates higher rates of information sampling and thus lower impulsivity.

Table 1

Descriptive Statistics of tIST and IS

		tIST	IS
N	Valid	38	38
	Missing	0	0
Mean		1391.32	.19
	DN Condition	1391.51	.21
	NN Condition	1391.11	.18
Std. Deviation		195.62	.14
Minimum	DN Condition	690	.00
	NN Condition	1060	.00
Maximum	DN Condition	1600	.85
	NN Condition	1620	.35

Note. tIST = Total Score on the IST, IS = Tendency to Sample Information.

Test for Normality

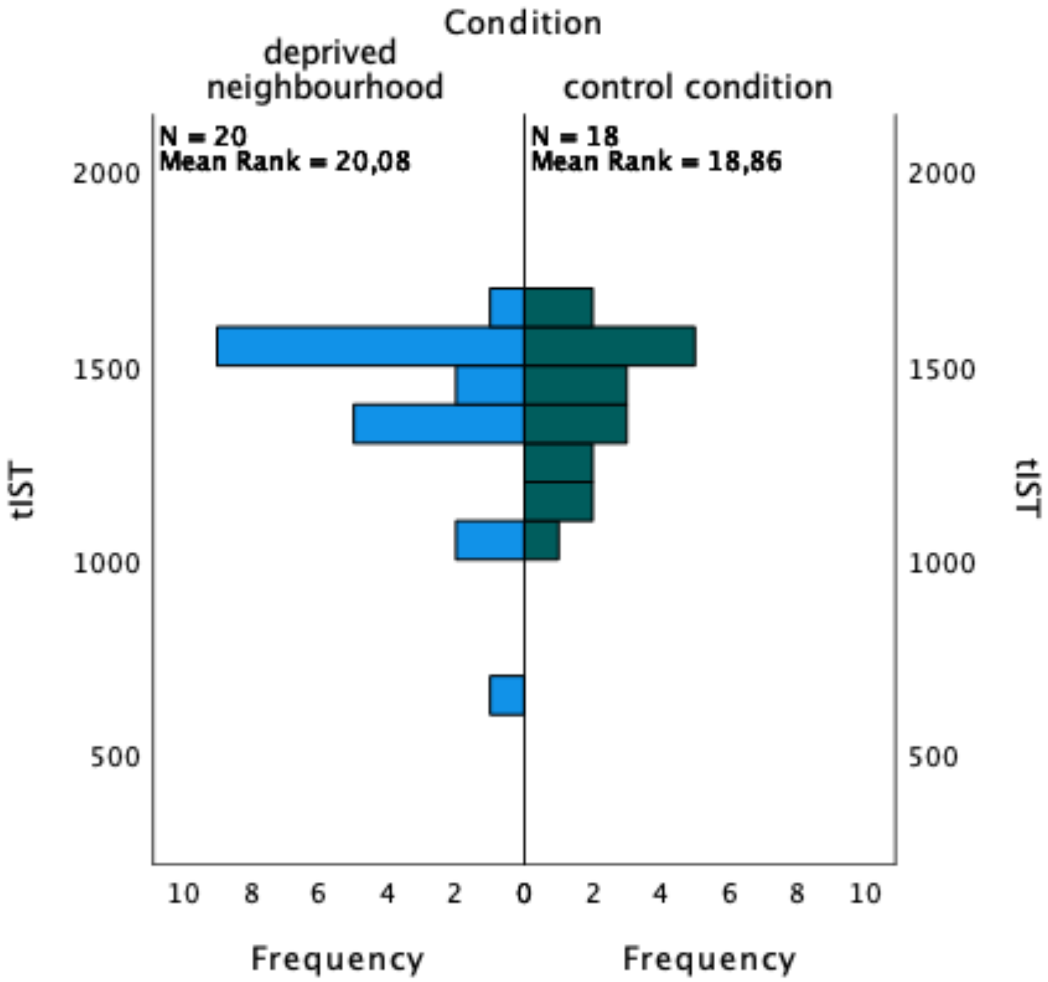
To be able to determine whether parametric tests such as the before mentioned Independent Samples *t*-Test could be carried out, the data was tested for normality. For this, the two measures of the dependent variable, meaning total IST score and information sampling tendency, were tested. Both measures did not appear to be approximately normally distributed in both conditions (see Appendix I for description of results). Therefore, instead of doing an Independent Samples *t*-Test, non-parametric statistical analysis was performed.

Inferential Statistics

To evaluate the difference between the two conditions with regard to total IST score as well as the tendency to sample information, the Mann-Whitney *U* Test was used. For the total IST score, the test revealed non-significant differences between the DN condition (Median = 1495.00, n = 20) and the control condition (Median = 1435.00, n = 18), $U = 168.5$, $Z = -.34$, $p = .74$, $r = -.05$. The distributions of the two groups as well as their mean ranks can be seen in the chart in Figure 2. Although the results of the Mann-Whitney *U* indicated otherwise, the DN condition appeared to have slightly higher ranks, suggesting that this group generally had higher IST scores.

Figure 2

tIST Means Across Conditions

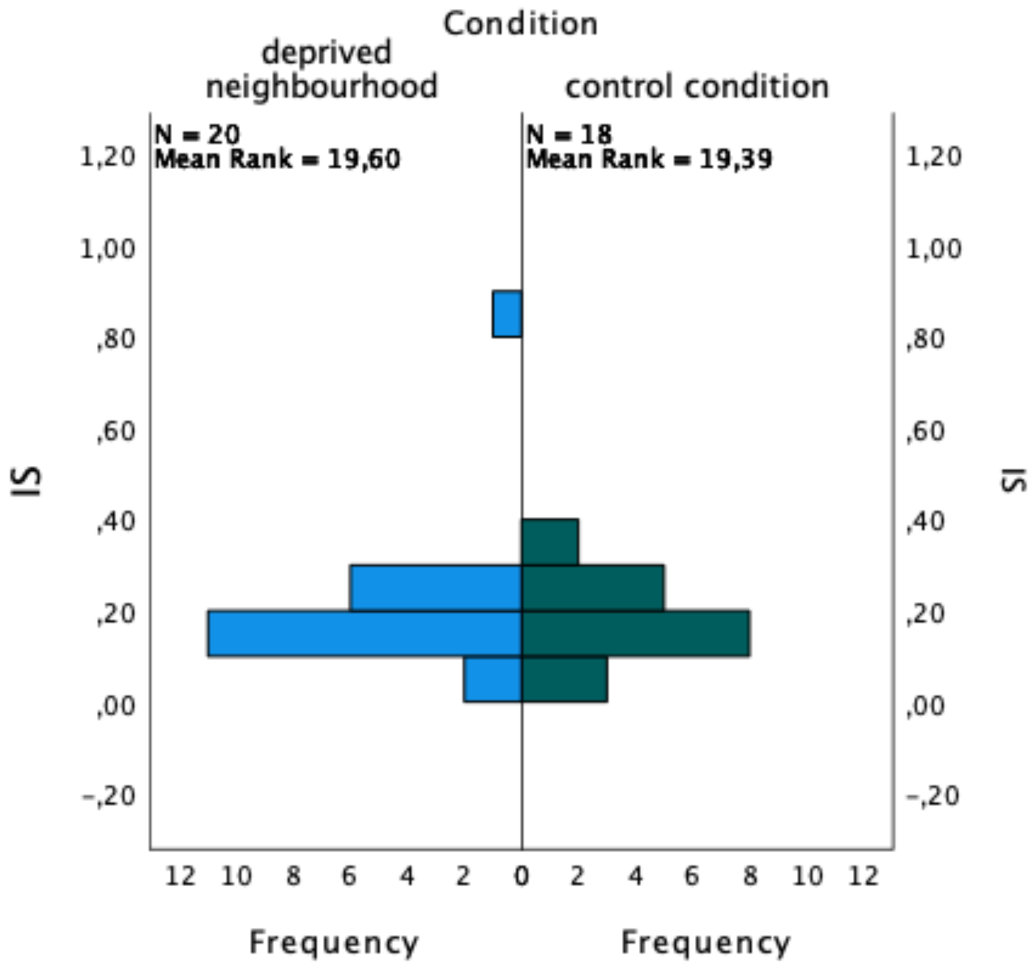


Note. tIST = Total Score on the IST.

Regarding the tendency to sample information, the test also revealed non-significant differences between the DN condition (Median = .18, n = 20) and the control condition (Median = .19, n = 18), $U = 178.00$, $Z = -.06$, $p = .95$, $r = .00$. The chart (see Figure 3) shows the distributions of the two groups as well as their mean ranks. Similarly to the mean ranks of the tIST variable, the DN condition for IS appeared to have slightly higher ranks, suggesting that this group generally scored higher on the tendency to sample information.

Figure 3

IS Means Across Conditions



Note. IS = Tendency to Sample Information.

Since the results of the test on both measures indicated non-significant differences between the conditions, the null-hypothesis, stating that there is no effect of situational harshness on IST score and the tendency to sample information, had to be retained.

Discussion

This study investigated whether there was an effect of the exposure to environmental cues of harshness on reflection impulsivity. It was hypothesized that environmental harshness would increase participants' reflection impulsivity compared to an exposure to an environment with no cues of harshness. The focus here was to explore whether there is an immediate effect of harshness on impulsivity. Analysis of the present data could not confirm this hypothesis. No significant effect of the experimental conditions on reflection impulsivity, measured by the score on the IST and the tendency to sample information, was found. This is why the null-hypothesis that cues of harshness do not increase impulsive behaviour had to be retained.

These findings are not in line with literature that indicates that there might be an effect of harshness in the environment on impulsivity (Griskevicius et al., 2013; Paal et al., 2015). Furthermore, they are also not in line with more general findings from research on the effect of environmental conditions on behaviour, for example the finding that certain urban environmental conditions are reflected in physiological indicators of stress (Benita & Tuncer, 2019). In this study, the present findings could not confirm such tendencies.

However, there are also findings from previous research that may help explain why no significant effects were obtained in the present study. Available studies on the effect of environmental harshness indicate that early exposure in life to such environments are more predictive of later impulsive behaviour (Griskevicius et al., 2013). It might be that the effect of harshness on impulsivity is mediated by early exposure to harshness. However, the present study did not include early exposure as an additional variable. This could explain why no significant effects where obtained, especially if most participants did not experience environmental harshness earlier in life. Additionally, it may not be the case that harsh environments increase impulsivity, but that instead environments low in harshness decrease it. This could be supported by an experiment conducted by Berry et al. (2014), who found that impulsive decision making among participants decreased after being exposed to natural scenes compared to built and geometric scenes. Furthermore, research indicates that there appears to be an immediate effect of cues of harshness on concepts such as social trust and paranoia (Nettle et al., 2014). It may be that cues of harshness do not have a direct effect on reflection impulsivity but exert their effects indirectly through other concepts.

Limitations and Future Research

There are limitations to this study that may have had an influence on and further explain the results of the experiment. As mentioned before, available research indicates that increased impulsivity mostly follows from harsh environments if individuals grew up in those environments. Impulsivity manifests during childhood as an adaptation to the conditions of the environment and becomes dormant until one is exposed again to those cues of harshness (Griskevicius et al., 2013). For most participants in the present sample, this was not the case, as indicated during the second questionnaire. Thus, the results of the present study could be interpreted in that the cues presented during the experiment are not sufficient to cause an effect of environmental harshness on impulsivity. It may be that participants need to be exposed to these conditions for a longer period of time for there to be a significant effect. Future research could test this to see whether participants who spend more time in a VR scene high on harshness cues, for example 15 minutes instead of only 7, display increased impulsivity. In that case, the environment itself could also be adjusted to include more space to explore to avoid participants getting bored. In line with this, interactive elements within the VR scene could be added to increase immersion (Hudson et al., 2019), which might then also increase the effect of the experimental condition.

Apart from that, the homogeneous nature of the present sample makes it difficult to generalize the non-significant results found in this research as well as possible significant findings. This can partly be attributed to the small sample size. A more diverse sample with more variation with regard to participants' socio-demographic background likely would have yielded different results, especially because of the before mentioned point that childhood experiences likely play a role in this research. Therefore, future research should make sure to collect more participants with a diverse background. In doing so, it should also be investigated whether childhood experiences indeed mediate the effect of environmental conditions on impulsivity.

Another limitation of this study that future research could improve concerns the design of the study. Here, only two conditions where used, where the condition with no harshness cues was used to be the control condition. However, as mentioned before, it may be that this condition decreases impulsivity, instead of the environmental condition that is high in harshness increasing it. Therefore, it could be of added value to add a third condition as a baseline or control condition, to be able to explain which condition exerts which effect on impulsivity. Alternatively, impulsivity could also be measured before and after exposure to each condition, so that increases or decreases in impulsivity can be clearly distinguished.

As with many studies that include VR, it is a concern how participants react to this type of technology. There are several factors that might have affected how immersed participants felt and thus also the effect of the independent variable. These factors include dizziness, nausea, or nervousness and might not have been voiced by participants. Furthermore, although the researchers tried to be as quiet as possible, their presence in the room while participants were in the VR-scenes could also have led participants to feel less immersed. With a decrease in immersion, the total effect of both conditions may have also decreased.

Lastly, some procedural choices during the experiment might also explain why no significant results were found. Although it was attempted to avoid interference with other cues during the experiment, there were points during the procedure of the experiment where this was difficult. For example, to start playing the IST, participants had to take off the VR-headset and receive the instruction to leave on the hair cover, and then redirect their attention to the computer screen. Furthermore, this was also when participants were asked by the researchers if they felt ready to continue, which might have felt comforting to the participant. This moment thus allowed for possible interference of noise with the effect of the experimental condition, which therefore might have decreased this effect.

Future research could aim to improve these limitations. For one, the sample size as well as its variation with regard to participants' socio-demographic background should be increased. Furthermore, to decrease the possibility of other cues interfering with the independent variable, the IST could be played in VR as well, so that there is no switch from VR to a computer screen. A semi-replication study of this kind could yield insights on whether the results of this study are due to its limitations or whether there is indeed no immediate effect of harshness cues on impulsivity. These findings could then be used to add to the research on how different environmental conditions affect human cognition and behaviour.

Conclusion

The present study aimed to answer the question whether cues of environmental harshness influence reflection impulsivity as measured by the IST. To do this, two different neighbourhoods were created and implemented in VR, one low and one high on harshness cues. The results showed that there was no significant difference between the two conditions. It can be concluded that environments high in harshness do not increase individuals' tendency to behave impulsively immediately after. However, this study can be considered an impulse to further investigate the immediate effect of such environments on human cognition and behaviour, for example to use knowledge about this topic as a basis for improving environmental conditions.

References

Benita, F. & Tuncer, B (2019). Exploring the effect of urban features and immediate environment on body responses. *Urban Forestry & Urban Greening, 43*, 126365. Doi: 10.1016/j.ufug.2019.126365

Berry, M. S., Sweeney, M. M., Morath, J., Odum, A. L., & Jordan, K.E. (2014). The nature of impulsivity: Visual exposure to natural environments decreases impulsive decision-making in delay discounting task. *PLoS ONE, 9*(5), e97915. Doi: 10.1371/journal.pone.0097915

Cannon-Bowers, J. A., Salas, E., & Pruitt, J. S. (1996). Establishing the boundaries of a paradigm for decision-making research. *Human Factors: The Journal of the Human Factors and Ergonomics Society, 38*(2), 193-205. Doi: 10.1518/001872096779048066

Cicchetti, D., & Rogosch, F. A. (2002). A developmental psychopathology perspective on adolescence. *Journal of Consulting and Clinical Psychology, 70*(1), 6-20. Doi: 10.1037/0022-006X.70.1.6

Clark, L., Robbins, T. W., Ersche, K. D., & Sahakian, B. J. (2006). Reflection impulsivity in current and former substance users. *Biological Psychiatry, 60*(5), 515-522. Doi: 10.1016/j.biopsych.2005.11.007

Cosmides, L., & Tooby, J. (2006). Evolutionary psychology: Theoretical foundations. In L. Nadel (Ed.). *Encyclopedia of Cognitive Science* (s00529). Chichester: John Wiley & Sons, Ltd.

Dickman, S. J. (1990). Functional and dysfunctional impulsivity: Personality and cognitive correlates. *Journal of Personality and Social Psychology, 58*, 95-102.

Ellis, B. J., Figureredo, A. J., Brumbach, B. H., & Schlomer, G. L. (2009). Fundamental dimensions of environmental risk: The impact of harsh versus unpredictable environments on the evolution and development of Life History strategies. *Human Nature, 20*(2), 204-268. Doi: 10.1007/s12110-009-9063-7

Fenneman, J., & Frankenhuis, W. E. (2020). Is impulsive behavior adaptive in harsh and unpredictable environments? A formal model. *Evolution and Human Behavior, 41*(4), 261-273. Doi: 10.1016/j.evolhumbehav.2020.02.005

Figner, B., & Weber, E. U. (2011). Who takes risks when and why? Determinants of risk taking. *Current Directions in Psychological Science, 20*(4), 211-216. Doi: 10.1177/0963721411415790

Frankenhuis, W. E. & de Weerth, C. (2013). Does early-life exposure to stress shape or impair cognition? *Current Directions in Psychological Science, 22*(5), 407-412. Doi: 10.1177/0963721413484324

Frankenhuis, W. E., Panchanathan, K., & Nettle, D. (2016). Cognition in harsh and unpredictable environments. *Current Opinion in Psychology, 7*, 76-80. Doi: 10.1016/j.copsyc.2015.08.011

Griskevicius, V., Ackerman, J. M., Cantú, S. M., Delton, A. W., Robertson, T. E., Simpson, J. A., … Tybur, J. M. (2013). When the economy falters, do people spend or save? Responses to resource scarcity depend on childhood environments. *Psychological Science, 24*(2), 197-205. Doi: 10.1177/0956797612451471

Griskevicius, V., Tybur, J. M., Delton, A. W., & Robertson, T. E. (2011). The influence of mortality and socioeconomic status on risk and delayed rewards: A life history theory approach. *Journal of Personality and Social Psychology, 100*(6), 1015-1026. Doi: 10.1037/a0022403

Halpern, D. F. (1997). *Critical thinking across the curriculum: A brief edition of thought and knowledge*. Mahwah, New Jersey: L Erlbaum Associates.

Hudson, S., Matson-Barkat, S., Pallamin, N., & Jegou, G. (2019). With or without you? Interaction and immersion in a virtual reality experience. *Journal of Business Research, 100*, 459-468. Doi: 10.1016/j.jbusres.2018.10.062

Johnson, S. B., Dariotis, J. K., & Wang, C. (2012). Adolescent risk taking under stressed and nonstressed conditions: conservative, calculating, and impulsive types. *Journal of Adolescent Health, 51*(2), 34-40. Doi: 10.1016/j.jadohealth.2012.04.021

Kagan, J. (1966). Reflection-impulsivity: The generality and dynamic of conceptual tempo. *Journal of Abnormal Psychology, 71*, 17-24.

Kanjo, E., Younis, E., & Sherkat, N. (2018). Towards unravelling the relationship between on-body, environmental and emotion data using sensor information fusion approach. *Information Fusion, 40*, 18-31. Doi: 10.1016/j.inffus.2017.05.005

Kenrick, D. T., Griskevicius, V., Sundie, J. M., Li, N. P., Li, Y. J., & Neuberg, S. L. (2009). Deep rationality: The evolutionary economics of decision making. *Social Cognition, 27*(5), 764-785. Doi: 10.1521/soco.2009.27.5.764

Narayan, S. M., & Corcoran-Perry, S. (1997). Line of reasoning as a representation of nurses' clinical decision making. *Research in Nursing and Health, 4*, 353-64. Doi: 10.1002/(sici)1098-240x(199708)20:4<353::aid-nur8>3.0.co;2-f

Nettle, D., Pepper, G. V., Jobling, R., & Schroeder, K. B. (2014). Being there: A brief visit to a neighbourhood induces the social attitudes of that neighbourhood. *PeerJ*, 1–20. https://doi.org/10.7717/peerj.236

Neuberg, S. L., Kenrick, D. T., & Schaller, M. (2010). Evolutionary social psychology. In S. T. Fiske, D. T. Gilbert, & G. Lindzey (Eds.). *Handbook of Social Psychology* (pp. 2-21). Hoboken, New Jersey: John Wiley & Sons, Inc.

Murphy, E. A., & Elston, R. C. (1978). Genetic and evolutionary fitness. *American Journal of Medical Genetics, 2*(1), 51-79. Doi: 10.1002/ajmg.1320020107

Paál, T., Carpenter, T., & Nettle, D. (2015). Childhood socioeconomic deprivation, but not current mood, is associated with behavioural disinhibition in adults. *PeerJ, 3*, e964. Doi: 10.7717/peerj.964

Porcelli, A. J., & Delgado, M. R. (2009). Acute stress modulates risk taking and financial decision making. *Psychological Science, 20*(3), 278-283. Doi: 10.1111/j.1467-9280.2009.02288.x

Winterhalder, B. (2007). Risk and decision-making. In R. Dunbar & L. Barrett (Eds.). *Oxford Handbook of Evolutionary Psychology*. Oxford: Oxford University Press.

Yao, S., & Kim, G. (2019). The effects of immersion in a Virtual Reality game: Presence and physical activity. In: X. Fang (Ed.). *HCI in Games* (pp. 234-242). Cham: Springer International Publishing.

Zinn, J. O. (2015). Towards a better understanding of risk-taking: Key concepts, dimensions and perspectives. *Health, Risk & Society, 17*(2), 99-114. Doi: 10.1080/13698575.2015.1023267

Appendix A

Poster Used for Participant Recruitment

Appendix B

Appendix B1. Information used to brief participants.

Welcome!

You are invited to take part in a study investigating how people experience a Virtual Reality environment and how they make decisions. The project is conducted by Maike Wohlgemuth, Stella Scholz, and Salomé Hackenfort and supervised by Jeanette Hadaschik (Department of Psychology of Conflict, Risk and Safety, University of Twente). The study is approved by the Ethics Committee of the Faculty of Behavioural, Management and Social Sciences at University of Twente. 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. We are looking for women and men who are above 18 years old. Participation is completely voluntary and anonymous. If you decide to take part, you will be asked to complete the following steps: [details of procedure, e.g. VR, then questionnaires]. Some of the information that is asked in the questionnaire can be considered to be of sensitive nature. All data collected during the study will be kept strictly confidential and anonymous. That is, your responses cannot and will not be traced to your person and no identifying information will appear in any documents or in the final report. We do not ask for personal identifiers. Only the main researchers have access to the collected data. Therefore, we ask you to answer as honestly as possible.

By taking part you can win 1 of 5 20€ vouchers (VVV or BoL). Your email address will be stored separately from your response and would only be used in case you win a voucher. At the end of the data collection and after the winners have been contacted, all email addresses will be deleted permanently. Before you can start with the survey, we ask you to read the information on the next page carefully, and agree by clicking 'YES'.

Thank you in advance for your participation! Should you have any questions about this study, please feel free to contact the researchers.

Jeanette Hadaschik, MSc

j.hadaschik@utwente.nl

Appendix B2. Informed consent form.

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 my identity.

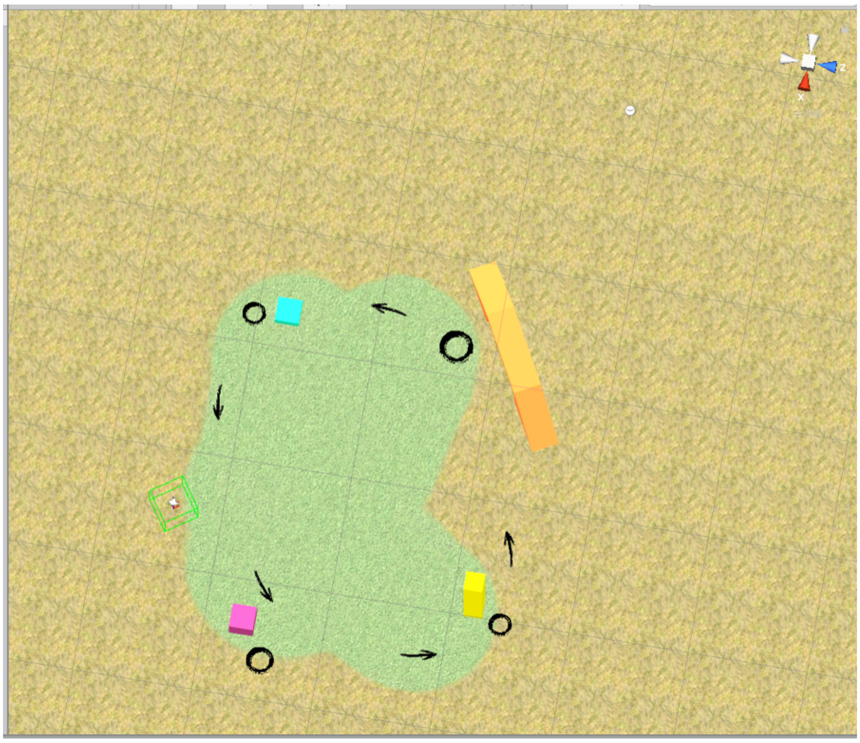
I understand and agree that the purpose and hypotheses of the current study cannot be revealed to me because it could bias my answers. However, after completion of the study I will receive a full debriefing.

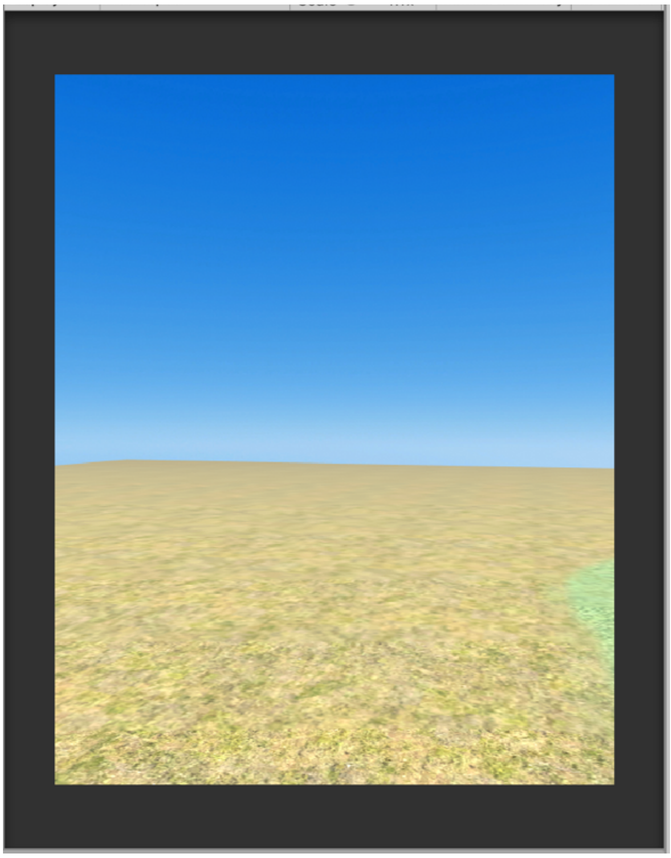
I agree to keep the procedures and explanation of this study to myself and will not pass this information on to others because this might negatively influence the study results.

I agree to participate in the study: YES / NO

Appendix C

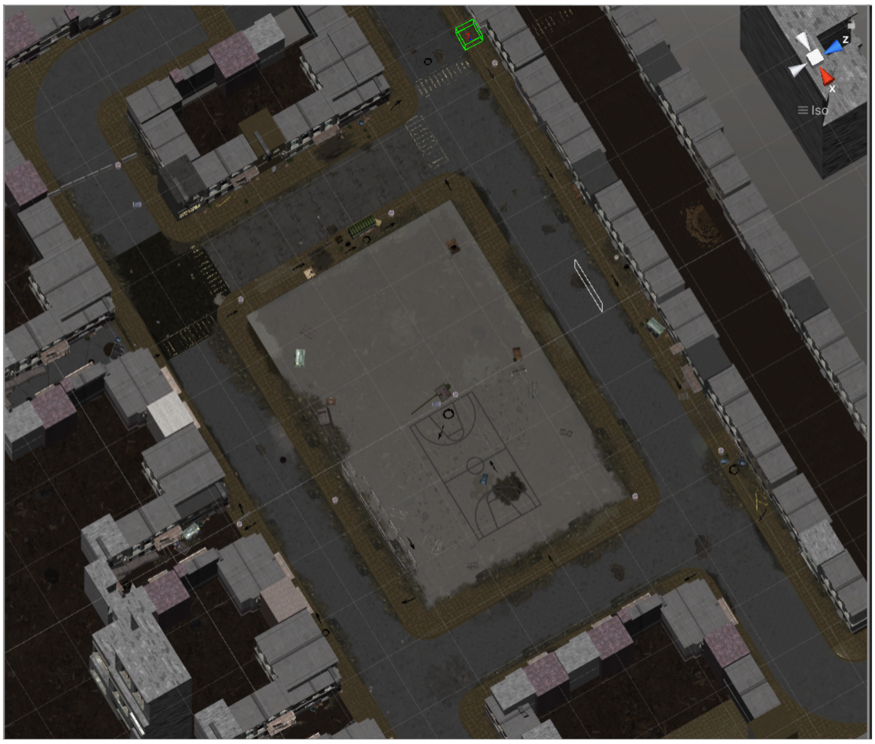
Screenshot of Practice Scene in VR

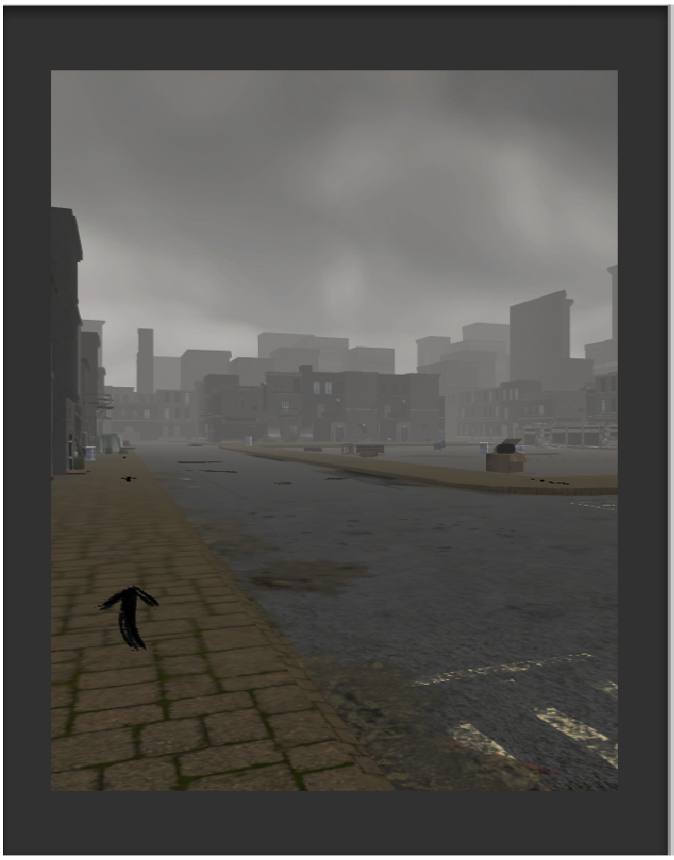




Appendix D

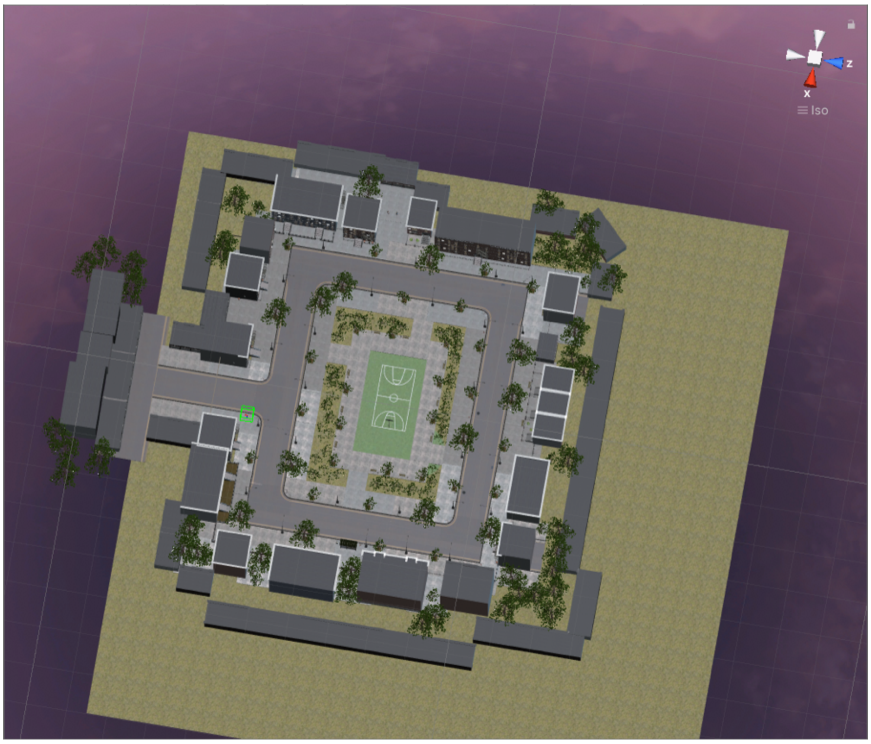
Screenshot of the Deprived Neighbourhood Condition in VR





Appendix E

Screenshot of the Non-Deprived Neighbourhood Condition in VR



Appendix F

Screenshots of Instructions for the IST Shown on Screen

Welcome to the Square Game!

In this game, you can win points. There are five trials and at the start of each trial, you receive 250 points.

You will be shown a matrix of grey squares. When you click on a square, it will reveal it's colour: yellow or blue.

You are asked to decide which colour is in the majority. Are there more yellow or blue boxes?

At the bottom of the screen you will see two rectangular boxes. If you think the majority of boxes is yellow, you click the yellow one.
If you think there are more blue boxes, you click on blue,

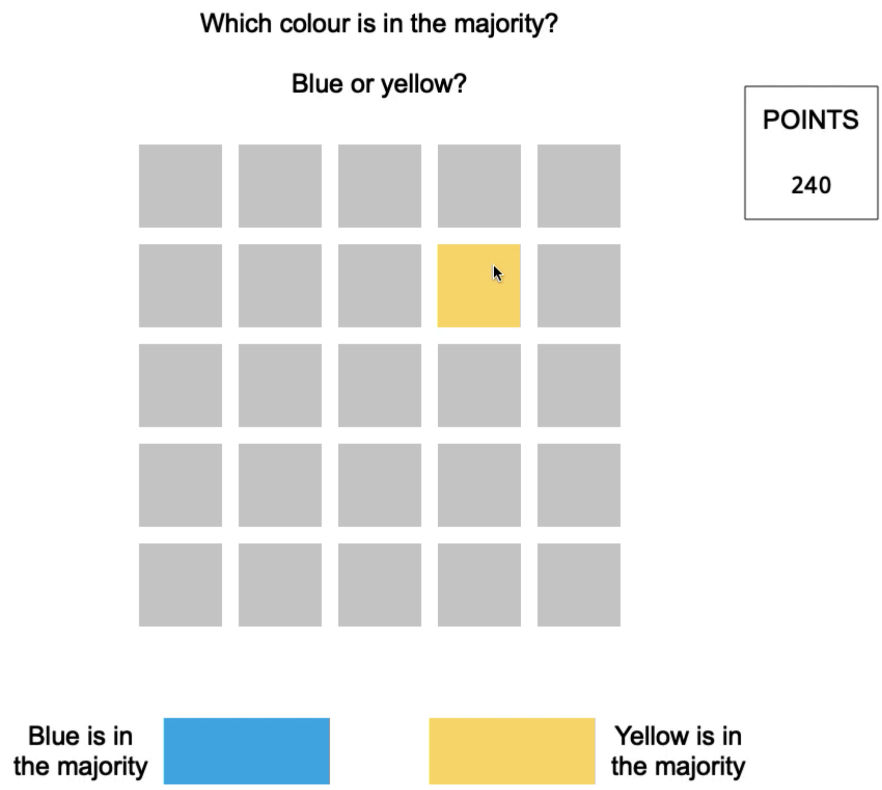
It is up to you how many boxes you click on, but every time you reveal a colour you loose 10 points.
When you make a correct decision, you win 100 points. If your decision is wrong, you loose 100 points.

Let's do one practice trial to get the hang of it. The points you win or loose during the practice don't count.

Press any key to continue.

Appendix G

Screenshot of Example Trial from the IST



Appendix H

Syntax for the Computation of the IS Variable, Normality Check and Non-Parametric Statistics

```
* Encoding: UTF-8.

DATASET ACTIVATE DataSet1.

*Computation of a variable for the tendency to sample information; the mean
tendency for each participant across all 5 trials, ABCDE.
    *The practice trial is not included in the computation of the mean.

COMPUTE
mean_IS=MEAN(inf_sampling_m_a,inf_sampling_m_b,inf_sampling_m_c,inf_sampli
ng_m_d,inf_sampling_m_e).
EXECUTE.

*Investigating the two variables total IST score and IS for normality.

EXAMINE VARIABLES=mean_IS BY condition
  /PLOT BOXPLOT HISTOGRAM
  /COMPARE GROUPS
  /STATISTICS DESCRIPTIVES
  /CINTERVAL 95
  /MISSING LISTWISE
  /NOTOTAL.

EXAMINE VARIABLES=ist_points_global BY condition
  /PLOT BOXPLOT HISTOGRAM
  /COMPARE GROUPS
  /STATISTICS DESCRIPTIVES
  /CINTERVAL 95
  /MISSING LISTWISE
  /NOTOTAL.

*Carrying out the Mann Whitney U test on both variables.

*Nonparametric Tests: Independent Samples.
NPTESTS
  /INDEPENDENT TEST (mean_IS ist_points_global) GROUP (condition)
MANN_WHITNEY
  /MISSING SCOPE=ANALYSIS USERMISSING=EXCLUDE
  /CRITERIA ALPHA=0.05  CILEVEL=95.
```

Appendix I

Results of the Test for Normality

Both measures of the dependent variable, meaning total IST score and information sampling tendency, were tested for normality.

A Shapiro-Wilk's test (p>.05) and a visual inspection of their histograms, as well as non-normal Q-Q plots and box plots showed that the IST scores were not approximately normally distributed for the DN condition, with a skewness of -2.035 (*SD* = 0.512) and a kurtosis of 4.581 (*SD* = 0.992). The contrary was true for the control condition, where histograms, normal Q-Q plots and box plots showed an approximately normal distribution of IST scores, with a skewness of -.46 (*SD* = .536) and a kurtosis of -.945 (*SD* = 1.038).

Regarding the scores of the variable measuring the tendency to sample information, a Shapiro-Wilk's test (p>.05) and a visual inspection of their histograms, as well as non-normal Q-Q plots and box plots showed that these scores were not approximately normally distributed for the DN condition, with a skewness of 3.36 (*SD* = .51) and a kurtosis of 13.8 (*SD* = .02). For the control condition, the visual inspection of histograms, normal Q-Q plots and box plots showed an approximately normal distribution of scores, with a skewness of -.15 (*SD* = .54) and a kurtosis of -.21 (*SD* = 1.04).

Both total IST scores and scores measuring the tendency to sample information did not appear to be approximately normally distributed across both conditions. Therefore, instead of doing an Independent Samples *t*-Test, non-parametric statistical analysis was performed.