Investigating the Impact of Socio-Environmental Cues of Harshness on Risk-Taking Behaviour: A Virtual Reality Experiment

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Abstract

Risk-taking behaviour is subject to individual differences. While risk-taking is often interpreted as maladaptive, evolutionary-developmental psychology claims it serves an adaptive purpose under specific environmental conditions. Thus, behaving riskily in environments characterised by harshness (high morbidity and mortality rates beyond the individual's control) is theorised to increase the individual's fitness. The objective of the present study was to examine the effect of socio-environmental cues of harshness on risk-taking behaviour. It was hypothesised that exposure to socio-environmental cues of harshness increases risk-taking behaviour. Furthermore, it was hypothesised that experience of resource scarcity in early childhood positively moderates the effect of socio-environmental cues of harshness on risk-taking behaviour. An experimental between-subjects design was used. Participants (N = 51) were allocated to one of two Virtual Reality (VR) scenes. VR scenes showed two distinct neighbourhoods that differed in level of harshness (low vs high). Risk-taking was measured by the Balloon Analogue Risk Task implemented in both VR scenes. A questionnaire was used to measure resource scarcity in early childhood. An independent sample t-test was conducted to test the first hypothesis, t (45) = -.28, p = .78. A multiple linear regression was conducted to test the second hypothesis, F (3,47) = 0.55, p = .65. Exposure to harshness did not increase risk-taking behaviour, and resource scarcity did not act as a moderator. The lack of diversity of the sample was a limitation. A strength was the successful manipulation of harshness through VR scenes. A proposal for future research was made.

Keywords: risk, risk-taking, harshness, life history theory, virtual reality

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Investigating the Impact of Socio-Environmental Cues of Harshness on Risk-Taking Behaviour: A Virtual Reality Experiment

The willingness to take risks can manifest in a variety of behaviours. Examples are engaging in unprotected sex, trespassing, vandalism, gambling, or speeding. There are plenty of opportunities to do something risky every day. Speeding alone has been a factor in a third of fatal traffic accidents in Germany in 2019, resulting in the deaths of 963 people. (Statistisches Bundesamt, 2020). This example shows the detrimental consequences risk taking can have for both the individual and society. The enforcement of policies aiming to make speeding less attractive seems to have borne fruits, as shown by the overall decrease in accidents from 1991 to 2019 (Kords, 2020). However, this leads to the question of why, despite all its known and potentially negative consequences, many individuals still exceed speed limits, have unprotected sex or gamble while others do not.

According to Leigh (1999), risk-taking behaviour is defined as any behaviour that includes a certain probability of paying off in the form of benefit while also bearing the potential to induce harm or danger. As risky behaviours can have detrimental effects on the individual and society, a vast body of research is dedicated to investigating this topic. People generally differ in the degree to which they engage in risky behaviour (Bromiley & Curley, 1992). Associated aetiological determinants range from sex, personality, and innate traits to emotional state, cognition, and upbringing (Cooper et al., 2006; Morrongiello & Lasenby-Lessard, 2007). As plentiful as the factors that correlate with risk-taking tendencies are, as diverse are the branches of psychology concerned with investigating the subject matter. Although risk-taking is often interpreted as maladaptive, evolutionary-developmental psychology proposes an alternative perspective. The remainder of this introduction presents central ideas of evolutionary-developmental psychology in explaining human decision-making and, therefore, risk-taking behaviour. Drawing on Life History Theory, the role of the fundamental environmental condition, harshness, in explaining individual differences in risk-taking is emphasised. Further, the importance of environmental conditions in early childhood is highlighted. Finally, the advantages of virtual reality as a research method in experimental research are outlined.

Optimal Decision-Making

Optimal decision-making refers to the ability to select the most advantageous option, considering both immediate and delayed consequences from a range of alternatives (Bechara, 2005). However, humans are limited in their capacity to perceive, memorise, and integrate information. Therefore, humans engage in a simplifying evaluation of outcomes. According to Verdejo-Garcia et al. (2018), people sample information and assign value to potential outcomes regarding risk and reward in a process called preference formation. Preference formation is entirely subjective as it involves assigning value to options and thus results in a preference for whatever option is interpreted as most valuable for the individual given current conditions (Verdejo-Garcia et al., 2018). How one assigns value is influenced by personal traits as well as characteristics of the situation. According to Figner and Weber (2011), behaviour - and therefore risk-taking - is domain-specific and dependent on the environment. Hence, an individual with a general proclivity towards risk-taking might evaluate the choice with the most outcome variability (risk) as the subjectively optimal choice if certain factors of the environment contextually influence that individual. Evolutionary-developmental psychology provides an integrative framework that considers the impact of socio-environmental context on risk-taking behaviour.

Evolutionary-Developmental Psychology and Risk-Taking

The evolutionary-developmental domain of psychology originates from the field of evolutionary biology. Geary and Bjorklund (2003) define it as the "study of the genetic and ecological mechanisms that govern the development of social and cognitive competencies common to all human beings and the epigenetic processes that adapt these competencies to local conditions". Darwin's theory of evolution is located at the heart of this interdisciplinary theoretical framework which postulates that an organism's reproductive success is determined by its adaptiveness to the environment (Cosmides & Tooby, 2006). Consequently, an organism that is sufficiently adapted to its environment has greater relative success in passing on its genes through reproduction than another organism that is poorly adapted. Evolutionary-developmental psychology thus argues that human behaviour is ultimately governed by the goal of reproduction (Neuberg et al., 2010). This notion applies to all sorts of behaviour, including risk-taking. Therefore, risk-taking, which seems maladaptive at first glance, may serve the goal of maximising fitness under certain environmental circumstances (Kenrick et al., 2009). Nevertheless, individuals differ in their tendency to take risks despite this presumedly underlying motivator of reproduction that should apply to all humans. Life History Theory (LHT) (Fisher, 1930) provides an explanation.

LHT focuses on how energy as a resource is allocated across the lifespan to growth, survival, and reproduction (Charnov, 1993; Roff, 1992, as cited in Sear, 2020). LHT assumes that organisms undertake a trade-off between reproduction and survival (Sear, 2020). Accordingly, species have developed to adopt various traits and characteristics to ensure either longevity or rapid reproduction. Evolutionary biologists have recently criticised the inaccurate application of LHT in behavioural sciences (Sear, 2020; Stearns & Rodrigues, 2020). More precisely, research in psychology has often omitted the theory's central idea of trade-offs at species level and instead focused on the idea of individual LH strategies. Presumedly, these strategies could be clustered along a fixed continuum ranging from “slow” (e.g., late reproduction, high somatic and parental effort) to “fast” (e.g., early reproduction high mating effort) (Nettle & Frankenhuis, 2020). The divergence between the original theory and its derivate in social sciences is shown by Nettle and Frankenhuis (2019). They demonstrated that literature from articles in both fields only seldomly shows any overlap. Despite eligible criticisms, the concept of trade-offs in LHT proves valuable for the domain of psychology (Sear, 2020). Conditions of the environment exert selection pressure on genes which determines the general LH of a species (e.g., age of sexual maturity, age at first birth, and number of offspring) (Griskevicius et al., 2013). Similarly, environmental conditions affect the expression of life-history traits on an individual level as a result of *phenotypic plasticity* (Sear, 2020). Phenotypic plasticity refers to an organism's ability to modify the developmental course through exposure to and experience of environmental conditions (DeWitt et al., 1998; Frankenhuis & Panchanathan, 2011; West-Eberhard, 1989). This emphasises the importance of the environment during the development of any individual in investigating individual differences in risk-taking.

A Fundamental Environmental Condition

Harshness

In evolutionary-developmental psychology, harshness is identified as a fundamental environmental condition that influences the individual. According to Frankenhuis et al. (2016), environmental harshness is characterised by morbidity and mortality rates beyond the control of the individual exposed to said environment. Consequently, an environment high in harshness encompasses many threats to life, opportunities to get injured or sick, or scarce resources (Chang et al., 2019; Ellis et al., 2009; Frankenhuis et al., 2016). In Western, modernised, and industrialised societies, cues of harshness are more subtle. Individuals of low socioeconomic status (SES) are often exposed to cues of harshness (Belsky et al., 2012; Griskevicius et al., 2013). Low SES residents of urbanised and deprived neighbourhoods often experience crime, violence, and vandalism and are exposed to, for instance, street gangs (Chang et al., 2019). Moreover, low SES is considered a reliable determinant of chronic illness in developed countries (Chen et al., 2012). More specifically, conditions and diseases associated with low SES include metabolic risk and insulin resistance in adolescents (Goodman et al., 2005; Goodman et al., 2007), as well as an increased risk of suffering from cardiovascular diseases (Kaplan & Keil, 1993; Pollitt et al., 2005). In summary, individuals of low SES experience many factors that increase the likelihood of becoming sick or injured, suggesting heightened relative morbidity and mortality compared to individuals of higher SES.

Interestingly, the degree of harshness of the present environment is associated with the expression of particular behaviour in humans. A substantial body of literature suggests differences in goal orientation due to harshness of the environment (de Baca et al., 2016; Figueredo & Jacobs, 2011; Zhu et al., 2018). More precisely, goal orientation of participants was found to be more present-centred in harsh environments, whereas it was more future-centred in less harsh environments. Accordingly, LHT predicts that individuals exposed to environmental harshness are willing to make more risky decisions because it offers a chance for an additional short-term or immediate benefit. Hence, exposure to, for example, a deprived neighbourhood characterised by cues of harshness (e.g., crime, violence, and vandalism) is expected to influence risk-taking tendencies positively. Furthermore, decreased life expectancy, as implied by harshness of the environment, suggests the possibility of early death or injury that would utterly impede the individual's ability to produce offspring. Therefore, potential harm associated with the risky choice is disregarded, and decision-making becomes more present-centred.

Early Childhood Adversity (ECA)

Childhood is a critical period for any human's development. ECA is characterised by neglect, psychological-or physical abuse, parental loss, harsh parenting, and general experience of stress (Tyrka et al., 2013). Moreover, ECA increases the probability of suffering from childhood psychopathology and enhances the risks of psychological disorders in adulthood (Tyrka et al., 2013). These detrimental experiences and conditions are in line with the concept of harshness.

Childhood is the most crucial phase in the development of any individual. Parenting and upbringing significantly impact social and emotional maturation and cognitive development (Zeynel & Uzer, 2020). Furthermore, the degree to which childhood experiences shape the individual declines with increasing age (Fawcett & Frankenhuis, 2015). Correspondingly, phenotypic plasticity is higher in early childhood. To sum up, cues of harshness exert high pressure on development during childhood as a function of the age-dependant decline in phenotypic plasticity. Therefore, children adapt more strongly to adverse environments than adults and preserve the developed traits in the future. Consequently, evolutionary-developmental theory states that ECA is an essential factor that accounts for individual differences in risk-taking tendencies, as cues received during early childhood are hypothesised to be exceptionally influential in forming behavioural and cognitive patterns.

Empirical Evidence of an Interaction Between Childhood SES and Harshness of the Current Environment in Explaining Risk-Taking Behaviour

Griskevicius et al. (2013) argue that early developmental conditions sensitise humans to respond in distinct and predictable ways if harshness is present in subsequent life periods. White et al. (2013) discovered that mortality threats influence diversification of resources depending on childhood SES. Whereas low childhood SES participants preferred to diversify resources when primed with cues of harshness, high childhood SES participants preferred the opposite. Allocating resources is a way of managing risks. While diversification leads to increased variation of resources and a lower probability of losing greater relative amounts, investing in a reduced number of options falls at risk of losing greater relative amounts (White et al., 2013). Thus, to put all eggs in one basket, is a risky decision. In a study conducted by Griskevicius et al. (2011), researchers found that cues of mortality predicted risk-taking behaviour if moderated by low childhood SES. As such, participants tended to make the riskier choice if exposed to cues of harshness and if their childhood SES was low but not if their childhood SES was high. Additionally, when testing this interaction with current SES, no significant result was obtained. This further stresses the importance of early childhood in the formation of risk-taking tendencies, presumedly as a result of increased phenotypic plasticity in early developmental periods. These findings were partly replicated in Griskevicius et al. (2013). Griskevicius et al. (2011) and White et al. (2013) manipulated harshness utilising an artificial but authentic newspaper article called “Dangerous Times Ahead: Life and Death in the 21st century”. The article described a dangerous future by pointing out the latest increase in violence and death in the United States, where the study was conducted. Control groups received a neutral article. Consequently, participants were not directly exposed to a harsh environment but primed. Pepper et al. (2017) conducted a replication study in the UK, adjusting the newspaper article to their sample. However, they were unable to replicate the findings of Griskevicius et al. (2011), which stresses the necessity to examine this topic further.

The Present Study

This study investigated the influence of exposure to socio-environmental cues of harshness on risk-taking and whether resource scarcity in childhood moderates this effect.

This study used the Balloon Analogue Risk Task (BART) to measure risk-taking behaviour. The BART is commonly used when measuring risk-taking propensity. According to Li et al. (2020), it is frequently used in developmental research and neuroimaging and yields moderate to high test-retest reliability. Moreover, the BART seems to parallel risky behaviour outside the laboratory successfully. Due to the BART's high ecological validity, a substantial body of research has focused on the relationship between BART performance and real-world risky behaviour (Aklin et al., 2005; Lejuez et al., 2002; Lejuez et al., 2003; Lauriola et al., 2014). Lejuez et al. (2002) suggest positive correlations between performance on the BART and driving without a seatbelt, gambling, unprotected sex, and stealing.

Griskevicius et al. (2011) adopted an indirect way of exposing participants to either control-or harshness conditions. Thus, participants were primed with harshness using a newspaper article but were neither physically present in a harsh environment nor did they make decisions in the said environment but in a laboratory. The current study addressed these shortcomings by exposing participants to a simulated environment in which they performed the BART. For this purpose, Virtual Reality (VR) was used.

Over the last years, VR has been employed as a research tool and is considered a powerful technology when studying human-environment interactions (Kuliga et al., 2015). Researchers can adjust conditions to their needs as any environment can be designed in great detail. Therefore, VR is considered a reliable experimental tool because it allows researchers to isolate the effect of the variable of interest by keeping scenes identical across conditions apart from said variable (Blascovich et al., 2002). Consequently, VR is high in experimental control and allows for accurate replicability. Additionally, in VR, many aspects of reality can be represented, which makes the experience of the computer-generated environment feel real. Moreover, immersion through technology can eventually result in the subject forgetting about the virtual setting (Slater, 2009).

VR can be particularly beneficial in obtaining measures of risk-taking. Most risk-taking assessment tools are either explicit measures or questionnaires which lack validity (de-Juan-Ripoll et al., 2018). While the BART seems valuable as a measurement tool due to its implicit measure of risk-taking, de-Juan-Ripoll et al. (2018) suggested developing a more ecological system with the use of VR specifically. The current study addressed this implication by being the first to ever implement the BART in VR to obtain a measure of risk-taking.

Negative consequences of risk-taking behaviour affect both the individual and society. This study aims to contribute valuable information on the aetiology of individual differences in risk-taking. Results of this study can contribute to the design of effective interventions to decrease risk-taking behaviour.

Research Question and Hypotheses

The current study used VR to manipulate socio-environmental cues of harshness. The following research questions were formulated based on evolutionary-developmental psychology and previously established relationships between risk-taking, harshness, and childhood resource scarcity.

"Does exposure to socio-environmental cues of harshness influence risk-taking behaviour?" and "Is the impact of socio-environmental cues of harshness on risk-taking behaviour moderated by childhood resource scarcity?". It is hypothesised that:

H_1: Participants exposed to socio-environmental cues of harshness will display higher levels of risk-taking behaviour than participants not exposed to socio-environmental cues of harshness.

H_2: There is a positive interaction effect between childhood resource scarcity and socio-environmental cues of harshness on risk-taking behaviour. For higher levels of childhood resource scarcity, the effect of exposure to socio-environmental harshness on risk-taking behaviour is higher.

Methods

Design

An experimental between-subjects design was used. The dependent variable (DV), "risk-taking behaviour", was measured using the BART (Lejuez et al., 2002). The independent variable (IV), "socio-environmental cues of harshness", was operationalised using two different VR scenes. The IV thus has two levels (low vs high). 22 participants were exposed to the low harshness condition, while 29 participants were exposed to the high harshness condition. Thirdly, "childhood resource scarcity" was operationalised using a questionnaire that measures perceived childhood resource scarcity and acts as a covariate measure to examine a potential moderator effect on the relationship between exposure to socio-environmental cues of harshness and risk-taking.

Participants

The ethics committee of the University of Twente (UT) approved this research project before data collection. The sample consisted of 58 participants aged between 18 and 59 (*M* = 22.6, *SD* = 5.4). More than half of the participants were female (53.4%), while the remaining were male (46.6%). Participants were mostly German (60.3%) or Dutch (19%) (see Appendix A). Regarding education level, 82.8% selected "High School", 15.5% selected "College/University-Undergraduate degree", and 1.7% selected "College/University-Graduate degree". Participants were recruited using convenience sampling. The test subject pool system SONA of the Faculty of Behavioural-, Management-, and Social Sciences (BMS) of the UT was used to recruit participants. Apart from SONA, researchers advertised the study using various social media platforms such as WhatsApp and Instagram. Moreover, a recruitment flyer was created for advertisement purposes and distributed in various locations on campus (see Appendix B). Individuals without access to SONA were able to participate by notifying the research team via E-mail. Exclusion criteria for participants were age younger than 18 years and participation in similar studies of the same research line. Completing the BART required the ability to interact with a red button. Because red-green colour blindness is the most common type of colour vision deficiency (Roostaei & Hamidi, 2022), colour blindness is an additional exclusion criterion. Moreover, many people suffer from cybersickness when experiencing a VR environment (Oh & Son, 2022). Cybersickness is similar to motion sickness because it causes nausea, general discomfort, and disorientation (Kennedy et al., 2009). Susceptibility to motion sickness is a risk factor for nausea and vomiting during pregnancy which 80% of pregnant women suffer from (Laitinen et al., 2020). Therefore, pregnancy was added as an exclusion criterion not to induce preventable discomfort or harm to subjects. Participants recruited from SONA received 1.5 SONA credits. Based on their performance on the BART, all participants had the opportunity to obtain one out of five VVV-Vouchers, worth 20€ each.

Materials

Pre-VR Questionnaire

The questionnaire included items about demographic data related to gender, age, educational level, nationality, and country of residence until five years old. For the complete questionnaire, see Appendix C.

BART in VR

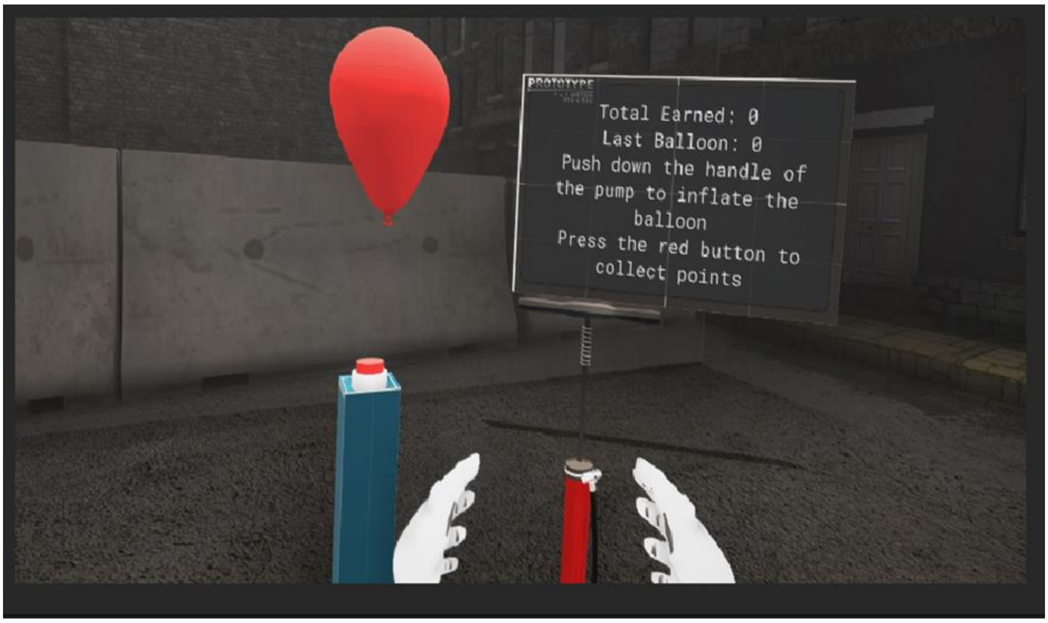
To measure the DV, risk-taking, the BART (Lejuez et al., 2002) was adapted to this experiment. In the original article in which the BART was first introduced, it is defined as "a computerised, laboratory-based measure that involves actual risky behavior for which, similar to real-world situation, riskiness is rewarded up until a point at which further riskiness results in poorer outcomes" (Lejuez et al., 2002). The task involves balloons which can be inflated with air at will. Participants are instructed to use a virtual pump to increase the balloon size. Each time the pump is used to inflate the balloon, 50 points are added to a temporary bank. With each successive pump, the same number of credits is transferred. However, each balloon has an inherent and probability of bursting unknown to the participant. If the balloon bursts, another balloon appears, and the procedure repeats as many times as trials are selected. Moreover, all credits accumulated in the temporary bank are inevitably lost if the balloon bursts. It is up to the participant to decide how many pumps to commit and, hence, credits to accumulate. With each trial, there is the option to save the credits in the temporary bank while the balloon is still intact. Saving credits will result in the number of credits in the temporary bank being transferred to a permanent bank while terminating the current balloon trial and entering the next one. Credits in the permanent bank are not affected by bursting balloons. Therefore, the number of credits in the permanent bank can either increase or stagnate. The goal of the task is to accumulate as many credits as possible in the permanent bank, given a fixed number of trials. As the goal is to maximise credits in the permanent bank, participants must commit many pumps while at risk of losing all temporary credits accumulated through pumps. The question is when to stop pumping and start transferring credits.

The BART used in this experiment resembled the task from Lejuez et al. (2002) with a few exceptions. Unavoidable changes were related to the change of a BART conducted on a computer screen to a BART conducted in VR (see Figure 1). Elements of the BART in this study were a pump, balloons and a screen showing instructions. Furthermore, a red button on a pedestal was added to interact with the task and transfer accumulated points to the permanent bank. Moreover, a collider was activated once the participant entered the task area to prevent incomplete responses. If a participant attempted to leave the task area early, the collider would prevent it. A transparent material was used not to distract participants from the task. Additionally, participants did not need to click on "next" using a computer mouse to proceed to the next screen, as in the original BART. However, they had to press the red button implemented in the scene by moving the controllers in three-dimensional space to press down the button literally. Similarly, to pump the balloon, it was necessary to push down the handle of a virtual pump instead of clicking on a button called "pump" on the screen. For instructions received by participants, see Appendix D.

Additional changes were made. Firstly, the number of trials was lowered from 90 to 15 to reduce the amount of time participants were exposed to the virtual environment to prevent experience of cybersickness for more extended periods. Secondly, the number of distinct types of balloons was reduced to one. Whereas in the original study, three balloon classes with differing probabilities of bursting were used, this study used only one type of balloon of red colour. The explosion probability of the BART was determined by constructing an array with *N* numbers. With each pump, one number is selected from the array without replacement. If the selected number is equal to 1, the balloon explodes. In Lejuez et al. (2002), *N* was dependant on the balloon's colour, either 8, 32, or 128. However, in the current study, $N = 15$. The average explosion point is 7.5 pumps.

Figure 1

First person view of the Balloon Analogue Risk Task implemented in a virtual reality scene



Manipulation of Socio-Environmental Cues of Harshness

Two VR scenes were designed in accordance with neighbourhoods that show differing levels of socio-environmental cues of harshness. Socio-environmental cues of harshness was therefore operationalised by the two neighbourhoods, with a high harshness neighbourhood (experimental condition) and a low harshness neighbourhood (control condition). VR equipment included the Oculus Rift S and respective Controllers. All VR scenes were created with the programme “Unity, version 2020.3.28f1”. In both neighbourhoods, the BART was implemented. A second task called “Task H” was implemented as part of a second research project, which measured discounting of future suffering on a slider scale ranging from 1 to 100 using five items.

The neighbourhoods strongly differed visually but had a similar layout. Similarities between the two neighbourhoods included streets, houses, and a public area in the centre of the scene. Both neighbourhoods included white and orange arrows and circles placed along the streets for participants to follow. Because individuals unfamiliar with VR often struggle when experiencing VR for the first time, researchers decided to devise a tour of the neighbourhood using understandable signs. Arrows pointed in the direction participants should go next. Circles were a sign to stop walking for about 10 seconds and shift one's attention to the environment. This was done to ensure equal exposure to all cues among participants and to give participants short breaks from walking in VR, which helps to reduce symptoms of cybersickness. Arrows and circles were coloured orange if located at the end of the tour through the neighbourhood. To not disrupt participants from their impression of the neighbourhood, the colour of arrows and circles was adapted to match the overall chromatic character of the respective scene. Neither neighbourhood specified where it was located. However, due to the overarching design of houses, street layout, and architecture, it can be assumed that both neighbourhoods resembled Western and urbanised cities. Moreover, audio tracks implemented in both conditions were in English, indicating that the neighbourhoods were located in a country where English is the official language.

High Harshness Condition (HHC). Many cues suggested deprivation, i.e., broken windows, damaged roads and streets, and an out-of-use bus stop. Additionally, the streets were full of garbage, filth, and cigarettes, further indicating that few to no intact maintenance measures were employed. This displayed a lack of infrastructure and inadequate involvement of the local authorities with public services. The scene included not only visual cues but also auditive ones. When entering certain areas in the scene, audio sequences were activated. These included the siren of a police car on the streets in the distance and people having a severe and loud argument from within two houses alongside the street. Furthermore, houses and properties were created to look shabby through graffiti, broken windows, or damaged property (see Figure 2). This was done to indicate substantial rates of criminality and missing resources to afford maintenance. Houses mainly resembled apartment buildings and industrial facilities. More cues adding to the deprived state of the neighbourhood were yellow barrier tape indicating a crime scene, “stay out” signs, and a sleeping bag on a worn-out mattress at a bus stop. Additionally, a non-interactive human avatar was placed in one of the alleys sitting on a garbage bin. These cues were implemented to model a harsh neighbourhood characterised by high morbidity and mortality rates. See Appendix E for an annotated bird's eye view of the scene.

Figure 2

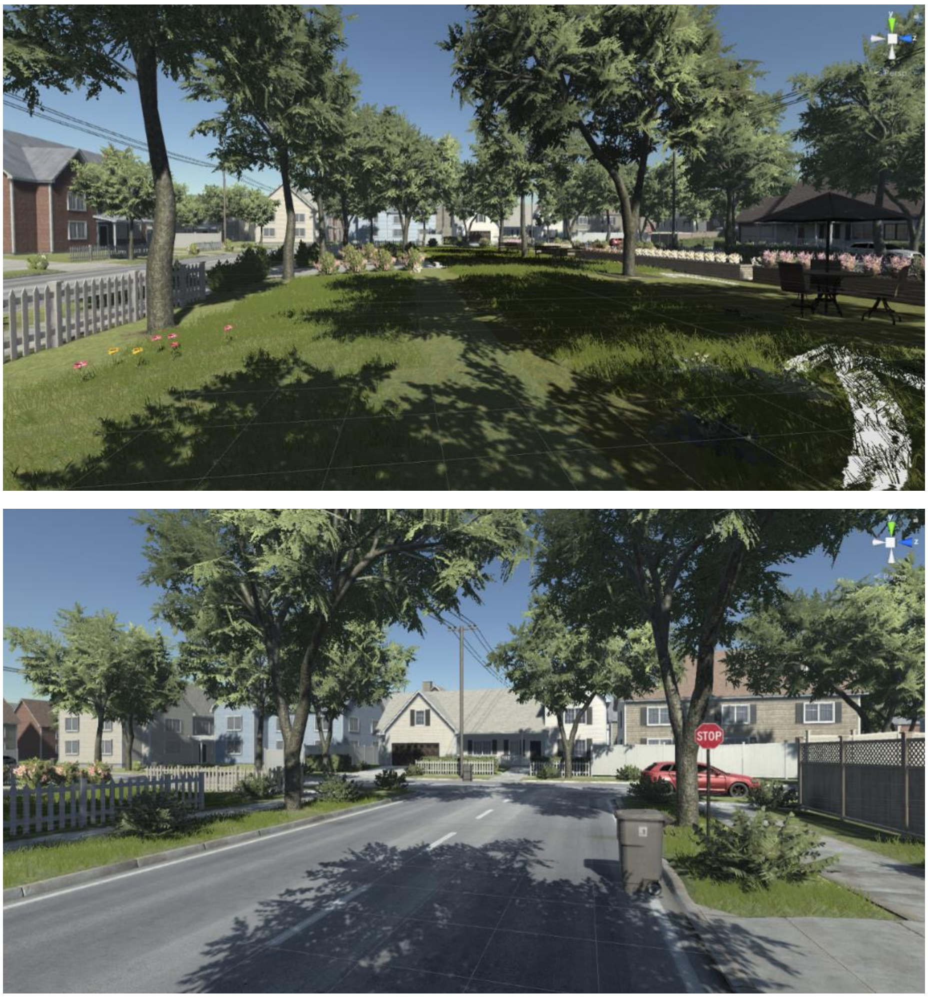
First person view of two locations in the High Harshness Condition

Note. Brightness of images was increased for demonstration in this report

Low Harshness Condition (LHC). On the other hand, the control condition was modelled to convey the impression that the shown neighbourhood is free from danger and well-kept. No features of the HHC were present. Most residential houses were single-family homes. The scene included many trees, bushes, and flowers (see Figure 3). Private property and the streets appeared in good condition. In the centre of the scene, a public space resembling a park was created, which included benches, water sprinklers, stones, and white wooden fences. Audio tracks of this scene included suburban background noise, such as dogs barking in the distance, birds chirping, and faint traffic sounds. Two locations in the neighbourhood emitted additional audio tracks. Both were placed inside houses to convey that the houses are inhabited. Participants heard people murmuring while having dinner in the first location, while in the second location, dilettante violin practice was heard. In contrast to the HHC, no human avatar was implemented in the scene due to time constraints. While this violates the overall comparability of the two conditions slightly, it does not affect the level of harshness conveyed in the neighbourhood. See Appendix F for an annotated bird's eye view of the scene.

Figure 3

First person view of two locations in the Low Harshness Condition



Practice Scene

A third VR scene, the Practice Scene, was created. The Practice Scene consisted of an even ground and eight objects. The environment was designed neutrally and kept simple to avoid priming of participants (see Appendix G). White and orange arrows and circles were implemented in the Practice Scene. Furthermore, the Practice Scene included a shorter version of the BART (BART-practice). Instructions for BART-practice were based on Lejuez et al.'s (2002) instructions for the BART and were complemented by additional instructions that emphasised that this task was only meant to practice interacting with certain elements of the task (see Appendix H). The decision to devise a Practice Scene and implement a BART-practice was based on observations from piloting. Participants unfamiliar with VR were unable to follow instructions and complete the task as intended. As this would lead to invalid and inaccurate measures, the research team decided to let participants practice using the controllers to interact with the task in the Practice Scene.

Post-VR Questionnaire

For the complete questionnaire and debriefing, see Appendix I.

VR Experience. The Post-VR Questionnaire consisted of seven items serving as a manipulation check regarding the effectivity of VR conditions in displaying differing levels of harshness. These items measured the participants' experience of the VR neighbourhood scene. Additionally, an item concerning experienced nausea or sickness as a result of VR exposure was added. The manipulation check items were measured on a slider scale ranging from 1 to 100 and required participants to indicate to what extent they 1) had a "sense of being there", 2) perceived a "feeling of safety" 3) experienced "stress" 4) wanted to "protect themselves from potential dangers", 5) experienced "relaxation", 6) "perceived danger", and 7) "perceived the neighbourhood's residents as trustworthy". Moreover, a naivety check item was added.

Childhood Resource Scarcity. Following Griskevicius et al. (2013), three items about perceived childhood resource scarcity were presented. Respondents had to indicate their agreement with the following statements on a 10-point Likert scale (1 = *strongly disagree* to 10 = *strongly agree*). 1) "My family usually had enough money for things", 2) "I grew up in a relatively wealthy neighbourhood", and 3) "I felt relatively well-off compared to other children in my nursery, kindergarten, or school". Cronbach's α showed the scale to have good reliability, $\alpha = .83$.

Procedure

Participants were invited to the BMS lab of the UT. Before entering the lab, each participant was randomly assigned to either the HHC or the LHC and given a subject number. Participants were administered the Pre-VR Questionnaire and thus informed about potentially arising risks, discomforts, or benefits resulting from participation, confidentiality, and the right to withdraw from the experiment at any moment. Not all information was disclosed to participants at the beginning of the experiments not to undermine the power of the results of the experiment. After completing the Pre-VR Questionnaire and giving informed consent, participants were made familiar with the VR equipment. Windows were closed, and smartphones and other electronic gear were muted. Then, the practice scene was started, and participants were asked to put on the headset and hold the controllers. Scripted instructions were read aloud to the participants (Appendix J). The scripted instructions were strictly adhered to, to reduce inconsistencies in verbal instructions between experimenters. Furthermore, these instructions were used as a procedural protocol among researchers. Participants were told how to use the controllers to navigate in VR and given time to practice.

Next, participants were instructed to tour the environment using the white arrows as a guide and told to stop inside the white circles to get a profound impression of the environment by looking around. Participants were informed that they would do two tasks in the environment. Orange arrows would lead them to the task area, while orange circles mark the task area. Once the participant entered the first task area, they completed BART-practice.

Afterwards, the participant completed Task H. After completing both tasks, participants were encouraged to ask questions regarding the use of controllers, the general procedure, or the BART-practice. Furthermore, participants were told that contact between researcher and participants during later stages of the experiment was prohibited not to distract participants from their experience, which would weaken the effect of immersion. Next, participants were told that they would enter the neighbourhood scene. Before entering the scene, it was emphasised that the meaning of circles and arrows in the neighbourhood scene is identical to the practice scene. Additionally, it was made explicit that participants should follow the arrows to do a tour of the virtual neighbourhood. After 5-8 minutes, participants felt able to successfully navigate and finish the tasks using the equipment, which resulted in the termination of the practice scene.

The neighbourhood scene assigned to each participant was started. While being immersed in one of the two conditions, researchers present in the lab reduced any noise they made to a minimum not to distract participants. Participants did the neighbourhood tour as indicated by white arrows and circles and followed the orange arrows to the BART. 15 trials had to be done by participants. Upon completion, participants walked for approximately one minute to complete Task H. Since participants had to walk from one task to the other for approximately one minute in both conditions, the order of the tasks was reversed after 30 participants to nullify a potential effect of the order of tasks on the measures obtained. After completing both tasks, the experimenters instructed participants to take off the headset because the end of the VR component of the experiment was reached. Afterwards, the Post-VR Questionnaire was administered. Interaction between participant and researcher was kept at a minimum between taking off the VR equipment and filling in the second questionnaire to influence participants as little as possible. While participants filled in the Post-VR Questionnaire, experimenters left the room. Participants could indicate personal contact information via which they would be informed if they won a voucher based on their performance on the BART. Once the Post-VR Questionnaire was completed, the experiment was concluded. Lastly, participants were debriefed. Participants were asked to share their experiences of the neighbourhood orally after their participation in the study was completed.

Data Preparation

58 participants completed the study. Due to missing data caused by technical issues in data collection, three responses had to be omitted from the data set. Four additional responses had to be omitted because of a mistake made by the researchers, which resulted in a different explosion probability on the first day of data collection. After preparation of the data set, 51 responses remained for data analysis. The program SPSS was used for data analysis.

Before data obtained from the BART could be analysed with SPSS, it had to be reformatted. A Python code was devised, which uses the libraries “Pandas” and “openpyxl”. The code scans all text files and converts them into respective excel-files. Because the text files are uniform in their format, the same function could be used to extract data.

For consistency reasons, data obtained from the DV (BART) were adjusted following Lejuez et al. (2002). Hence, trials in which the balloon exploded were not included in analyses because the number of possible pumps is by nature limited if the balloon explodes. Including exploded balloons does not adequately measure risk-taking behaviour because it does not give information about how many more pumps the participant would have committed, which would constraint the variability in total averages between participants. Additionally, trials in which participants skipped balloons without pumping by accident were omitted. Researchers scanned the dataset for trials with no inflations and no explosion to identify skipped balloons. Thus, the variable “mean pumps adjusted for explosions” (mean pumps) was created by computing the mean number of pumps for each participant, excluding exploded balloons, and accidentally skipped balloons.

Data from the three items measuring childhood resource scarcity from the Post-VR Questionnaire were used to compute the covariate “childhood resource scarcity” as a measure of childhood SES. This was done by computing the average of all three items.

Results

Descriptive Statistics

Participants spent on average 6 minutes and 13 seconds in the HHC before reaching the first task and described the HHC as “scary”, “sad”, and “interesting”. Participants in the LHC spent on average 7 minutes and 39 seconds before reaching the first task and described the LHC as “peaceful”, “delightful”, and “relaxing”. For “mean pumps”, participants in the LHC had a mean of 3.84 with a standard deviation of 0.87. Participants in the HHC had a mean of 3.74 with a standard deviation of 1.59. One positive outlier was identified in the HHC but not omitted. Further descriptive statistics can be seen in Table 1. For the covariate, childhood resource scarcity, the mean score was equal to 4.1 with a standard deviation of 1.87. One positive outlier was identified (see Appendix K). No reason was detected to omit the response. Means and standard deviations of items measuring the effectiveness of the manipulation of harshness can be seen in Table 2.

Table 1

Mean and Standard Deviation of “mean pumps adjusted for explosion” (mean pumps) and “childhood resource scarcity” in the High Harshness Condition (HHC) (n=29) and the Low Harshness Condition (LHC) (n=22)

Measure	HHC		LHC		Total	
	M	SD	M	SD	M	SD
mean pumps	3.74	1.59	3.84	0.87	3.79	1.32
childhood resource scarcity	4.03	1.98	4.18	1.76	4.1	1.87

Table 2

Mean and Standard Deviation of Manipulation Check Items across the High Harshness Condition (HHC) (n=29) and the Low Harshness Condition (LHC) (n=22)

Measure	HHC		LHC	
	M	SD	M	SD
sense of being there	77.1	15.13	71.86	20.39
feeling of safety	41.24	29.97	84.77	20.07
stress	45.9	28.06	20.32	17.55
protect themselves from potential dangers	70.41	21.14	25.86	28.04
relaxation	38.9	27.04	74.14	20.62
perceived danger	77.34	14.51	10	12.73
perceived the neighbourhood's residents as trustworthy	18.86	16.03	78.27	18.9

Inferential Statistics

Manipulation Check

Inferential analyses were conducted to test the effectiveness of attempted manipulation of harshness employing VR conditions. For a table of mean scores on manipulation check items across conditions of harshness, see Appendix L. Due to violation of the normality assumption, a Mann-Whitney U test was conducted for all variables except "immersion". For "sense of being there", equal variances were assumed, F (49) = 1.36, p = .25. An independent samples t-test yielded a non-significant results with t (49) = 1.05, p = .3. Participants had the same sense of being in the neighbourhood in both conditions. For "feeling of safety", a significant result was obtained, U (51) = 569,000, p < .01. Participants felt less safe in the HHC than in the LHC. For "stress", a significant result was obtained, U (51) = 137,000, p <

.01. Participants felt more stressed in the HHC than in the LHC. For "protect themselves from potential dangers", a significant result was obtained, $U\ (51) = 72{,}500$, $p < .01$. Participants wanted to protect themselves from potential dangers while being in the virtual neighbourhood to a greater extent in the HHC than in the LHC. For "relaxation", a significant result was obtained, $U\ (51) = 542{,}500$, $p < .01$. Participants were less relaxed in the HHC than in the LHC. For "perceived danger", a significant result was obtained, $U\ (51) =,500$, $p < .01$. Participants perceived the neighbourhood as more dangerous in the HHC than in the LHC. For "perceived the neighbourhood's residents as trustworthy", a significant result was obtained, $U\ (51) = 621{,}500$, $p < .01$. Participants perceived residents of the neighbourhood as less trustworthy in the HHC than in the LHC.

Hypothesis 1

To test the first hypothesis, an independent sample *t*-test was used to determine if "mean pumps" is significantly different among conditions of socio-environmental cues of harshness.

Scores on "mean pumps" resembled a normal distribution with a Skewness of 0.82 and a Kurtosis of 1.68. A Kolmogorov-Smirnov test was used to test for normality of scores within both conditions. The scores on "mean pumps" for the HHC, $D\ (29) = .11$, $p = .2$, and responses of "mean pumps" for the LHC, $D\ (22) = .11$, $p = .2$, both indicated that the data resembled a normal distribution. Likewise, the Shapiro-Wilk test supported this assumption. The test showed a nonsignificant departure from normality in the HHC, $W\ (29) = .94$, $p = .12$, and in the LHC, $W\ (22) = .99$, $p = .97$. Independence of observations between groups is given by nature of the study design.

Results of an independent sample *t*-test showed that Levene's test of Equality of Variance is significant with $F\ (49) = 5.29$, $p = .026$. Therefore, equal variance was not assumed. The *t*-test showed that participants exposed to socio-environmental cues of harshness did not display higher risk-taking behaviour than participants not exposed to socio-environmental cues of harshness, $t\ (45) = -.28$, $p = .78$. Consequently, the null hypothesis was accepted.

Hypothesis 2

The second hypothesis was tested by conducting a multiple linear regression. Multiple linear regression was chosen over a two-way ANOVA because it allowed for the covariate to stay continuous. Transforming the covariate into an ordinal variable would have resulted in loss of explanatory power. Multiple linear regression tested if "childhood resource scarcity" moderated the effect of socio-environmental cues of harshness on “mean pumps”. Five statistical assumptions were checked.

Residuals were normally distributed with both Kolmogorov-Smirnov, D (51) = 0.08, p = .2, and Shapiro-Wilk, W (51) = 0.96, p = .09, being non-significant (see Appendix L1). Independence of residuals was checked using the Durbin Watson test, a measure of autocorrelation. Since $d = 2.17 > d_L = 1.49 > d_U = 1.64$, autocorrelation cannot be assumed which suggested independence of residuals. Thus, the assumption was not violated with a test statistic of 2.17 (Field, 2009). Unstandardised residuals were plotted against unstandardised predicted values. The scatterplot does not show a funnel-like distribution and appears random (see Appendix L2). Consequently, homoscedasticity was assumed. Multicollinearity between the covariate and the IV does not exist, Variance Inflation Factor (VIF) = 1. Finally, linearity of scores was checked using a scatterplot (see Appendix L3).

Table 3 shows the results of multiple linear regression analysis. $R^2 = 0.03$ revealed that the predictors explained 3% of the variance of the dependent variable, “mean pumps”, with F (3,47) = 0.55, p = .65. The findings show that “childhood resource scarcity” does not predict “mean pumps”. Neither does the IV significantly predict “mean pumps”. The hypothesised interaction effect between the covariate and the IV is non-significant. The null-hypothesis was accepted. There is no positive interaction effect between childhood resource scarcity and socio-environmental cues of harshness on risk-taking behaviour.

Table 3

*Moderation Analysis: Resource Scarcity, Harshness, and Resource Scarcity*Harshness predicting “mean pumps adjusted for explosion” (mean pumps) in a Multiple Linear Regression model (n=51)*

Effect	Estimate	*SE*	95% CI		*P*
			LL	*UL*	
Intercept	3.62	1.37	0.87	6.37	.001
Childhood Resource Scarcity	<.01	.31	-0.61	0.61	.989
Harshness	.48	.94	-1.42	2.38	.612
Childhood Resource Scarcity*Harshness	-.09	.21	-0.51	.33	.676

Post-Hoc Analysis of Number of Explosions on BART across Conditions of Harshness

Lejuez et al. (2002) suggested that number of explosions on the BART might be another indicator of risk-taking. While working with the dataset, it was observed that the mean number of explosions was higher in the LHC (*M* = 4.27, *SD* = 1.93) than in the HHC (*M* = 3.48, *SD* = 2.09). Post-hoc analysis was conducted to test whether a different measure of the BART to operationalise risk-taking behaviour would have yielded comparable results. Thus, it was tested whether number of explosions differs among conditions of socio-environmental cues of harshness. Because the normality assumption was violated, a non-parametric test was conducted. The significance level was adjusted as a consequence of Bonferroni correction ($\alpha = .017$). The Mann-Whitney U test showed no significant difference in the number of explosions between participants assigned to the HHC and participants assigned to the LHC, $U(51) = 410{,}00$, $p = .08$.

Discussion

The present study investigated the impact of the fundamental environmental condition, harshness, on risk-taking behaviour. Drawing on LHT and the results of the reviewed literature, two hypotheses were formulated. Firstly, it was hypothesised that exposure to socio-environmental cues of harshness increases risk-taking behaviour. Secondly, it was hypothesised that the experience of resource scarcity in early childhood would positively moderate the effect of socio-environmental cues of harshness on risk-taking behaviour. Results of the present study led to the rejection of both hypotheses. Participants exposed to socio-environmental cues of harshness did not display more risk-taking behaviour than participants not exposed to socio-environmental cues of harshness. Moreover, exposure to resource scarcity in early childhood did not moderate the hypothesised effect of exposure to socio-environmental cues of harshness on risk-taking behaviour. Nonsignificant results suggested that the observed effects are not generalisable to population level. This observation opposes the expectation that exposure to cues of socio-environmental harshness would lead to increased risk-taking behaviour.

These findings are inconsistent with the results of Griskevicius et al. (2011), who found that cues of violence and death lead to higher risk-taking behaviour for participants with low childhood SES. In that regard, the results of the present study are in line with Pepper et al. (2017), who failed to replicate the results of Griskevicius et al. (2011) in a replication study in the UK. These divergent findings are particularly intriguing considering that characteristics of the respective samples of Pepper et al. (2017), Griskevicius et al. (2011), and the present study are noticeably similar. All three samples mainly consisted of university students who participated in exchange for course credits. Moreover, mean ages were comparable. One might argue that observed effects are more likely to be replicated if demographics of the samples studied are overall similar, assuming that there indeed is an effect. However, it must be considered that although Griskevicius et al. (2011) and the present study use similar theoretical frameworks, the operationalisation of harshness is vastly different. While Griskevicius et al. (2011) manipulated harshness by making increased mortality explicit by referring to it directly in the newspaper article, the present study manipulated harshness through socio-environmental cues.

Not only are results of the current study incompatible with reviewed literature but seem puzzling from an evolutionary-developmental perspective. Evolutionary-developmental psychology, more precisely Life History Theory, predicts that individuals tend to make more risky decisions when exposed to harshness because risky decisions offer additional and immediate benefits. This preference has often been reported in literature (de Baca et al., 2016; Figueredo & Jacobs, 2011; Zhu et al., 2018). Concerning the hypothesised moderator effect of childhood resource scarcity on the relation between harshness and risk-taking behaviour, evolutionary-developmental psychology predicts that adverse childhood experiences lead to the development of increased risk-taking proclivity, which remains dormant until triggered by harsh environments in the future (Griskevicius et al., 2013). Hypotheses of the present study were formulated based on predictions derived from evolutionary-developmental psychology and supported by a vast body of research.

The rejection of hypotheses gives rise to reconsider the general applicability of LHT in explaining risk-taking behaviour. Human decision-making and, therefore, risk-taking behaviour might be too complex and multifaceted to be understood by a comparatively inflexible theoretical framework that solely focuses on an evolutionary-developmental perspective. One of the central presumptions of evolutionary-developmental psychology states that human behaviour is governed by the goal of reproduction (Neuberg et al., 2010). However, birth rates have declined steadily for the past 50 years (The World Bank, n.d.), in spite of relatively favourable reproductive conditions for the human species. It can be argued that human behaviour is not literally directed at reproductive success but fitness in general. Still, this suggests that the modern human holds a relatively peculiar place in the animal kingdom. Consequently, the possibility must be acknowledged that, for instance, our extensive social lives, reflective skills, culture, intelligence, personality, and linguistic skills, determine our decision-making to some extent. Subsequently, decision-making and, therefore, risk-taking might not be as hardwired as evolutionary-developmental psychology claims.

Limitations and Strengths

After discussing results of the present study, limitations need to be addressed. In retrospect, the study contains a number of flaws which need to be considered when putting results into perspective.

Firstly, it needs to be addressed that the sample shows a lack of diversity. According to Henrich et al. (2010) many studies in the top journals of psychology entirely rely on Western, Educated, Industrialised, Rich, and Democratic (WEIRD) societies for sampling. According to Arnett (2008), 96% of studies in the top six American Psychology Association (APA) journals sample from western, industrialised nations. Consequently, 96% of studies conducted tried to test or build universal theory based on observations of participants that make up only 12% of the entire human race (Rad et al., 2018). Additionally, Henrich et al. (2010) suggest that WEIRD participants are distinctively bizarre when compared to the rest of the species. Representatives of WEIRD societies score differently than members of non-WEIRD societies in a variety of measures, i.e., reasoning styles, self-concepts and related motivations, visual perception, and fairness. The present sample consists of predominantly WEIRD people (96%) with only two participants coming from non-WEIRD countries. This is especially concerning considering the evolutionary-developmental framework that informed the present study design. Evolutionary psychology is aimed at studying behaviour, thoughts, and feelings of humans, focussing on factors present in the entire species as a consequence of shared evolution. Therefore, drawing inferences based on a sample that merely captures a fraction of the diversity of humankind seems highly problematic. Furthermore, research indicates a strong link between low SES and low academic achievement and a slow degree of academic progress (Mompremier, 2009). Consequently, as the sample primarily consists of WEIRD university students, there is little variance in the covariate, Resource Scarcity (see Appendix K).

Secondly, it can be noted that the mean time spent in each neighbourhood before arrival at the BART was slightly different. While it took participants 7:39 on average in the LHC to reach the BART, participants in the HHC spent only 6:13 on average. As a result, participants assigned to the HHC were exposed 1 minute and 26 seconds less to cues of the condition than participants in the LHC. Accordingly, the possibility must be considered that exposure to socio-environmental cues of harshness was not sufficiently long to evoke increased risk-taking behaviour. While different exposure times could stem from differences in the length of the devised tour in the neighbourhood, another explanation could be that participant felt more inclined to spend more time exploring in the relaxing LHC than in the stressing HHC (Table 2). Retrospectively, this would have proved valuable to measure directly. Regardless, during the creation of the neighbourhoods, more resources should have been allocated to ensure equal length of both tours. Moreover, each neighbourhood should have the same number of circles and arrows implemented to avoid this shortcoming.

Lastly, the overall sample size and the difference between the number of participants across conditions need to be mentioned as limitations of the present study. A larger sample size decreases the relative impact of outliers on observed statistics and effects. Considering the difference in the number of participants across conditions (LHC, $N = 22$; HHC, $N = 29$), “mean pumps” is arguably less robust to the effect of extreme scores in LHC than in HHC.

Henceforth, strengths of the study are discussed. From a methodical point of view, the study design itself is a strength. Due to the experimental design of the study, erroneous, external variables are effectively eliminated which results in high internal validity. Further, controlled laboratory experiments are more powerful in identifying a directional effect of one variable on another compared to correlational, or descriptive research designs.

Reflecting on the methods, both the BART and the scale used to measure resource scarcity in early childhood, following Griskevicius et al. (2011), showed adequate test-retest reliability. The BART is considered a valid measurement tool to assess risk-taking behaviour due to its high ecological validity.

The VR scenes used in this study were specifically devised for the purpose of this study, which allowed researchers to directly influence the expression of harshness of the environment through different cues, ensuring high quality of the manipulation. This seemed to have borne fruits as reflected in the predominant success of the manipulation. Post-hoc analyses of the effectivity of manipulation employing VR scenes were exclusively significant. Thus, participants felt safer and more relaxed in the LHC than in the HHC. On the other hand, participants felt more stressed, perceived the neighbourhood as more dangerous, and felt a higher need to protect themselves from potential dangers in the HHC than in the LHC. Finally, residents from the LHC were considered more trustworthy than residents of HHC (Table 2). In sum, the attempted manipulation can be interpreted as successful. Differences in levels of harshness are therefore effectively reflected in the two neighbourhood scenes implemented in VR.

Further, this study was the first to obtain real time measures of risk-taking while manipulating the environment in which the measure was obtained. Other than in Griskevicius et al. (2011), no time passed between manipulation of the IV and measurement of the DV, which undoubtedly is a methodical improvement. This was possible by adopting VR as a research method. Exposing participants to real word harsh environments would be both practically difficult to realise and ethically questionable. Using VR can circumvent this issue, as VR has the ability to evoke responses similar to a comparable real-world setting (van Gelder et al., 2017).

Recommendations for Future Research

To close the circle, directions for future research are proposed. Consequences of risk-taking can be detrimental. Both the individual and society at large can be affected negatively by, e.g., speeding, trespassing, and engaging in unprotected sex. Therefore, it is of utmost importance to carefully examine risk-taking behaviour in subsequent studies. Results of the present study are not in line with all of the reviewed literature. Several suggestions for an improved study design become apparent when considering limitations of the present study. Thus, it is recommended to replicate the present study with a more diverse sample and an equal allocation of participants to conditions. This would adequately address the shortcomings of the predominantly WEIRD nature of the present study's sample. Moreover, the time of exposure needs to be equalised across conditions by putting increased emphasis on the length of respective tours in both conditions and controlling for possible side effects of the manipulation that could make participants want to rush to leave the condition early.

For a more informed perspective on the effect of socio-environmental cues of harshness on risk-taking, level of relaxation should be considered in future studies. When looking at the average level of reported relaxation (Table 2), one can detect relatively high levels of relaxation in the LHC compared to the HHC. However, the manipulation intended to evoke relatively low levels of relaxation in the HHC and not predominantly high levels of relaxation in the LHC. In a study by Schmidt et al. (2013), participants with a low resting heart rate tended to assess gambling options as less risky than participants with a higher heart rate. Moreover, low heart rate participants behaved less risky after physical exercise, which increased heart rate. Therefore, the LHC could have affected risk-taking by evoking unexpectedly high rates of relaxation and thus low heart rates. Consequently, participants in the LHC might have evaluated the risk of committing successive pumps as lower and committed more pumps as a result. Thus, the degree to which VR scenes evoke states of nonessential relaxation should be addressed in future studies. Cardiologic measures of participants could be obtained using an electrocardiogram during exposure to VR scenes to investigate this notion in greater detail.

Conclusion

Without a doubt, it can be concluded that the effect of socio-environmental cues of harshness on risk-taking behaviour remains uncertain. Despite limitations, results of the present study and their implications cannot be disregarded; both hypotheses had to be rejected. This study was the first to study risk-taking behaviour by obtaining measures of the BART during immersion in VR scenes that manipulate level of socio-environmental harshness. Hence, this study lays the groundwork for future research through its innovative study design within evolutionary-developmental psychology, which motivates future replication of the present study.

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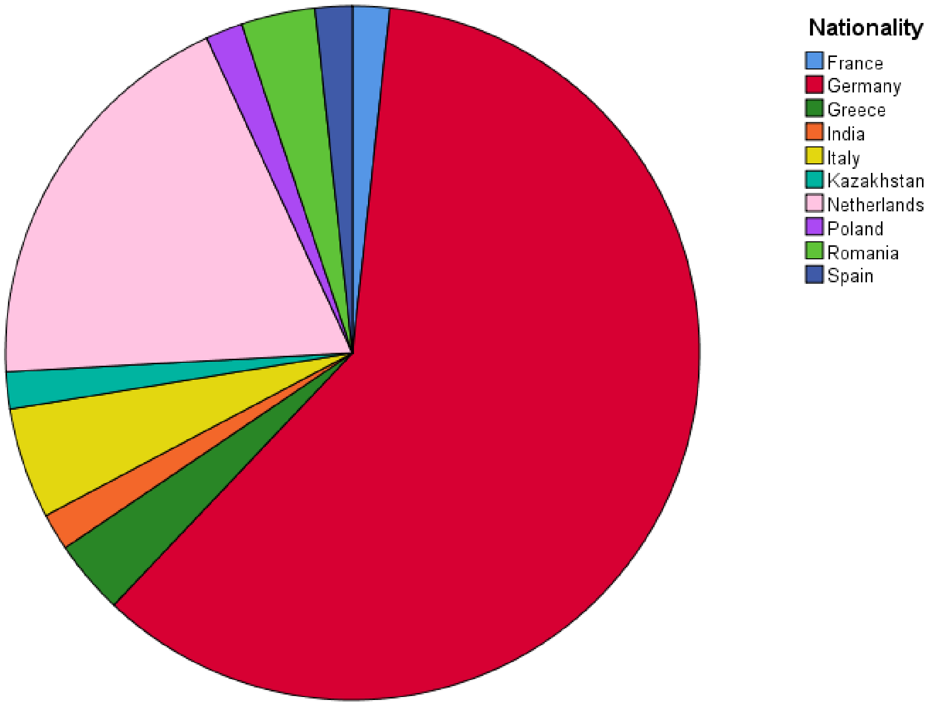
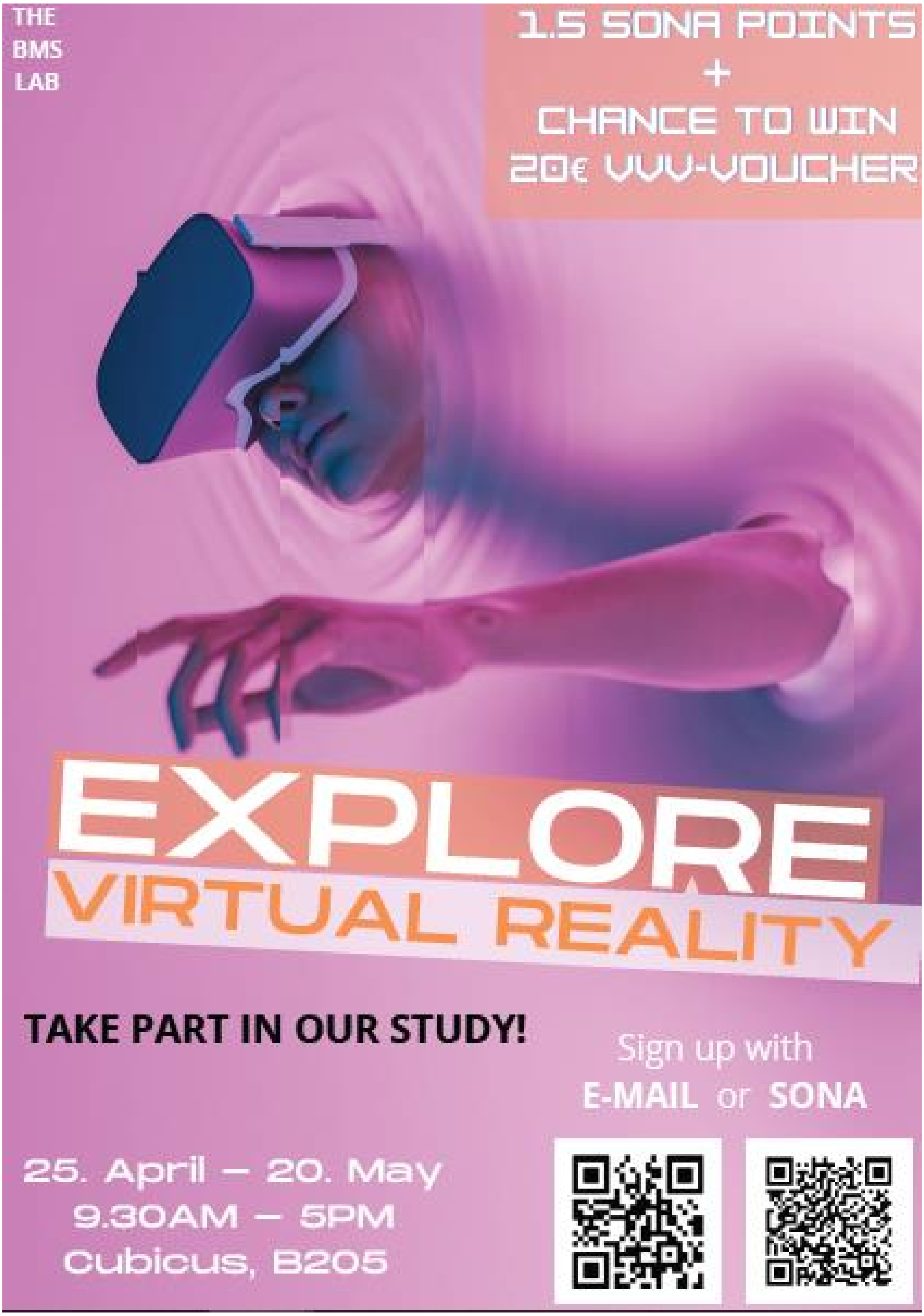
Appendix A.

Pie Chart of Nationality of Sample



Appendix B.

Recruitment Poster



Appendix C.

Pre-VR Questionnaire

Welcome **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.

Gender

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

With which gender do you identify most?

- ◯ Male (1)
- ◯ Female (2)
- ◯ Diverse (3)
- ◯ Transgender (4)
- ◯ Non-binary (5)
- ◯ Other (6) ____
- ◯ Prefer not to say (7)

Education What is the highest educational level you have achieved?

- ◯ Elementary school (1)
- ◯ High school (2)
- ◯ College/University - Undergraduate degree (e.g. Bachelor of Science, Bachelor of Arts or equivalent) (3)

◯ College/University - Graduate degree (e.g. Master of Science/Arts or equivalent) (4)

◯ Doctoral degree/PhD (5)

◯ Other (6) ____

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

____

Nationality What is your nationality?

▼ Afghanistan (1) ... Zambia (283)

ChildhCountry 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.

▼ Afghanistan (1) ... Zambia (283)

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

◯ Yes (5)

◯ No (6)

SONA ID If yes, please fill in your SONA ID:

____

Please mute your phone for the duration of your session. This is important to avoid any distraction. Thank you!

○ Ok, I've muted my phone. (1)

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. (1)

○ NO (you will be directed to the end of the study) (2)

Appendix D.

Instructions: BART

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 labeled "Total Earned." The amount you earned on the previous balloon is labeled "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.

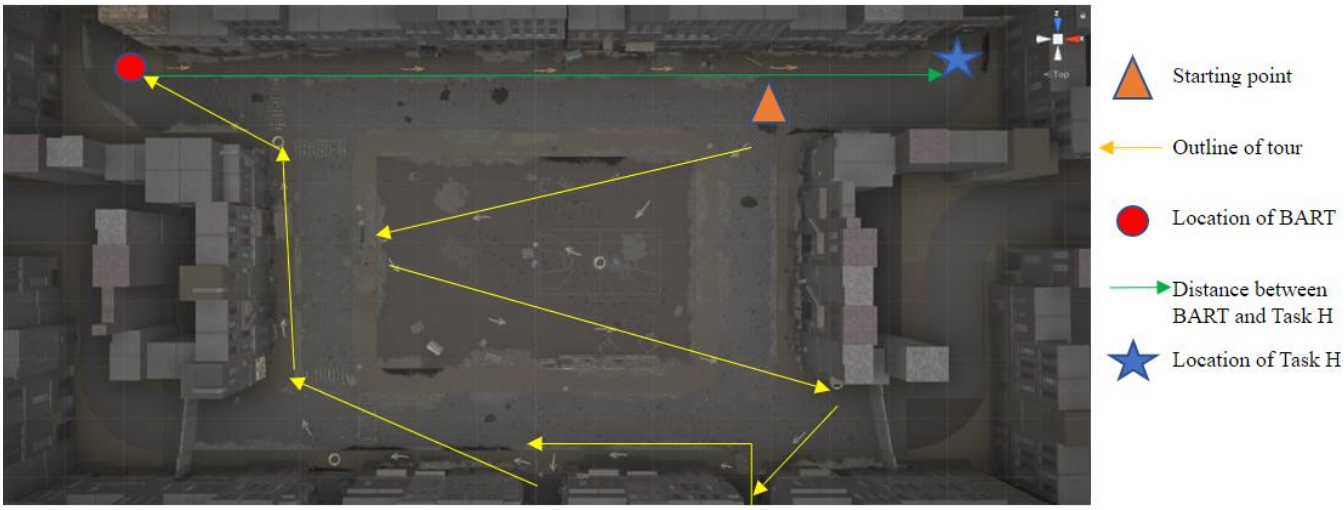
Press the red button to continue.
Exploded balloons do not affect the points accumulated in your permanent bank. The participants with the most amount of points will each win a voucher! Press the red button to continue.

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 E.
Layout of High Harshness Condition

Annotated bird's eye view of the High Harshness Condition



Note. The location of BART and Task H was switched after gathering 30 responses

Appendix F.

Layout of Low Harshness Condition

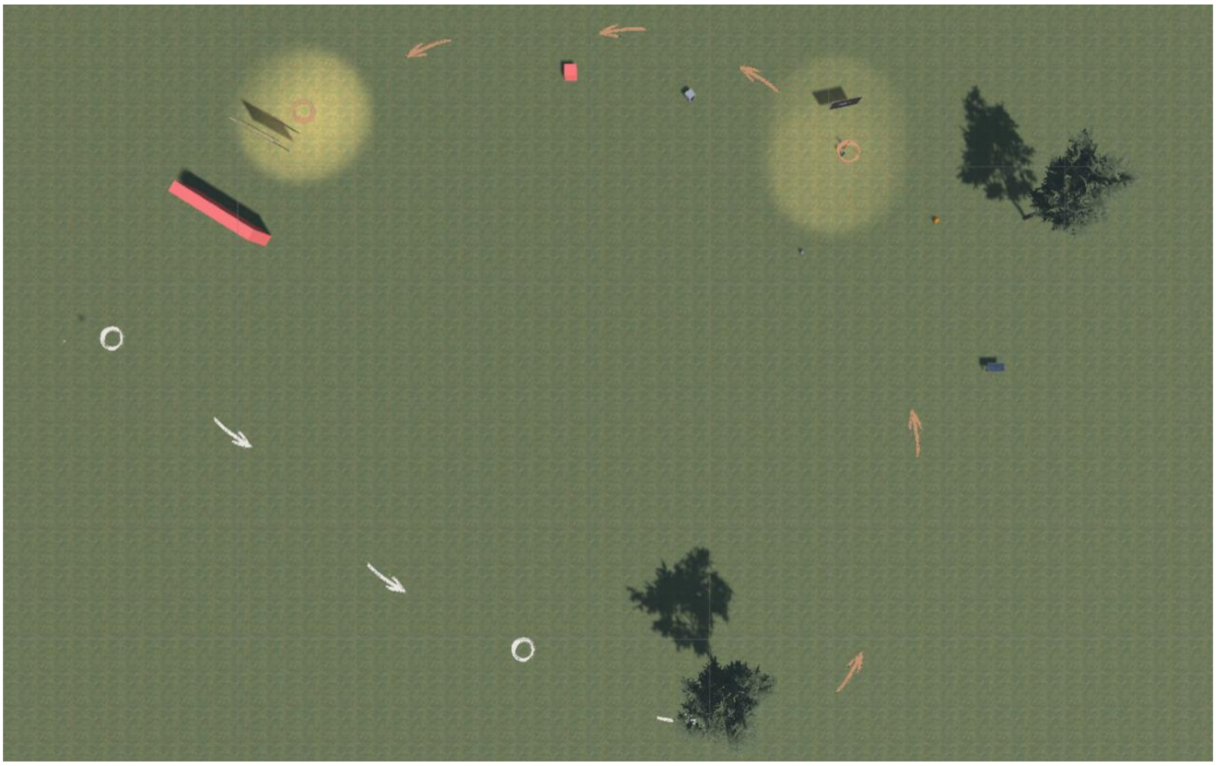
Annotated bird's eye view of the Low Harshness Condition

Note. The location of BART and Task H was switched after gathering 30 responses

Appendix G.
Layout of Practice Scene

Figure G1

Bird's eye view of the Practice Scene



Note. Participants started in the most left circle and stopped in the second most left circle. The BART-practice and Task H-practice are located in the illuminated spots

Figure G2

First-person view of the Practice Scene showing the BART-practice

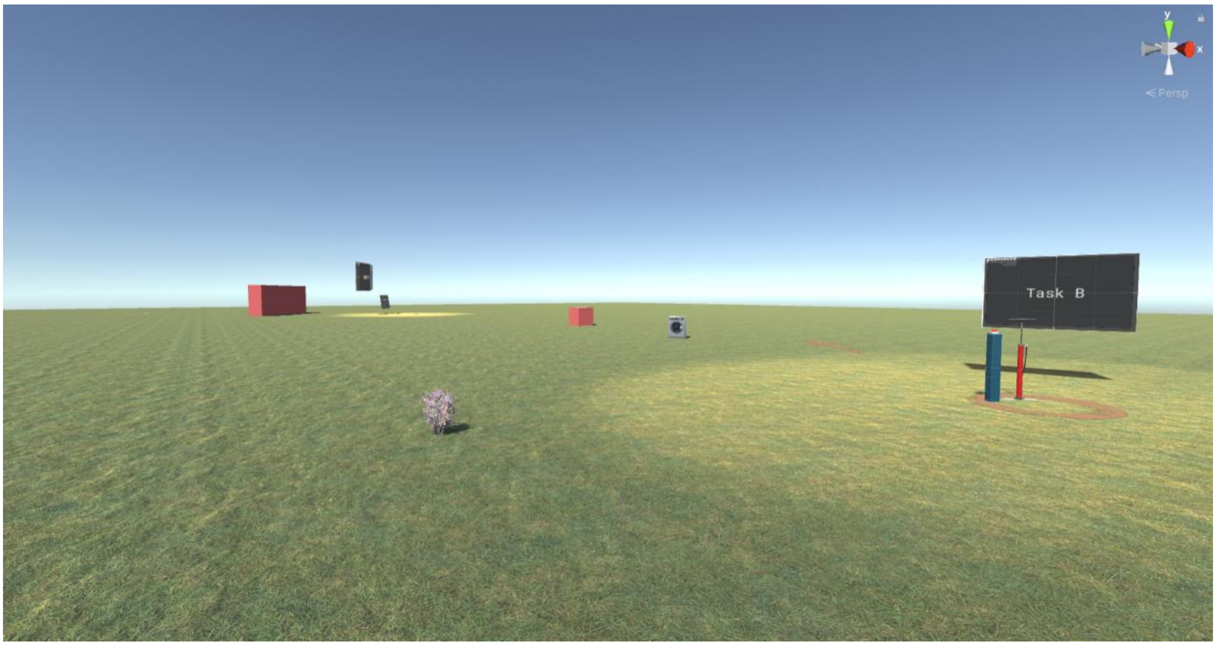
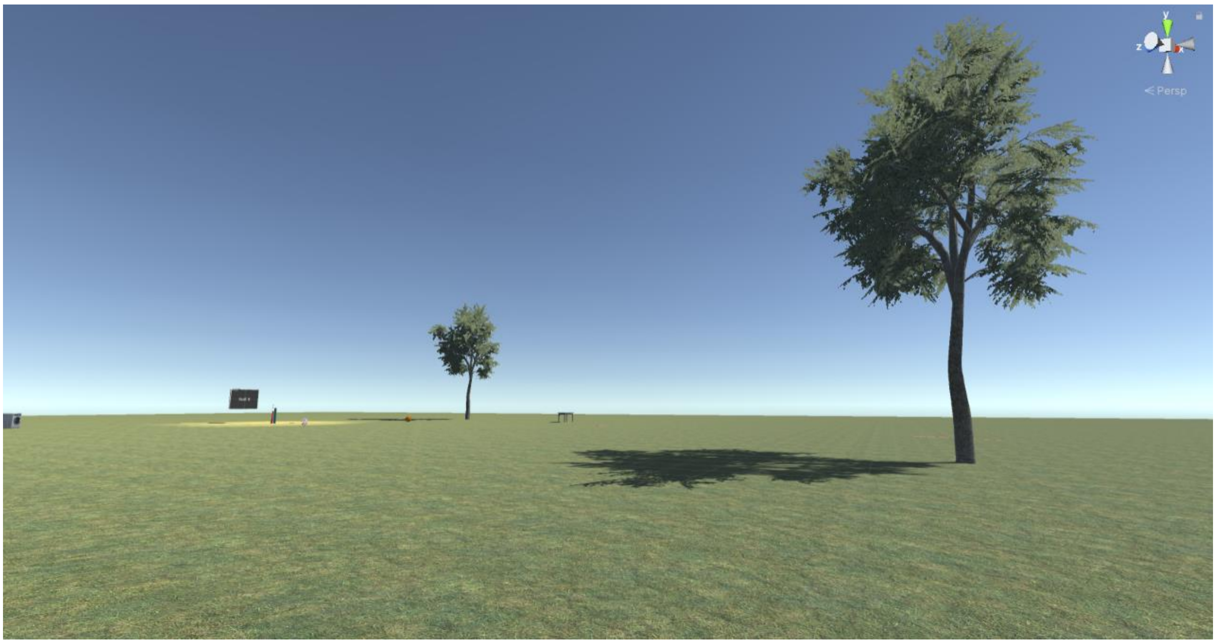


Figure G3

First person view of the Practice Scene



Appendix H.
Instructions: BART-practice

Welcome to Task B practice! In this practice, you will be presented with 3 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 labeled "Total Earned." The amount you earned on the previous balloon is labeled "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 very big. If the balloon explodes before you press the red button then you move on to the next balloon and all points in your temporary bank are lost. Exploded balloons do not affect the points accumulated in your permanent bank. The participants with the most amount of points will each win a voucher! Press the red button to continue.

The next three balloons are practice trials to get the hang of it. The points you win or loose during the practice don't count regarding your chance to win a voucher. Press the red button to continue.

Use one hand to interact with the pump by pushing down the handle. Try to make one of the three balloons explode to see what it will look like. Press the red button to start practicing.
You have finished Task B practice. Press the red button to leave this task area. Follow the orange arrows to the next task!

Appendix I.

Post-VR Questionnaire

Post VR 2022

Start of Block: ID & condition

Q155
Researcher: Fill in participant ID

Double check ID!

____

Q156 Condition

◯ D (1)

◯ N (2)

welcome Welcome back to the final part of your session.

In the next couple of questions, we'd like to ask you how you experienced Virtual Reality. We are interested in your subjective experience, there are no right or wrong answers.

nausea 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 ()	

beingthere-check
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"... ()	

safe_check
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... ()	

stressed_check
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... ()											

self-protection_chec
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... ()											

relaxed
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... ()	

dangerous
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? ()											

Q148
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? ()											

VR_attention 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. (4) ____

○ 2. (5) ____

○ 3. (6) ____

prob_vide_control 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 (1)

○ Minor issues but they didn't distract or confuse me (2)

○ Some issues that were moderately distracting/confusing (9)

○ Major issues that were very distracting/confusing (11)

Display This Question:

If Did you experience any technical issues while being in the virtual neighbourhood? For example, gr... = Minor issues but they didn't distract or confuse me

And Did you experience any technical issues while being in the virtual neighbourhood? For example, gr... = Some issues that were moderately distracting/confusing

And Did you experience any technical issues while being in the virtual neighbourhood? For example, gr... = Major issues that were very distracting/confusing

issues_text_entry We're sorry you experienced technical issues. Please briefly describe them below to help us improve the design.

____

____

____

____

____

ChildhInfo The following questions focus on **your perspective and subjective perceptions**. Please do not think too long over each question and choose the response that you feel fits best.

Please think back to the family environment and living situation in your childhood family, from **when you were born to when you were about 5 years old** to answer these questions.
We are aware that you might only remember things vaguely or that you might have been told stories about things that happenend when you were small. Please answer to the best of your knowledge and ability.

Perceived env.unpred Please indicate your response to the following statements on a scale of **1** to **10**,
where **1** represents **never** and **10** represents **always**.

In case you didn't live with your parents, please answer the questions in relation to your primary caregivers (e.g. grandparents, aunts/uncles, foster parents, etc.).

Until I was about 5 years old...

	Never 1 (18)	2 (19)	3 (20)	4 (21)	5 (22)	6 (23)	7 (24)	8 (25)	9 (26)	**Always** 10 (27)
There were changes in my mother's or father's employment status (e.g. transitioning from being employed to being unemployed) (11)	○	○	○	○	○	○	○	○	○	○
There were changes in residence (for example, moving to a different house or town) (12)	○	○	○	○	○	○	○	○	○	○
A genetically unrelated male moved in or out of the house (13)	○	○	○	○	○	○	○	○	○	○

resource available Please indicate how much you **agree or disagree** with the following statements on a scale of 1 to 10, where **1** represents **strongly disagree** and **10** represents **strongly agree.**

Until I was about 5 years old...

	Strongly disagree 1 (11)	2 (12)	3 (13)	4 (14)	5 (15)	6 (16)	7 (17)	8 (18)	9 (19)	**Strongly agree** 10 (20)
My family usually had enough money for things (4)	○	○	○	○	○	○	○	○	○	○
I grew up in a relatively wealthy neighbourhood (5)	○	○	○	○	○	○	○	○	○	○
I felt relatively well-off compared to other children in my nursery, kindergarden or school (6)	○	○	○	○	○	○	○	○	○	○

NbhSafe Please indicate your response to the following statements on a scale of **1** to **10**, where **1** represents **never** and **10** represents **always**.

Until I was about 5 years old...

	Never 1 (18)	2 (19)	3 (20)	4 (21)	5 (22)	6 (23)	7 (24)	8 (25)	9 (26)	**Always** 10 (27)
I generally felt safe in my neighbourhood (including at home, day-care facilities, playgrounds, etc.) (14)	○	○	○	○	○	○	○	○	○	○
The buildings, streets and facilities in my environment were run-down or in bad condition (15)	○	○	○	○	○	○	○	○	○	○
People around me enjoyed living or spending time in my neighbourhood (16)	○	○	○	○	○	○	○	○	○	○

ExtMortInfo **For the following questions, please think back to people that you were surrounded with and who were <u>important or in some way relevant to you and your family (or caregivers)</u> when you were growing up (for example close and extended family, neighbours, friends, teachers, etc.).**

ExtMort
Keep the people referred to above in mind when answering the following questions.

Please indicate your response to the following statements on a scale of **1** to **10**, where **1** represents **never** and **10** represents **always**.

Until I was about 5 years old...

	Never 1 (92)	2 (93)	3 (94)	4 (95)	5 (96)	6 (97)	7 (98)	8 (99)	9 (100)	**Always** 10 (101)
People in my environment died (1)	○	○	○	○	○	○	○	○	○	○
People in my environment were sick or suffered from serious illness (3)	○	○	○	○	○	○	○	○	○	○
People in my environment had physical disabilities or injuries (4)	○	○	○	○	○	○	○	○	○	○

ParInv1
Please indicate your response to the following statements on a scale of **1** to **10**, where **1** represents **never** and **10** represents **always**.

In case you didn't live with your parents, please answer the questions in relation to your primary caregivers (e.g. grandparents, aunts/uncles, foster parents, etc.).

Until I was about 5 years old...

	Never 1 (11)	2 (12)	3 (13)	4 (14)	5 (15)	6 (16)	7 (17)	8 (18)	9 (19)	**Always** 10 (20)
My parents/caregivers were responsive to my emotional and physical needs (13)	o	o	o	o	o	o	o	o	o	o
My parents/caregivers spent high quality time with me (for example: playing together, reading from a book, etc.) (14)	o	o	o	o	o	o	o	o	o	o
My parents/caregivers were stressed or annoyed when interacting with me (15)	o	o	o	o	o	o	o	o	o	o
I was afraid of my parents/caregivers (16)	o	o	o	o	o	o	o	o	o	o

ParInv2
Please indicate your response to the following statements on a scale of **1** to **10**,
where **1** represents **never** and **10** represents **always**.

In case you didn't live with your mother and/or father, please answer the questions in relation to

your primary caregivers (e.g. foster parents, a grandmother, uncle, etc.).
Until I was about 5 years old...

	Never 1 (11)	2 (12)	3 (13)	4 (14)	5 (15)	6 (16)	7 (17)	8 (18)	9 (19)	**Always** 10 (20)
Overall, I had a good relationship with my mother/female caregiver (1)	o	o	o	o	o	o	o	o	o	o
Overall, I had a good relationship with my father/male caregiver (3)	o	o	o	o	o	o	o	o	o	o

ExpViol Please indicate your response to the following statements on a scale of **1** to **10**, where **1** represents **never** and **10** represents **always**.

Until I was about 5 years old...

	Never 1 (11)	2 (12)	3 (13)	4 (14)	5 (15)	6 (16)	7 (17)	8 (18)	9 (19)	**Always** 10 (20)
I was exposed to physical violence in my environment (1)	o	o	o	o	o	o	o	o	o	o
I was exposed to verbal aggression in my environment (2)	o	o	o	o	o	o	o	o	o	o

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naivity 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 (4)
- Yes, I have an assumption (5)

Display This Question:

If When people participate in research, they might have their own associations, ideas or suspicions... = Yes, I have an assumption

naivity_freetext Please briefly describe your assumptions below.

____

____

____

____

____

email Please fill in your email address below.

We will use your email address only for the following purposes:

- To contact you in case you win one of the five 20 Eur VVV-vouchers
- For non-SONA participants, to send you your 5 Eur VVV-voucher

- To send you your identifier code which you need in case you'd like to withdraw from the study
- To send you a copy of the debriefing information

____

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identifier
This is your random identifier code which will be send to you via email. In case you decide that you would like us to delete your data, we need to be able to distinguish your response from those of other participants. For this purpose, a random code is generated and linked to your response. If you'd like us to delete your data, you can contact us via email and provide the code.

END 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.
As some of the questions are of sensitive nature regarding childhood experiences, the following resources might be useful for those seeking information or support. If you are feeling stressed at the moment, try this brief meditation:
https://www.youtube.com/watch?v=sG7DBA-mgFY
Netherlands /Belgium:

https://www.deluisterlijn.nl/https://www.tele-onthaal.be/https://www.rijksoverheid.nl/onderwerpen/geestelijke-gezondheidszorg/vraag-en-antwoord/waar-vind-ik-hulp-bij-psychische-problemen Germanyhttps://www.telefonseelsorge.dehttps://www.stiftung-gesundheitswissen.de/gesundes-leben/psyche-wohlbefinden/hilfe-bei-psychischen-problemen-diese-stellen-koennen-sie-sich UK
https://www.samaritans.orghttps://www.mind.org.uk Should you have any questions about this study, please feel free to contact the researchers.

vr-study-bms@utwente.nl
Jeanette Hadaschik, MSc

j.hadaschik@utwente.nl

You will receive a copy of this information via email.

Appendix J.
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]

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 cybersickness. 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.

[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.]

<u>The light ray might look a bit different in the virtual neighbourhood but it will work the same way.</u>

…

[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"

"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]

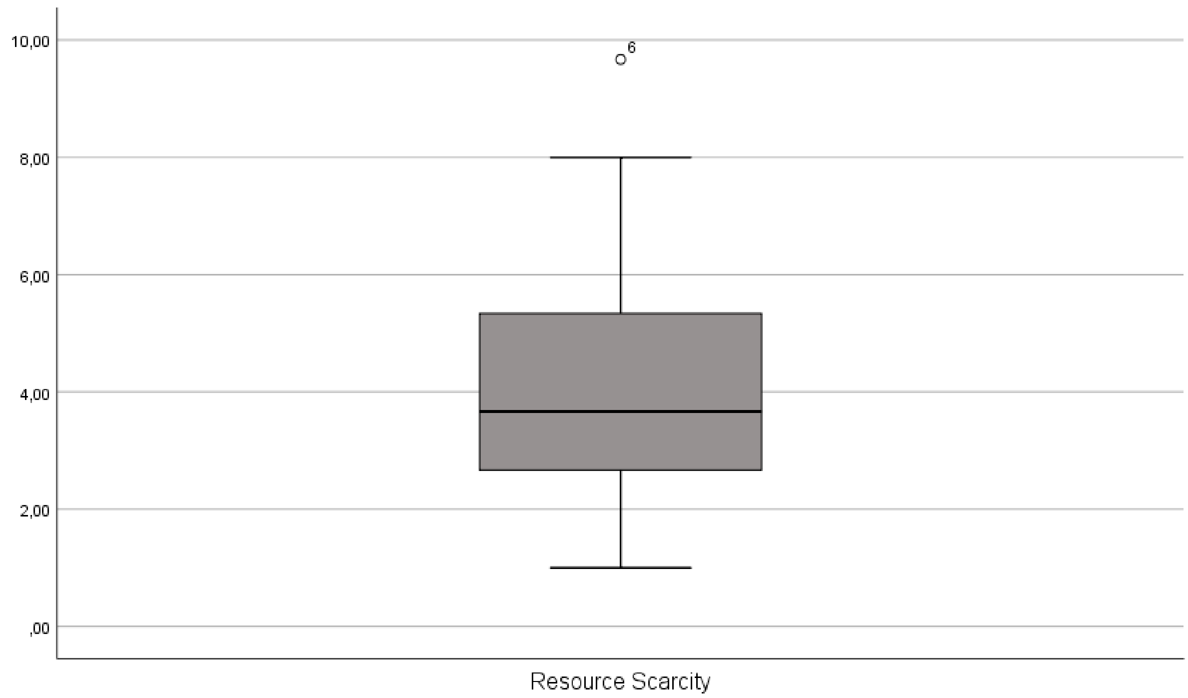
[ask them if they feel ok and if they have any questions; offer sweets]

[approve SONA credits]

Appendix K.

Boxplot of Distribution of Covariate: Childhood Resource Scarcity

Boxplot displaying the distribution of scores on Childhood Resource Scarcity (n=51)



Appendix L.

Testing Statistical Assumptions

Figure L1

Histogram of frequency of distribution of unstandardised residuals of the fit between the multiple linear regression model and the data (n=51)

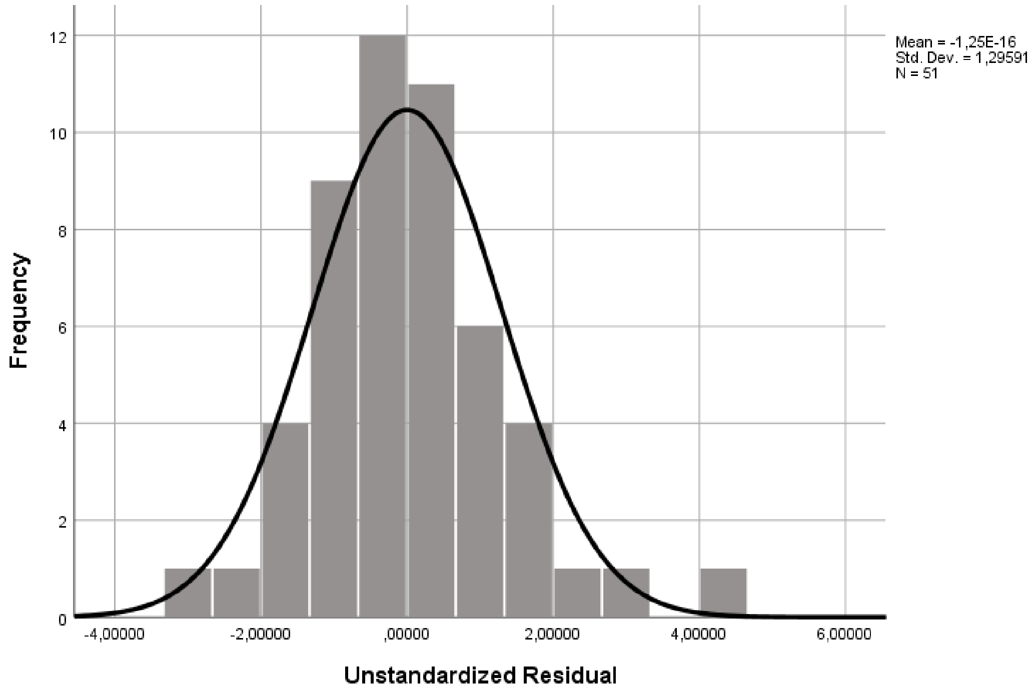


Figure L2

Scatterplot plotting unstandardised residuals of the fit between the data and the multiple linear regression model against unstandardised predicted values by the multiple linear regression model, by condition of harshness(n=51)

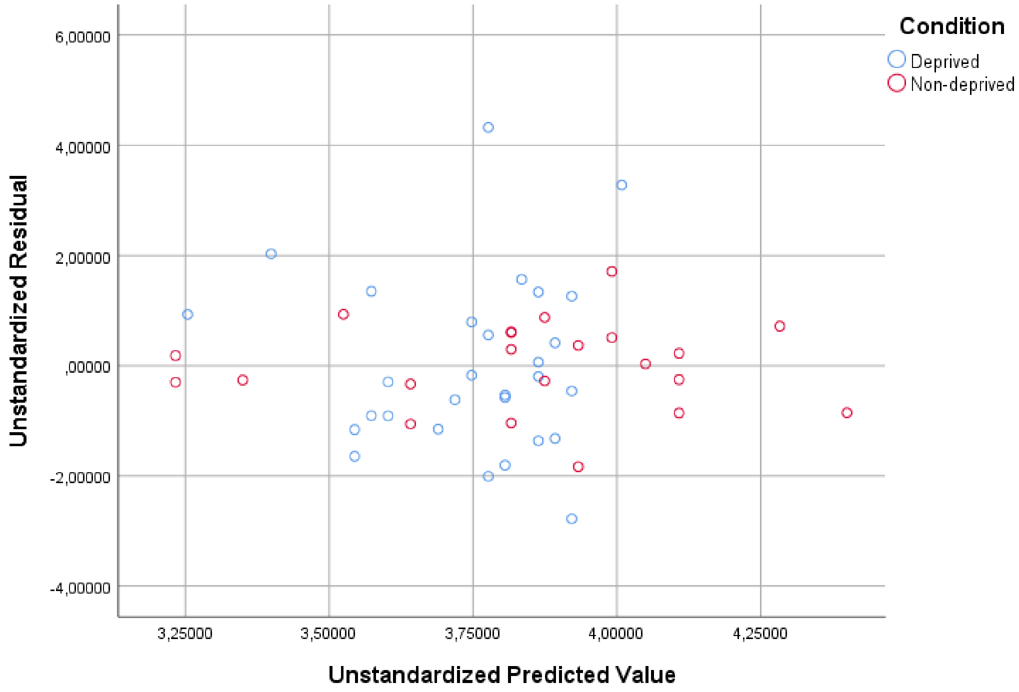


Figure L3

Scatterplot displaying "mean pumps adjusted for explosion" (mean pumps) against "Resource Scarcity" with regression lines grouped by Harshness (n=51)