VR-based Balloon Analogue Risk Task (VR-BART) Experimental Tool

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1 Background and Introduction

1.1 Balloon Analogue Risk Task (BART)

The Balloon Analogue Risk Task (BART) is an experimental task designed to measure risk-taking behavior of individuals. It was introduced by the psychologists (Lejuez et al., 2002) and has been used in many studies investigating the psychological and behavioral mechanisms underlying risk-taking behavior.

In a traditional computerized BART experiment, the participants are shown with a virtual balloon that they can inflate by pressing a button. Each inflation of the balloon brings the participant some amount of money as the experiment payoff. But there is also a chance that the balloon will explode in an inflation, resulting in the loss of all accumulated money. Figure 1 is a screenshot of a traditional computerized BART experiment. All figures are in the appendix.

The participants' behavior is recorded and analyzed by the experimenter. Measures such as the number of inflations before the balloon explosion and the average amount of money earned per trial are used to measure the participant's risk-taking behaviors.

1.2 Risk attitudes and measurements

People's risk attitude or risk preference is a fundamental concept in psychology and economics that refers to an individual's willingness to take risks in decisions.

One of the most influential theories in risk is the Prospect Theory proposed by Kahneman and Tversky (1979). People's choices are influenced not only by objective probabilities and outcomes but also by subjective perceptions of these factors. The theory suggests that people are risk-averse when it comes to gains. Conversely, people are risk-seeking when it refers to losses.

Risk measurement is a crucial aspect of risk researches. In finance, risk measurement enables investors to quantify potential losses and make better decisions. One of the widely used methods of risk measurement is Value at Risk (VaR), which estimates the maximum potential loss that could happen. A popular pen-paper-based multiple-price list design of risk preference elicitation was proposed by Holt and Laury (2002).

1.3 Related work in VR

Many papers propose the use of virtual reality (VR) as a tool to study risk-taking behavior by creating immersive environments that create hazardous situations and use objective assessment methods to obtain accurate measures (De-Juan-Ripoll et al., 2018).

De-Juan-Ripoll et al. (2021) designed a tool for measuring risk-taking behavior through VR to discriminate between individuals with high and low scores in personality traits such as sensation seeking and impulsivity. Singh et al. (2012) found that VR balance games (VRBG) can effectively decrease risk and fear of falls among women. De-Juan-Ripoll et al. (2020) proposed that Spheres and Shield Maze Task (SSMT) can assess risk taking in decision making and provide more accurate results compared to self-report questionnaires. Frankenhuis et al. (2010) found that male physical risk-taking behavior is influenced by the gender of the virtual observer in a VR environment. Males crossed a virtual bridge faster in the presence of a female virtual observer.

1.4 Objective and overview

The objective of this project is to develop a VR-based Balloon Analogue Risk Task (VR-BART) experimental tool that can accurately assess risk-taking behavior of individuals. The VR-BART will be designed to simulate real-life decision-making situations involving risk and provide an immersive environment for the participants.

The tool will be developed using the Unreal Engine 5 (UE5), a powerful game engine that provides high-quality graphics and physics. The VR-BART task will be designed to work with popular VR devices such as the Oculus Quest 2, allowing the participants to interact with the virtual environment in a natural way.

2 VR-BART Manual

2.1 Purpose of use

The VR-BART experimental tool can be used in psychological research to study risk-taking behaviors. The purpose of using VR-BART is to assess an individual's willingness to take risks and their decision-making behaviors in response to increasing risks. The task is designed to simulate a real-life decision-making situation that involve risk which is inflating a fragile balloon. The VR environment makes the decision-making situations more immersive and natural.

In addition, physiological measures such as heart rate and skin conductance may be recorded to investigate the underlying neural and physiological processes involved in risky decision-making.

2.2 User groups

The VR-BART experimental tool can be used by psychologists and behavioral economists in classrooms and laboratories. In particular, there is one experimental "participant" who is being investigated by the study. Another "experimenter" can help setup the experiment parameters including the payoff function and explosion probability for the participant to collect experimental data under different experimental settings.

2.3 Experimental process

In a VR-BART experiment, the participant is placed in virtual simulation with a red balloon. Standing in the pumping position (i.e., triggerbox in UE5), the participant can pump up the balloon by pressing "E" on the PC keyboard (or the linked button of VR headset). Each successful pump can accumulate money rewards as payoffs. The larger the balloon is, the more money rewards he will get once he chooses to stop pumping.

However, the balloon may explode at any given attempt of pumping, resulting in a loss of all accumulated money. Specifically, after each pump, the probability that the balloon will explode at this pump is increasing as follows: (1) without any pump, the balloon has 0% probability of explosion; (2) at the first pump, the balloon has 10% probability of explosion; (3) at the second pump, the balloon has 20% probability of explosion; (4) at third pump, the balloon has 33% probability of explosion; (5) at fourth pump, the balloon has 50% probability of explosion; and (6) the balloon will definitely explode at the fifth pump.

Participants must decide how many times they will pump the balloon, balancing the potential for additional rewards with the risk of the balloon exploding. For each participant, the experiment can be conducted for multiple trials for the participant to learn about the payoff function and balloon explosion risk. Figure 2 shows VR-BART overview in "Play In Editor" mode, and Figure **??** VR-BART end screen (with a next trial option).

2.4 Manipulable parameters

The experimenter can manipulate different factors in the experiment setting to study how they affect risk-taking behaviors. Various factors, such as (1) the rate of increase in the potential rewards (the payoff function), (2) the number of times the balloon can be pumped before explosion, can be adjusted to study different aspects of risk-taking.

Additional factors that can be manipulated include (3) whether the participant knows the explosion probability in advance (or he needs to learn from historical trials by himself), and (4) whether a virtual observer exists in the scene and the identity of the virtual observer, etc.

2.5 Data and analysis

The experiment provides researchers with quantitative data that reflects the participant's risk attitude. The experimenter can record the number of times each participant pumps the balloon, and how much he earns or loses from each balloon from the outcome text printed on the screen. The results usually indicate the individual's propensity for risk-taking and how various factors impact decision-making behaviors.

References

De-Juan-Ripoll, C., Llanes-Jurado, J., Giglioli, I. A. C., Marín-Morales, J., and Alcañiz, M. (2021). An immersive virtual reality game for predicting risk taking through the use of implicit measures. *Applied Sciences*, 11(2):825.

De-Juan-Ripoll, C., Soler-Domínguez, J. L., Chicchi Giglioli, I. A., Contero, M., and Alcaniz, M. (2020). The spheres & shield maze task: a virtual reality serious game for the assessment of risk taking in decision making. *Cyberpsychology, Behavior, and Social Networking*, 23(11):773–781.

De-Juan-Ripoll, C., Soler-Domínguez, J. L., Guixeres, J., Contero, M., Álvarez Gutiérrez, N., and Alcañiz, M. (2018). Virtual reality as a new approach for risk taking assessment. *Frontiers in Psychology*, 9:2532.

Frankenhuis, W. E., Dotsch, R., Karremans, J. C., and Wigboldus, D. H. (2010). Male physical risk taking in a virtual environment. *Journal of Evolutionary Psychology*, 8(1):75–86.

Holt, C. A. and Laury, S. K. (2002). Risk aversion and incentive effects. *American Economic Review*, 92(5):1644–1655.

Kahneman, D. and Tversky, A. (1979). Prospect theory: An analysis of decision under risk. *Econometrica*, 47(2):363–391.

Lejuez, C. W., Read, J. P., Kahler, C. W., Richards, J. B., Ramsey, S. E., Stuart, G. L., Strong, D. R., and Brown, R. A. (2002). Evaluation of a behavioral measure of risk taking: the balloon analogue risk task (bart). *Journal of Experimental Psychology: Applied*, 8(2):75.

Singh, D. K., Rajaratnam, B. S., Palaniswamy, V., Pearson, H., Raman, V. P., and Bong, P. S. (2012). Participating in a virtual reality balance exercise program can reduce risk and fear of falls. *Maturitas*, 73(3):239–243.

3 Appendix of Figures

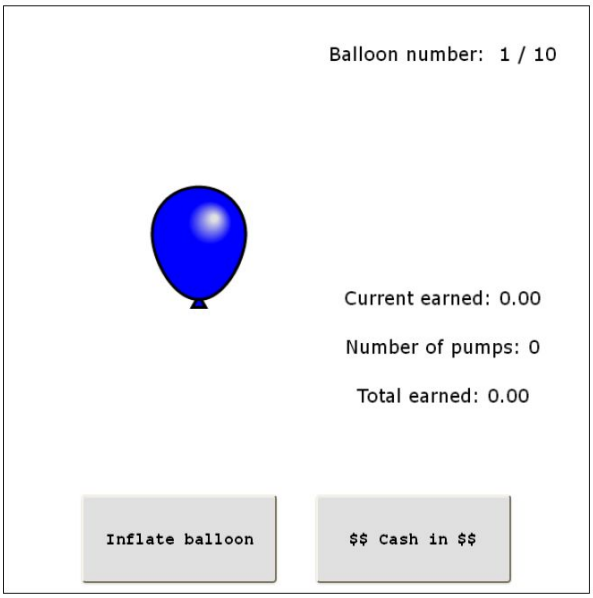

Figure 1: Traditional computerized BART experiment.

Figure 2: VR-BART overview in UE5 “Play In Editor” mode.

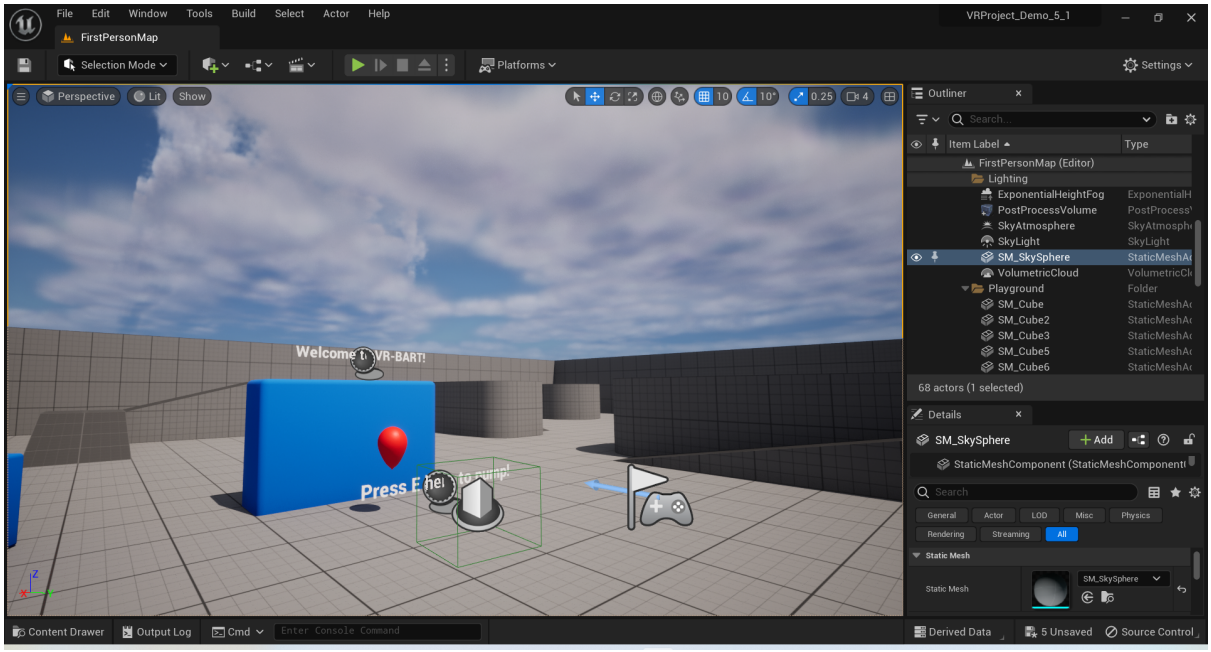

Figure 3: VR-BART overview in UE5 “Editor” mode.

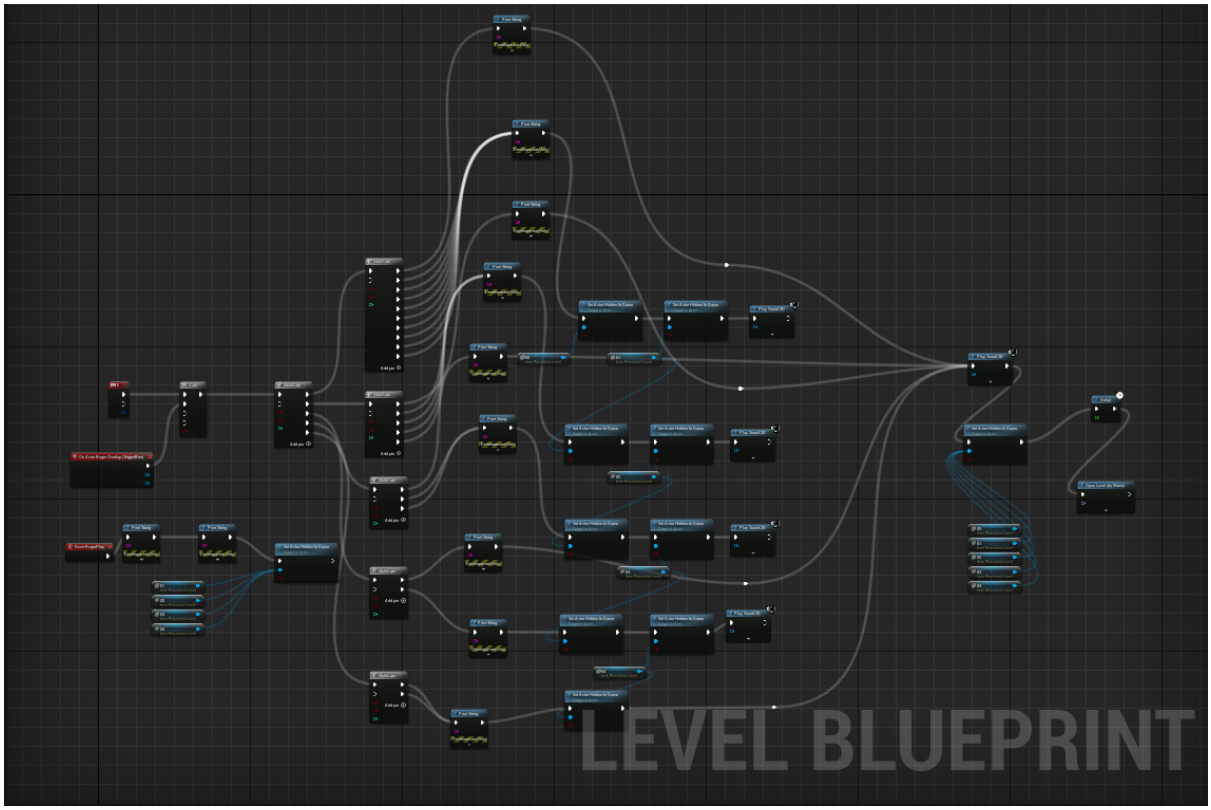

Figure 4: VR-BART UE5 level Blueprint overview.

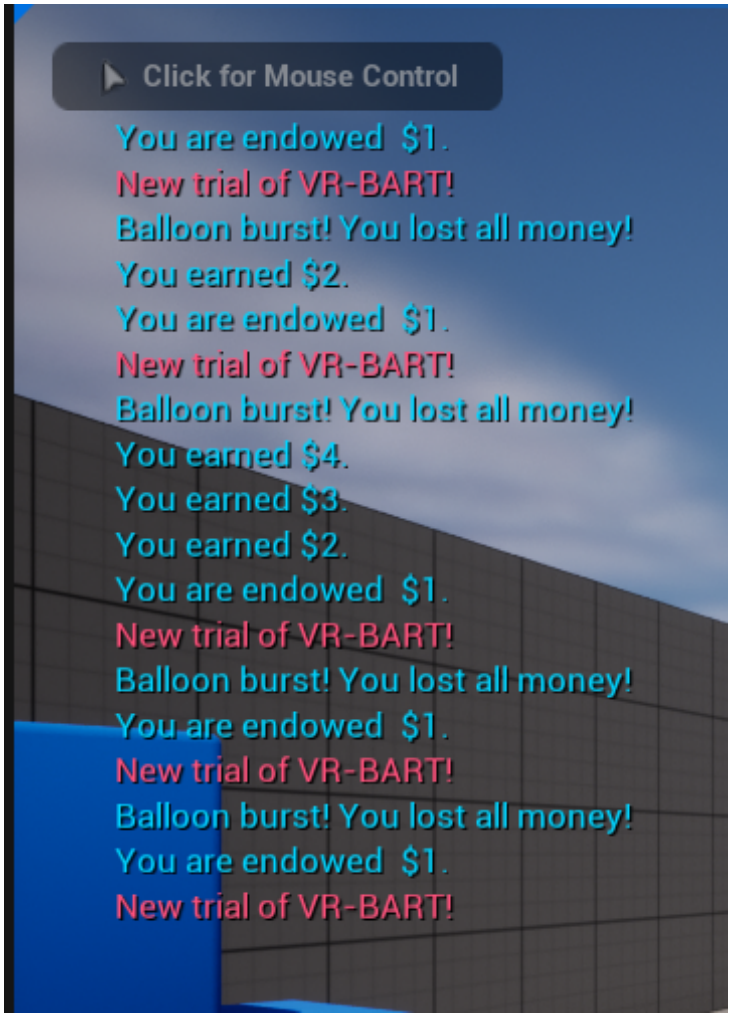

Figure 5: Outcome text printed on screen in trials.