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Measuring the Effects of Virtual Environment Design on Decision-Making

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Figure 1: Comparison of our three IGT versions. Left: IGT played on desktop in the laboratory. Center: IGT played in the virtual laboratory. Right: IGT played in the virtual forest.

Abstract

Recent research indicates an impairment in decision-making in immersive Virtual Reality (VR) when completing the Iowa Gambling Task (IGT). There is a high potential for emotions to explain the IGT decision-making behavior. The design of a virtual environment (VE) can influence a user's mood and hence potentially the decision-making. In a novel user study, we measure decision-making using three virtual versions of the IGT. The versions differ with regard to the degree of immersion and design of the VE. Our results revealed no significant impact of the VE on the IGT and hence on decision-making.

Index Terms: Human-centered computing—Human computer interaction (HCI)—HCI design and evaluation methods; Human-centered computing—Human computer interaction (HCI)—Empirical studies in HCI; Human-centered computing—Interaction paradigms—Virtual Reality;

1 Introduction

Real-life decision-making situations are complex. People are obliged to deal with uncertainties in the context of punishment and reward [4]. This also applies to artificial situations, such as training [9] and gaming [12] in Virtual Reality (VR). Research demonstrates an impairment in decision-making when completing the *Iowa Gambling Task* (*IGT*) in immersive VR [11]. The IGT is an experimental paradigm for measuring *real-life* decision-making in a laboratory environment [3].

Decision-making and hence the IGT behavior can be influenced by emotions [2]. Just as the surrounding environment influences a person's mood, the design of a virtual environment (VE) might have a similar effect. Therefore, it is critical to further investigate the impairment in decision-making in immersive VR. The IGT should be integrated in VEs that differ with respect to their emotional design.

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2 Theoretical Background

Research has measured and analyzed decision-making using the IGT [3, 4] for more than 20 years. Research administered the IGT to investigate the underestimated effect of emotions on decision-making [2]. The *Somatic Marker Hypothesis* [2] has a high potential to explain this emotionally-influenced IGT decision-making behavior [4]. The task simulates real-life decision-making, featuring uncertainties with respect to assumptions and outcomes. During the task, participants draw 100 cards from four different decks. Following a fixed win and loss schedule, two of these are advantageous, and two are disadvantageous. The number of advantageous minus the number of disadvantageous cards drawn determines a subject's decision-making.

External stimuli and their perception can evoke and determine emotions [7, 13]. The surrounding environment is a prominent external stimulus affecting a person's mood. Research demonstrates that people feel happier outdoors. Ranked by their impact, people prefer to be in (1) sea and coastal regions, (2) mountains, moors, heathlands, (3) forests, and (4) semi-natural grassland [10]. Providing access to nature (window views, plants, and landscapes, etc.) leads to lower stress and higher job satisfaction in working environments, and better recovery of patients in hospitals [6]. Considering the light, people perceive warm, reddish light as pleasant, thus experiencing positive feelings such as enthusiasm and joy [1]. In contrast, a lack of windows in closed rooms leads to anxiety and depression [15]. The feeling of being trapped induces feelings of isolation, uncertainty, and anxiety [14]. People feel less relaxed and pleased in cooly-lit rooms [1].

3 Method

We developed three IGT applications: a low immersion *desktop*, a high immersion *VR desktop*, and a high immersion *VR forest* version. While all versions implement the same IGT realization, i.e., visualization and card-selection technique, they differ in the medium used and environment. The *desktop* version displays the virtual IGT on a physical computer screen. The *VR desktop* version replicates the physical laboratory as a 3D-model-based VE. It displays the virtual IGT on a 3D model of the physical computer screen. The virtual computer screen has the same dimensions as the physical screen. The blinds are shut and both laboratories are closed and cooly-lit rooms with no access to nature. Thus, both environments represent the negative side of the design space. The *VR forest* version is based on the theoretically best characteristics of the design space. It uses a 3D-model-based VE of a forest featuring a wooden forest cabin. We designed a landscape of hills covered with conifers and bushes to create a pleasant view with different vegetation. We decided to use a brightly lit daylight setting with a few light clouds in the sky. We further placed a rustic wooden table and chair on the cabin's terrace as shown in Fig. 1. The wooden table features the 3D model of the physical computer screen to show the IGT gameplay.

With a higher visual angle, the *emotional response* to audiovisual stimuli is *increased* [8]. We kept the position of the user with regard to the computer screen the same across all versions. This ensured the same visual angle on the IGT and the surrounding environment.

We chose an *in-between subjects* experimental design. We randomly assigned the participants to one of the three conditions. Our study was approved by the Human-Computer-Media institutional ethics review board of the University of Würzburg.

4 Results

We recruited participants from the staff and students enrolled at the University of Würzburg. In total, 60 participants (38 females, 22 males) took part in the study. They had a mean age of 23.45 ($SD = 3.81$) years. None had completed the IGT before.

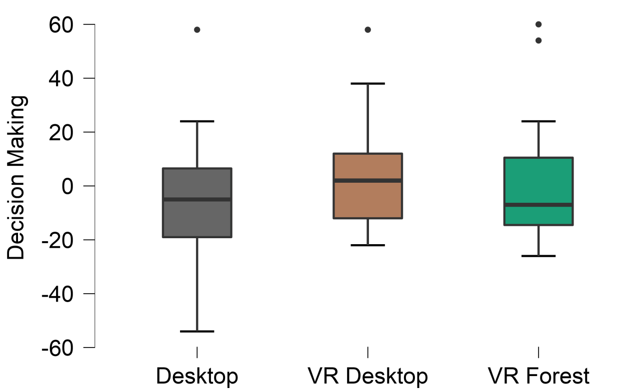

Figure 2: Tukey-style box plot comparing the IGT decision making.

The *Desktop* condition yielded a mean IGT decision-making of -5.90 ($SD = 25.07$), the *VR desktop* condition of 4.60 ($SD = 21.30$), and the *VR forest* condition of -0.90 ($SD = 23.82$). Computing an ANOVA revealed no significant difference between the three conditions with respect to IGT decision-making, $F(2,57) = 1.00$, $p = 0.37$, $\eta^2 = 0.03$; see Fig. 2.

5 Discussion

Our study revealed no significant difference between the conditions with respect to IGT decision-making. This indicates that *neither immersion nor the design of a VE causes impairment in decision-making*. This outcome could be a result of the presentation of the IGT. We chose to present the IGT on a virtual computer screen with the same dimensions as the physical screen. In this manner, the gameplay took place in only a very small portion of the entire VE. As in the physical world, participants had to focus on the virtual screens. Hence, the surrounding VE was not as perceptible as it would have been if the IGT was presented more prominently. A different explanation might be the structure of the task. We instructed the participants to play the game. As a result, they might have felt the urge to immediately start playing without taking in the atmosphere of the VE. Finally, the result may be explained by a strong effect of flow [5]. Evoked by a clear goal and the immediate feedback, participants may have been in a strong state of flow. Thus, they fully focussed their attention on the IGT gameplay and disregarded all other stimuli, i.e., the VE.

6 Conclusion

This article reported novel findings on IGT decision-making in immersive VR, i.e., the effects of the design of VEs on decision-making. We kept the visual angle on the IGT identical across all conditions. We found *no significant* impairment of decision-making caused by the degree of immersion or the design of the VEs. This suggests that the visual angle of the stimulus potentially affects decision-making.

Future work should investigate if other prominent VR factors influence decision-making. For instance, using an embodied VE could affect IGT decision-making in immersive VR.

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