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AVATAR STYLES AND CHOICES: WHAT MATTERS IN SOCIAL VR CONTEXTS?

A thesis submitted in partial satisfaction of the
requirements for the degree of

MASTER OF SCIENCE

in

COMPUTATIONAL MEDIA

by

Sabrina Starr Fielder

June 2022

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Abstract

Avatar Styles and Choices: What Matters in Social VR Contexts?

by

Sabrina Starr Fielder

Remote collaboration has become increasingly necessary in recent years, especially during the COVID-19 pandemic. Many coworkers and collaborators have moved in-person meetings to video conferencing (VC) interfaces such as Zoom. While not yet as common as video conferencing platforms, social virtual reality (VR) tools are becoming an increasingly viable option for how we choose to work remotely. Unlike other remote collaboration interfaces, VR affords near-complete immersion in a virtual environment while allowing users to construct virtual representations of themselves in the form of avatars. Remote teams may choose to use VR applications over traditional VC interfaces to feel more connected with one another, or enter office-like virtual spaces to foster a work-like environment. However, there is a surprising lack of research investigating how avatar presentation affects group collaboration, on both the individual and group level, with the added variable of environment. The present research investigates how creative brainstorming in virtual group settings is affected by avatar styles, environment, and an interplay between these two main elements of social VR platforms. We show that when given the choice, participants overwhelmingly prefer to embody fanciful-styled avatars as opposed to humanoid in both creative and business-style environments during a brainstorming task. Choosing such avatars led participants to report increased comfort and ease in engaging with their partner, as well as more potent feelings of creativity. Such results demonstrate that creative freedom in avatar choice matters more than using environment or situational context as a proxy in decision making. We expect that the

findings of our research will catalyze reflection for developers and designers of social VR applications, namely those offering business or productivity-styled platforms, on what avatars their users truly want to embody and what should be offered to them.

Acknowledgements

Please note that in this paper, "we" is used rather than "I" when referring to the preliminary research, development, and execution of this project. This project was a team effort ("we"), not the work of an individual ("I"), of several different co-collaborators at the University of California, Santa Cruz and San Francisco State University: myself, Katherine Isbister, Anya Osborne, Lee Taber, Joshua McVeigh-Schultz, Max Kreminski, Tara Lamb, Sarah Banks, Tym Lang, George Butler, and more. As I mention in the text, the survey research that I drew upon in planning my study was led by Anya Osborne. I led the planning, execution, and analysis of the study itself. I was supported in this by Anya Obsborne, Joshua McVeigh-Schultz, and Katherine Isbister in terms of mentorship in planning the research. Tara Lamb and Sarah Banks helped to run data collection sessions. Lee Taber assisted with the quantitative analysis of the results. Anya Osborne helped to write portions of the study description, which also appears in her PhD advancement document.

Chapter 1

Introduction

Remote collaboration has become increasingly necessary in recent years, especially during the COVID-19 pandemic. Entering the playing field of remote collaboration tools are social virtual reality applications, which afford users the unique ability to adopt embodied virtual representations in the form of avatars. Such applications can be used for social or gaming purposes, or may be utilized for business-style meetings. This opens up novel possibilities when it comes to digital self-representation. Social VR users can choose to create veridical–yet often stylized– digital versions of themselves, or opt for more outlandish representations taking on either humanoid or non-humanoid forms. The work that has been done on avatars in social VR largely focuses on avatar appearance, namely in how users choose to customize their own avatar [3, 4, 5, 12, 26], how users perceive their own avatars [4, 5, 26, 27], and what avatar appearances yield highest collaborative success [8, 10, 15, 17, 31]. To that end, research reporting on collaborative success often reports from an individual participant's perspective rather than a group perspective [4, 15, 17, 19]. Furthermore, the influence of environment on collaborative success is similarly reported with little consideration of the relationship between avatar and environment. The present research therefore aims to fill these gaps: why do users pick the avatars they do when entering a particular environment, and how do these avatars affect our ability to collaborate with others and how others collaborate with us?

1.1 Avatars in Social VR

Research on social VR avatars has generally indicated that avatars allow users to explore creative representations of themselves or adopt new identities. Mirroring one's true appearance is often shown to be less important than exploring novel appearances [3, 4, 5, 27], particularly in situations where it is advantageous, socially or otherwise, to present oneself in a particular way [12, 13, 19, 26, 30].

The ability for virtual avatars to afford novel identities to users is particularly unique. Self-representation in popular virtual/video conferencing systems typically allow users limited options for how they present themselves in social situations– either their true selves via webcam, or the ability to turn one's camera off with or without a picture of oneself in place of a webcam feed. VR, however, affords users the ability to show up in ways that would not be possible in real life or with most VC applications (with the recent exception of Microsoft Teams offering users the option to use expressive AR avatars in place of their camera feeds [22]).

Presenting as an avatar may foster increased user comfort in comparison to traditional VC settings, and may help to mitigate the effects of VC fatigue ("Zoom Fatigue") [2, 20]. Additionally, avatar customization with plenty of room for creative freedom could support increased confidence in interpersonal scenarios and help users to achieve behaviors otherwise more difficult to conjure when presenting as their true selves [30]. Here, we define creative freedom as providing users with a diverse set of avatar choices that allow them to present in ways that are not necessarily congruent with one's physical appearance. For example, offering non-humanoid avatars, a variety of hair colors, clothing, et cetera, that do not restrict users to looking only like themselves.

Many business-oriented social VR platforms strictly offer congruently styled avatars

with limited room for creative freedom. This is especially true of VR applications like Spatial, where users upload a picture of themself and Spatial overlays the picture mesh onto an avatar's head with a severely limited amount of further customization options. If research on social VR avatars suggests that presenting oneself accurately is less important than creative freedom, then many video chatting and business-oriented VR applications may be unfortunately restrictive in what avatar options users are provided with.

The current research investigates what matters to users in interpersonal social VR contexts when picking an avatar to embody– whether that be self-veridicality, creative freedom, or lack thereof. Additionally, we investigate what role environment and situational context play in choosing an avatar, and how such avatar choices may affect interpersonal dynamics and collaborative prowess. In this project, we chose a congruence between avatar style and environment in part 1 of the study. In our business-style environment participants were assigned to business-style avatars, and in our creative-style environment, participants were assigned a creative-style avatar. The environment and avatar decisions were informed by responses to a preliminary survey which asked participants what environments and avatars they perceive to be appropriate for business-like or creative-like meetings. This set up mirrors the approach of many social VR applications that provide congruently styled avatars to the environments offered. As mentioned, Spatial, a business-style VR meeting application, strictly offers professional-looking humanoid avatars (Figure 1.1). While VRChat, which has a more freestyle and less business-like approach to VR, offers a wide-range of fanciful styled avatars (i.e., non-humanoid and creative, like a banana) (also Figure 1.1). Part 2 of our study gave participants the ability to choose an avatar upon reentering the same environment. This approach enabled us to examine several things: how avatar styles (whether congruence or non-congruence) affect interpersonal collaborative and creative dynamics, and what avatar

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choice participants make after being assigned a congruent avatar when they reenter the same environment in part 2.

Figure 1.1. Avatar styles on two differently styled social VR platforms. Spatial above, VRChat below.

1.2 Related Work

Previous work on avatars has largely focused on avatar customization, user preferences, and avatars in social settings. Because the current research strives to investigate how avatars affect interpersonal dynamics and collaborative success, we also review literature on how collaborative success, namely creativity, has been measured with prior research.

1.2.1 Avatar Customization and User Preferences

Research in avatar customization and user preferences has examined what avatar styles yield the highest degrees of embodiment or personal satisfaction, or how environment and context influence the choices users make when picking or designing an avatar.

People often use their avatars as vehicles to create novel identities. Research has indicated that looking like oneself in social, non-business style VR environments is not of great importance to users, who rather allow themselves to explore unique embodiments not resembling themselves [3, 4, 5]. Customization is a careful process often taking into consideration how avatars can best serve users when it comes to following a trend, status, conforming to a particular environment, or standing out [3, 4, 5, 12]. In business environments, users generally express more comfort with "professional" appearing humanoid avatars, citing business or work appropriateness [10]. Avatar body representation similarly has user preferences, where more fully represented bodies tend to be slightly favored over partial representations (i.e., no legs, floating hands and no arms) [8, 17, 31]. However, partial representations are not viewed as much worse than fuller representations and could be interchangeable depending on context [8, 31]. As such, context appears to matter when making avatar choices or declaring preferences— different style avatars are better for different scenarios [14, 25, 26]. For example, Triberti et al. [26] finds that if a participant's goal is customization, leisure-style avatars (i.e., non-professional appearing avatars) rather than business-style are preferred. Trepte and Reinecke [25] report that depending on game style (i.e., competitive or non-competitive game), users will design their avatars differently. In competitive-style games, participants were shown to create avatars that did not look like themselves versus in non-competitive games, they created avatars that did look like themselves. Mitchell et al. [14] reports that depending on the business use case, different style

avatars achieve better results for different goals– such as sending messages, online discussions, branding, customer service, et cetera. In short, avatars are powerful tools in shaping virtual identities. Previous research has demonstrated that different styles of avatars are better for different use cases or goals, and that users customize their avatars in accordance with this.

1.2.2 Avatars Affecting Collaboration

Avatars in virtual environments affect collaborative or social success. Literature in this realm reports on avatar *appearance* being a determining factor of collaborative success– affecting how others interact with us and how we interact with others. As mentioned, users do not place great importance on looking like themselves in social VR settings [3, 4, 5, 27], and may find more comfort and ease in communication when not presenting as oneself [3, 19] or customizing to be consistent with the environment they're in [4, 5, 26]. Peña [19] reports that participants who embodied an avatar that looked like themselves in an ingroup identity study displayed "increased social distance", meaning that looking like oneself led to decreased interpersonal success. Regarding avatar and environment consistency, an interview study conducted by Freeman and Maloney [4] contended that social VR users like to construct virtual identities that are consistent with the platform they are entering.

However, there is a lack of research investigating how avatars affect collaboration beyond *humanoid* avatars. The aforementioned research strictly discusses how humanoid avatars affect collaboration– there is little to no research to be found on how non-humanoid avatars affect collaboration in social VR settings. Our research includes non-humanoid avatars in the investigation of how avatars affect collaboration, and the options that are provided to users when asked to make a choice.

1.2.3 Measuring Creativity

Early research on assessing creativity approaches creativity as part of an individual's personal skills [18, 21]. However, more recent research in this realm focuses on the production of novel and useful ideas in either individual or group settings (e.g., [1, 24]). Taggar [24], for example, had participants in groups of 5 or 6 brainstorm ideas in response to several different prompts, such as decision making or ideating products. Upon completion of the study, a rater scored the groups' brainstorming based on the appropriateness of the ideas, originality, amount of detail, and the total number of responses. The current research project focuses on measuring creativity as a collective achievement in virtual meetings within a small group of people (i.e., group creativity), similar to an approach like Taggar's.

There are several approaches to measuring creativity, which typically utilize a point-giving system depending if particular criteria are met. Such criteria may be the amount of ideas generated in an ideation task [9], the length of ideas [9], originality and novelty [9] [23, 29], validity and appropriateness [16, 23, 29], each of which may be awarded some amount of points if met.

The present research is primarily inspired by the work of Sun et al. [23] and Won et al. [29], which applied similar measures for evaluating the creative performance of a group. In the study procedures, participants were asked to generate novel strategies to conserve resources, such as water and energy use. In Sun et al.' study [23], participants were provided with a list of 15 environmental principles related to water use and were given 5 minutes to verbally brainstorm novel ideas with the instruction to avoid repeating ideas. Participants' conversations were recorded for later transcription and analysis. The transcribed audio files for each participant were rated independently for novelty and validity by two research assistants based on a given grading rubric. Ideas were rated as "valid" if they were reasonable

suggestions that did not duplicate the 15 environmental principles as listed in the experiment instructions. If the ideas were not derivative of the 15 prompts, they were also coded as "novel" and received an additional point. Valid and novel ideas were summed to get the total score for each participant.

Similarly, in Won et al.'s research [29], two people collaboratively generated novel strategies to conserve resources while being physically co-located in a lab-controlled environment. Each participant pair completed a learning task, where they had to memorize and recall 15 environmental principles related to water use. The experimenter instructed participant pairs that, as soon as they left the room, they would have 5 minutes to generate as many "new, good" ideas dealing with conserving water or energy, or reducing water or energy use, as they could. Participants were told that their responses would be recorded, so they did not need to remember anything or write anything down.

Won et al.'s approach for measuring creative group performance was slightly different from Sun et al.'s work. They followed Oppezzo and Schwartz's approach [16], which operationalized creativity as appropriate novelty using criteria modified from Guilford's (1967) scale for evaluating creativity [6]. Measures included the quantity and quality of ideas. For quantity, they summed every unique idea and gave it an initial value of 1. Ideas that were clearly inappropriate or facetious (i.e., "stop drinking water") were reduced to a score of zero and thus did not contribute to the final score. For quality, they gave an additional point to ideas that deviated from provided prompts. Thus, creativity was measured as a sum of quality and quantity of ideas, which was then compared with the total word count.

Upon reaching out to Dr. Won via email, we received the ideation prompts and relevant study materials for further adaptation of them in the present project on creative

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collaboration in VR meetings. In the next chapter, we describe what adaptations were made in providing an overview of the study design.

1.3 Research Goals

Upon reviewing current literature on avatars, it was clear that there's a notable gap in understanding how avatars affect group dynamics while taking setting into account. Here, we set out to investigate the interplay between these elements. Our research questions are as follows:

RQ1: How do avatars affect how we collaborate with one another?

RQ2: Does setting influence one's decision in picking an avatar to embody?

RQ3: Is congruence between avatar and setting, the current approach by many social VR applications, a reasonable approach?

RQ4: What matters when picking an avatar to embody? E.g., humor, likeness, congruence with setting?

Based on the above research questions, we hypothesized the following:

H1: Collaborative results (i.e. creativity scores) will be significantly higher in part 2 when participants get to choose their avatar in comparison to part 1 where participants are assigned a setting-congruent avatar.

H2: The highest creativity scores will be seen from participants assigned to the creative-style environment after they pick their avatar in part 2.

H3: Fanciful-styled avatars (i.e., non-humanoid and creative) will be preferred over humanoid-styled avatars and likeness, regardless of environment style (creative or business). participants will value the "fun element" afforded to them by fanciful-styled avatars more than likeness and/or looking human.

In the proceeding chapters, we elaborate on the study design, design rationale, and data collection.

Chapter 2

Design and Development Process

2.1 Preliminary Research

To inform the design of the present study, we conducted a survey designed by Anya Obsorne with 87 respondents in order to understand people's preferences for avatar styles and environments in various meeting contexts in VR. The survey was designed to answer the following set of questions: What kinds of avatar attributes (variables) matter to people in creative versus business environments and why? What kinds of environments people perceive as casual (creative) versus business, and why? Is there a relationship between the kinds of environments and avatars participants tend to select to 'fit in' depending on the platforms' atmospheres and/or meeting scenarios? We grouped survey questions into the following topics: demographic questions, participants' prior remote meeting experience, selection of avatars for different meeting scenarios in VR, questions about environments. Our rationale for designing each scenario was whether participants are meeting with people they already know or people they do not know. Prior research has shown that people tend to make strategic personal choices about the kinds of avatars they want to represent them, depending on the 'atmospheres' (i.e., vibe) of the platform and meeting contexts [4, 5]. Informed by this work, we developed meeting scenarios that specify the context and participants' level of familiarity with people they meet in these contexts.

While colleagues and friends fall under the same category of people you already know, degree of familiarity and personal relationship may vary between these groups.

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Colleagues, for example, may sometimes be perceived as 'friends', depending on external factors researchers may not be aware of (i.e., organizational cultures, personal relationships). Our behavior and social comfort typically vary around a group of colleagues, compared to being around a group of friends or family members. Therefore, we decided to distinguish meeting scenarios for each of these two sub-groups. Below is a range of meeting scenarios included in the survey, with the prompts as included in the survey:

1. Avatars for Business Purposes

Imagine you are applying for a job interview. The position you are applying for is very important to you. Instead of a video call on Zoom, the interview will take place in VR with few other interviewers.

2. Avatars for Creative Tasks (with people you don't know)

Imagine you are meeting a group of people that you have not met before in VR to work together on a creative project. Your goal is to produce effective results within a short time frame as a group.

3. Avatars for Creative Tasks (with people you know: colleagues)

Imagine you are meeting with a group of colleagues in VR to discuss plans for a surprise birthday party for your manager.

4. Avatars for Creative Tasks (with people you know: friends)

Imagine you are meeting a group of friends in VR to discuss plans for a surprise birthday party for a common friend.

Each of these meeting prompts is followed by a set of follow up questions with respect to avatar selections: What avatar would you choose (from the given set)? Please

explain why you think it would be a good fit for this meeting scenario. If you were to create your own full body avatar for this scenario, what would this avatar look like?

The survey concludes with a range of questions concerning the design environments. For the purposes of this study, we categorized the environmental aspects based on results of prior lab work and landscape investigations, where participants categorized the aesthetics of meeting spaces as either skeuomorphic targeted at business activities, or casual (i.e., creative) focused on play and leisure activities. Participants were asked to select the most creative spaces and the most business-looking spaces. Examples of these questions included the following: (1) Select the most business-like space to meet with others to do work in; (2) Where would you enjoy having a business meeting? (3) Please explain what makes this space seem like a great business meeting space; (4) Please rate from 1 to 5 the following characteristics of environments that you think are the most important in business settings, where 1 is the most important, and 5 is the least important.

2.1.1 Avatar Variables

To select a range of avatars for the survey study, we relied on variables presented in Figure 2.1. These variables were identified based on prior research on avatars in VR [4, 5, 7, 28] and results of an in-lab landscape analysis. It includes humanoid versus non-humanoid, realistic versus fanciful, and the overlap of these two categories.

Variables	**Humanoid**	**Non-humanoid**
Realistic	Realistic self	Non-humanoid realistic (e.g., food, animal)
Fanciful	Non-realistic self	Non-existing character

Figure 2.1. Avatar variables.

As illustrated in Figure 2.1, Avatar variables included four groups: (1) realistic self;

(2) non-realistic self ; (3) non-humanoid realistic avatars (e.g., food, a realistic animal); (4)

avatars that represent a non-existing character (e.g., ghost, monster, cyclops, game character).

Upon identifying these variables, we then selected ten avatars per each group from the

Mozilla Hubs platform (Figure 2.2). These variables were used to code participants'

responses in the survey. For example, avatar HR1 stands for the first avatar in the humanoid

realistic group, and NF10 – the last avatar in the non-humanoid fanciful group.
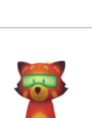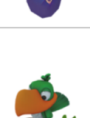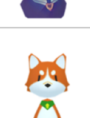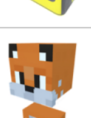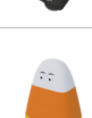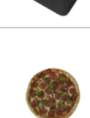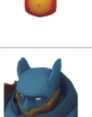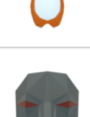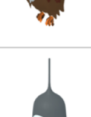
Figure 2.2. Selected avatars per each avatar variable: Humanoid realistic (HR), Humanoid
fanciful (HF), Non-humanoid realistic (NR), Non-humanoid fanciful (NF)

2.1.2 Environmental Variables

The variables for environmental design were fairly challenging to identify due to the lack of

prior work in HCI on aesthetical and architectural characteristics of collaborative virtual

spaces. Our workaround was to conduct an analysis of features that could serve to categorize

environments. First, we identified two general groups of variables – customizable and

non-customizable, followed by surfacing a range of specific variables for each group (Figure 2.3).

As noted earlier, the primary goal of this survey study was to inform the design of our lab-based study, as well as future technology probes with enabled tools for modulating environments (not a part of the current reported research). To achieve this goal, we decided to focus on the environmental attributes that participants can alter during a meeting and the kinds of environmental features that cannot be changed by participants. This helped us focus on a particular set of environmental features that guided our selection process of prospective meeting environments in Mozilla Hubs.

Customizable	Non-customizable
Lighting	Dimensions (e.g., oblong vs. circular)
Furnishings (props)	Access to vista (e.g. with vs. without)
Vista view	Indoors (e.g., high vs. low ceilings)
Selection of spaces for group travel	Open space

Figure 2.3. Environmental variables, divided into customizable and non-customizable features.

As shown in the Figure 2.3, customizable variables included the following:

1. **Lighting.** Participants can change room lighting from light to dark using a slider tool incorporated in the environment.

2. **Furnishings or meeting props.** Participants should be able to select and spawn 3D objects into a meeting space and position them according to their preferences.

3. **Vista view.** Participants will be equipped with tools to swap skyboxes in meeting spaces that either have windows, patios or other 'open air' areas.

4. **Group travel.** Participants will be able to preview other environments and travel together there as a group.

Our primary focus was on non-customizable variables for environments. The first two groups we looked at were whether a particular environment represented an open space or an indoor space. In applying real life metaphors to selecting virtual spaces, 'open air' (outdoor) spaces varied based on dimensions only, such as oblong and circular. We found a total of 7 open spaces with 3 oblong and 4 circular shaped environments. Examples of open spaces are demonstrated in Figure 2.4.
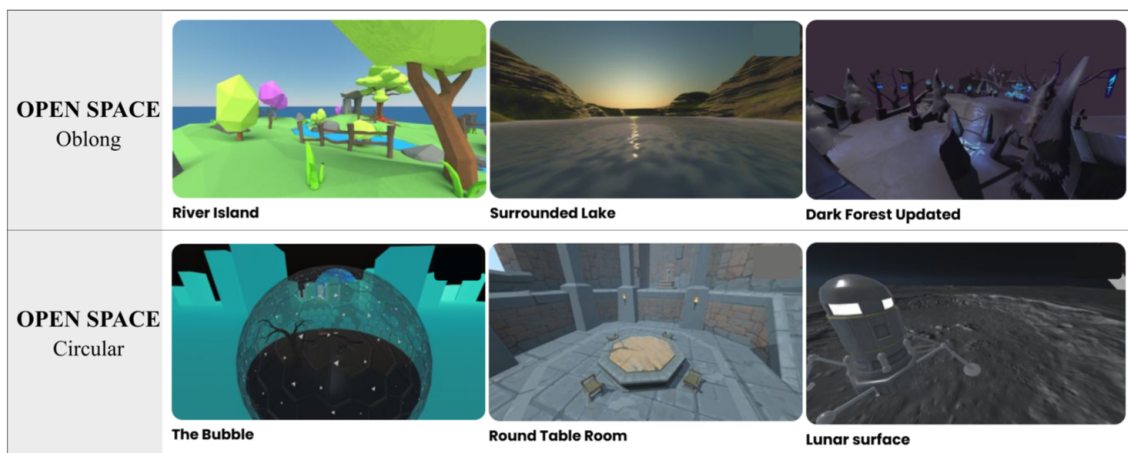
Figure 2.4. Variations of open space environments

While for open spaces there were only two identified variables, indoor spaces included a wider range of variations with respect to dimensions, ceilings, and access to vista, totaling in 8 groups. The total number of indoor spaces we found in Mozilla Hubs based on these variables was 15. To preselect these spaces, we created an account in Mozilla Hubs and added them to a list of favorite scenes. Since it is difficult to perceive the scale and geometry

of these environments solely relying on presented titles and cover images of these spaces, the next step was to visit these sites 'in-person' and take screenshots with an avatar present.

To complete this process, we entered the same environment from different browser tabs to capture one of our in-world avatars. Situating an avatar in each environment was an important step intended to provide participants with screenshots that create a better sense of scale and lighting in these environments. While the geometry of each site varied, with some including more than one room, we placed an avatar in a seemingly central spot, where participants were likely to gather around to work on a collaborative task.
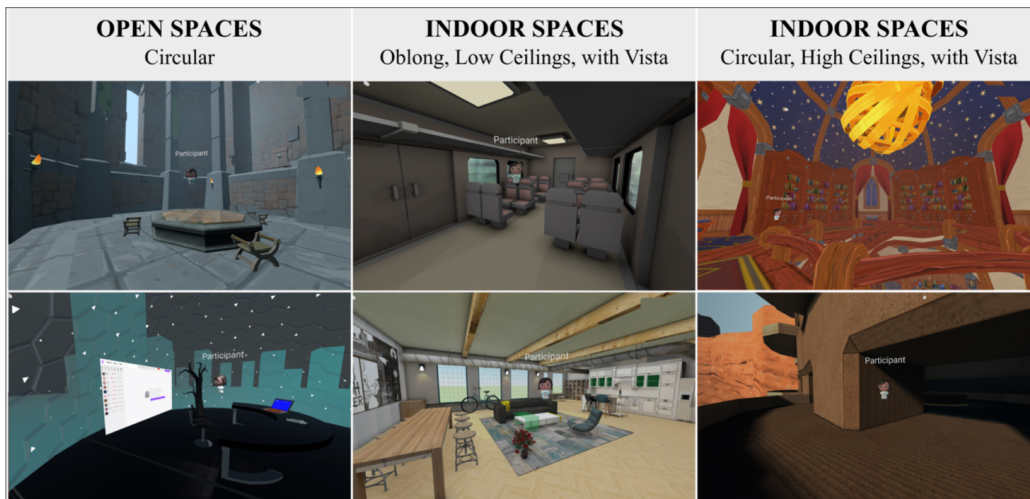
Figure 2.5. Variations of open and indoor environments.

Figure 2.5 above illustrates variations of open and indoor spaces. For example, the Round Table Room (top left) included different vertical levels users can potentially hop on or teleport into. However, the central spot of this room was a medieval-styled round table positioned in the center of this environment, where we situated an avatar to provide survey participants with a better sense of scale, lighting, and dimensions of the meeting space. We

set up the survey on Qualtrics in such a way that participants can zoom in on each image of the environment by clicking on it.

2.2 Design Process

The preliminary results of the survey study informed the design of the present research. Below, we detail what environments and avatars we selected based on survey responses and study needs, in addition to the prototyping and piloting processes.

2.2.1 Environment Selection

Survey responses to the questions *"Select the most business-like space(s) to meet with others to do work in"*, "Where would you enjoy having a business meeting?" "Select the best space(s) to complete a creative brainstorming with others", and "Where would you enjoy having a creative brainstorming?" informed our choices for the two different selected environments pictured in Figure 2.6. The business-style environment "Conference Room" (left hand side of Figure 2.6) received the most votes for the former 2 questions, while the creative-style environment "Wizard's Library" (right hand side of Figure 2.6) received the most votes for the latter 2 questions.
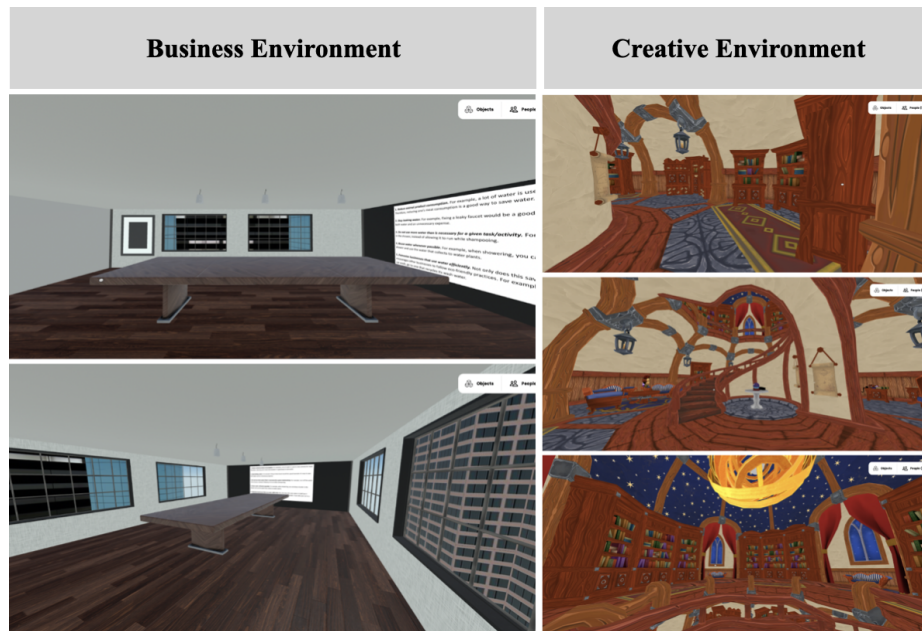
Figure 2.6. Final environments chosen for the present study. Business condition environment pictured left, creative condition environment pictured right.

2.2.2 Avatar Selection

We chose the avatars that received the highest amount of votes (i.e., top 5 votes) for questions regarding what avatars participants would choose to embody in particular environments and group dynamics. The group dynamics in question were a job interview, casual meeting with colleagues, meeting with strangers for a creative project, and casual meeting with friends. Between the questions, there was a good amount of overlap of which avatars received the highest amount of votes. In addition to picking the avatars most voted for, we also sought to include avatars that represented a variety of demographics and identities. For example, no female avatars made it into the top voted avatars but we included several female options with varying skin tones and hair colors to ensure fair representation. The final set of avatars amounted to 23. In part 2 of the study, participants were able to pick one of these avatars to embody. The final avatars picked for this study are pictured in Figure 2.7, with the top 5

avatars for each group dynamic specified on the left, and the avatars we added for diversity on the right. The avatars we chose to assign participants in part 1 of the study are indicated by the red arrows. In the business condition, avatar HR6 was assigned. In the creative condition, avatar NR4 was assigned. We landed on these two avatars due to the high amount of votes they received. Avatar HR6 received the highest number of votes for "avatars for a job interview", thus being the most suitable for the assigned business avatar. It also ranked highly in "avatars for a casual meeting with colleagues", and "avatars for meeting with strangers for a creative project". The fox avatar, NR4, was chosen as the assigned avatar in the creative environment because it consistently ranked highly in the following categories: "avatars for meeting with strangers for a creative project", "avatars for a casual meeting with friends", and "avatars for a casual meeting with colleagues" – ranking first in the former 2. NR1 similarly ranked highly in these 3 categories, but did not rank as highly as NR4.

2.2.3 Ideation Prompts

As stated in chapter 1, we reached out to Dr. Won to and received the ideation prompts used in her previous research on creative collaboration in VR meetings [23, 29]. These prompts were trimmed from an original list of 15 with the intention to modernize and encourage more fluid conversation between participants. After piloting, we learned that anything more than 7 prompts was a hindering factor to fluid conversation. Thus, the list was reduced to 5 to encourage participants to generate more ideas that deviated from the reduced list. The final reduced list of prompts used in the present research are pictured in Figure 2.8.

2.2.4 Prototyping and Piloting

The environments were available for modification on Mozilla Hubs Spoke– an online tool that allows users to create virtual environments or modify existing ones. We imported the necessary elements for the study into the environments (avatars and task prompts) and iteratively tested out the environments in VR and on PC to ensure cohesive design. The study was piloted with the research team to work out any possible kinks or design flaws in the environments and protocol. After piloting, minor issues were resolved and the study was ready for launch.
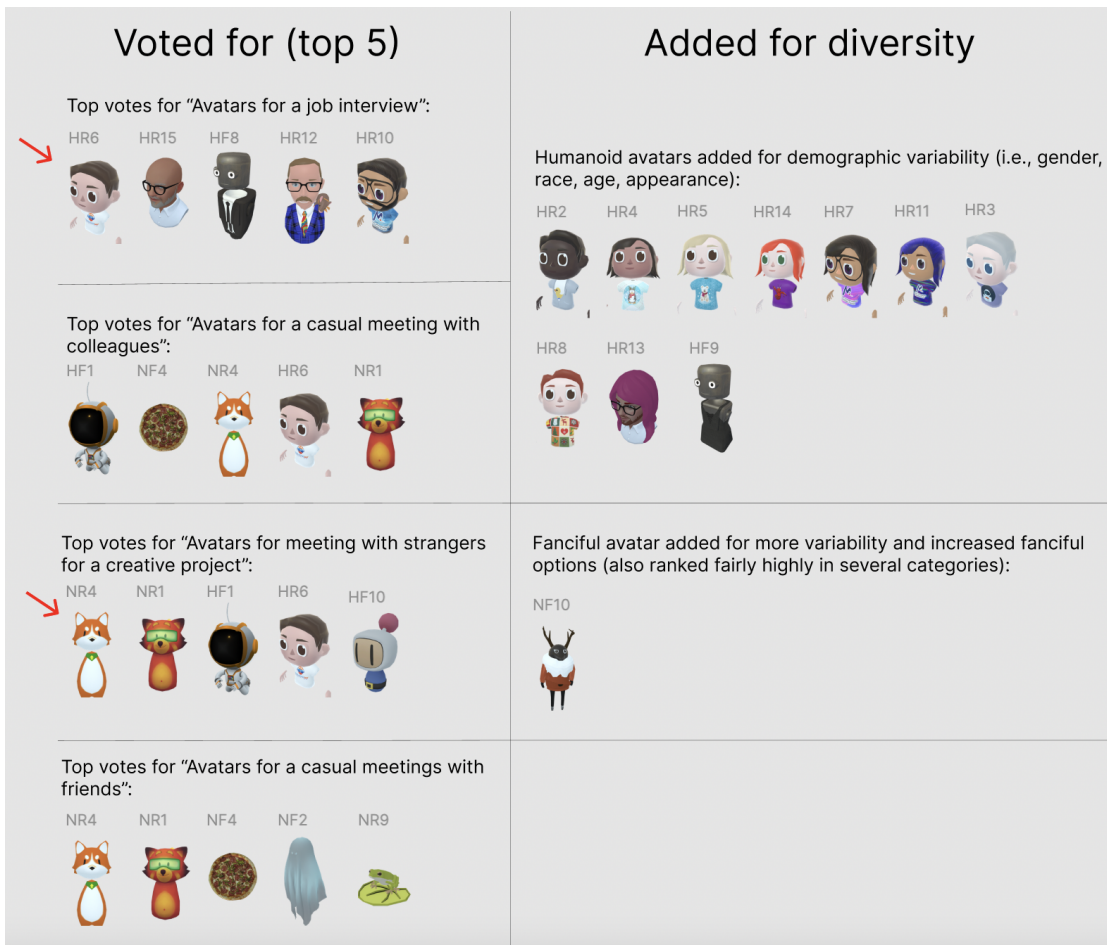
Figure 2.7. Final set of 23 avatars available for embodiment in part 2 of the study. Arrows indicate avatars selected for part 1 in study, where participants were given a pre-assigned avatar. HR6 was assigned for the business environment, where NR4 was assigned for the creative environment.

Conservation Prompts	
Water	**Energy**
1. ***Reduce animal product consumption.*** For example, a lot of water is used to raise animals for meat. Therefore, reducing one's meat consumption is a good way to save water. 2. ***Stop leaking water.*** For example, fixing a leaky faucet would be a good example of a way to save both water and an unnecessary expense. 3. ***Do not use more water than is necessary for a given task/activity.*** For example, turn off the water in the shower, instead of allowing it to run while shampooing. 4. ***Reuse water whenever possible.*** For example, when showering, you can keep a bucket in the shower and use the water that collects to water plants. 5. ***Patronize businesses that use water efficiently.*** Not only does this save water in itself, but it encourages other businesses to follow eco-friendly practices. For example, if you take your car to a car wash, go to one that recycles its wash water.	1. ***Heat water in the most energy efficient way.*** You want to make sure that as much as possible of the energy you use is going directly to heating the water that you want to use, and only that water. For example, when heating water for a hot drink, it is more energy efficient to heat water in an electric kettle instead of a microwave. 2. ***Limit your use of electricity during peak usage hours as much as possible.*** Using electricity in the late afternoon uses more energy than in the morning. 3. ***Use economy or eco settings on appliances.*** Many modern appliances have such options. For example, many space heaters can be set to turn off once the room reaches a particular temperature. 4. ***Turn off appliances when you are not using them or set them to be turned off by a set time.*** For example, if you often fall asleep watching TV, you can set your TV to turn off by a certain time so that it isn't on for hours without you watching. 5. ***Patronize businesses that use energy efficiently.*** This helps to support energy-saving practices and also encourages other businesses to follow eco-friendly practices. For example, choose a business that uses solar energy.

Figure 2.8. The final set of ideation prompts used in the present study. Which exact set came first, water or energy, rotated from participant pair to participant pair.

Chapter 3

Study Design and Procedure

3.1 Study Design

3.1.1 Participants

Participants (N=40, 20 pairs) were found via several channels in an advertisement, sign-up based recruiting effort or through word-of-mouth. Researchers shared digital fliers on VR-related Subreddits, Discord channels, Facebook pages, LinkedIn, and Craigslist. Physical fliers were posted on university campuses in the Bay Area, including University of California Santa Cruz, San Jose State University, and San Francisco State University. The digital and physical fliers included a tinyurl link and QR code leading to a consent form on Qualtrics. Once the consent form was completed, participants were provided with a link to scheduling software Calendly to select a time to participate. Prior to completing the consent form, participants were asked to attest to meeting certain demographic criteria. They had to be 18 years of age or older, presently residing in the United States, own a VR headset, and be able to access Zoom. The evening before their participation, participants were sent an email reminder with a Zoom link to join the session.

With nearly 400 responses[1] to our advertisements, our final set of viable participants amounted to 20 pairs, or 40 total participants. 27 of our participants identified as male, 10 as female, and 3 as non-binary. The bulk of participants fell within the age range of 25-34 years

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[1] Many participants who responded to the advertisements did not participate because they either: were a no-show at the time of their session, canceled, or lived outside of the United States and were thus disqualified from participating.

of age (25), followed by 18-24 (11), 35-44 (3) and 45-54 (1). 19 reported to be White, followed by Asain or Pacific Islander (8), Hispanic (8), mixed race (4), and Black (1). The most popular VR headset used for participation was the Oculus Quest 2 (32), but other devices used included the Oculus Quest 1 (3), desktop (3)[2], Valve Index (1), and the Oculus Rift (1).

3.1.2 Materials

Prior to entering the virtual environments, participant pairs convened with the researcher via Zoom video conferencing software supported by UC Santa Cruz. For the virtual environments, we used Mozilla Hubs– a open source software for virtual environments where users can create private rooms and invite others to join. The avatars were also from Mozilla Hubs. The environments and avatars chosen for this study are pictured in Figures 2.6 and 2.7, respectively. To audio and screen record the sessions, we used Open Broadcasting Software Studio (OBS Studio), available for free download off the internet. The consent form and post-session surveys were supported by UC Santa Cruz Qualtrics (post-session survey questions available under Appendix A). Participant data, condition tracking, and analysis were kept on the primary researcher's (Sabrina Fielder) UC Santa Cruz Google Suite.

In order to participate, participants needed to be in possession of a Zoom-capable device and a VR headset. The researcher joined the sessions– both Zoom and the virtual environments– from their personal computers. No headset was required for the researchers.

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[2] The desktop users had attempted to join from a wired-in headset, but we had encountered such severe technical issues with these headsets that we instructed them to participate from their desktops for the sake of time. Such headsets were the Valve Index and Oculus Rift.

3.1.3 Procedure

The final study design took on a 2x2 experimental approach with both within-subjects and between-subjects variables (Figure 3.1). Participant pairs were either assigned to see a business-style environment, or a creative-style environment in both part 1 and part 2 (between-subjects variable). Meaning, participants returned to the same environment in part 2 that they were introduced to in part 1. In part 1, participants were assigned an avatar congruent with the environment they were in. For the business-style environment, this was a humanoid, white and male-presenting avatar. For the creative-style environment, the assigned avatar was a non-humanoid fox avatar (see Figure 2.7 which pictures both of these assigned avatars). Both of these avatars were chosen based on the survey results in the aforementioned preliminary research, as they received the highest amount of votes for questions asking what avatar respondents would use for business-like meetings or creative brainstorming-like meetings, respectively.

2x2 study design	Business environment	Creative environment
Preassigned avatar (part 1)	Assigned business-style avatar	Assigned creative-style avatar
Avatar choice (part 2)	Free choice	Free choice

Figure 3.1. The 2x2 study design with both between and within subjects variables.

Prior to entering the virtual environments, participant pairs met with the researcher via Zoom. Here, participant IDs were assigned and instructions on how to open the virtual environment on their headsets was provided. Once the links for the virtual environments were successfully accessed on headset (or desktop, for those who had technical difficulties with their headsets), participants changed their display names to their participant ID numbers and

then entered into the virtual space. With all three people successfully in the space (the 2 participants and 1 researcher), the researcher in part 1 would instruct participants to embody the assigned avatar for their respective condition, located near the environment spawning point. Participants simply had to hover their controllers or mice over the avatar and select "use avatar". The researcher remained represented as a simple, non-distracting geometric-style avatar (Figure 3.2).
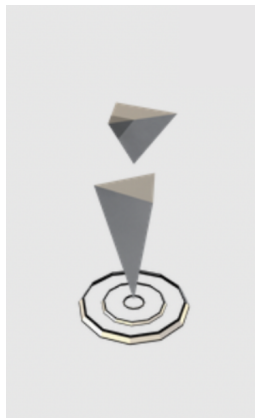
Figure 3.2. The avatar used by the researchers in VR.

With the assigned avatars successfully embodied in part 1, the researcher then instructed users to open up their virtual "selfie cameras" (Figure 3.3) so they would see themselves represented by that avatar. Participants then had a minute to explore the space before being instructed to complete their collaborative task for that part. The task either asked participants to generate new ways to save water or new ways to save energy that deviated from an existing list of 5 prompts (Figure 2.8). Which task came first varied from pair to pair to compensate for possible order effects. Participants were instructed to first familiarize themselves with the 5 prompts before they commenced their brainstorming. Once brainstorming began, participants had 10 minutes to generate as many ideas as they could. The 10 minutes was not intended to place a time restraint on them, but rather was

implemented after pilot sessions informed us that participants run out of ideas before or around that time, and anything longer than 10 minutes compromises the amount of time we promised participants would need to participate.

Figure 3.3. The in-VR selfie camera that participants were asked to use in order to see themselves represented by an avatar.

With part 1 completed, participants would reconvene with the researcher on Zoom and receive the second link for part 2 of the study. Participants would reenter the same environment for part 2, but this time the environments had 2 different display walls for either participant with 23 of the same avatar options on both (Figure 3.4). They were instructed to pick an avatar to embody from the display, and wait there for the researcher before moving around. The researcher would ask participants why they picked the avatar that they did, and then were instructed to prepare for the second task. The second task had the same rules as the first– participants first familiarized themselves with the list of 5 prompts (either water or energy conservation, depending on which one they did not do in the first part), and then were given 10 minutes to brainstorm. After part 2 was completed, participants would leave the virtual environment and reconvene on Zoom where the researcher would send the participants a post-session survey (Appendix A) to complete while remaining on the call.

Figure 3.4. One of the display walls in either environment. Business environment on the left, creative environment on the right. Participants were instructed to approach these walls in part 2 and choose an avatar to embody.

3.2 Measures

3.2.1 Creativity Performance

The ideas participants generated in the part 1 and part 2 water or energy conservation brainstorming tasks were scored by giving 1 point to every idea said, and an additional point if the idea was novel. 0 points were given to ideas that were facetious like "stop drinking water" or to ideas that had already been previously stated. The highest score an idea could receive was 2. 1 point was given if the idea was already on the list of 5 prompts, or was an extension of one of these prompts. For example, a water conservation prompt was: "Do not use more water than is necessary for a given task/activity. For example, turn off the water in the shower, instead of allowing it to run while shampooing." Therefore, 1 point would be rewarded if a participant said something like "turn off the water while you're brushing your teeth." This creativity scoring was adopted from Sun et al. [23] and Won et al. [29]. Scores were tracked while in session by the researcher, and later verified by watching the audio and screen recordings of the session.

3.2.2 Perceived Group Performance

We measured participants' perceived performance of the tasks in part 1 and part 2. To do so, we analyzed participant responses in the post-session survey. These were responses to questions in which participants were asked to provide their own estimate of creative performance and explain why they thought they were more creative in either part (e.g., During which task, first or second, do you feel you generated the most creative ideas? Why do you think you were more creative in this task?).

3.2.3 Participant Chosen Avatars

We kept track of the avatar each participant chose in part 2, and divided these into two different stylistic categories: humanoid and fanciful. We kept track of choices for both of the 2 different environments, as well as a combined sum of the 2. Tracking participant-chosen avatars helped us to gain insight into how environment might serve as a guiding factor shaping avatar choice. This also helped us get a sense of preferred avatar styles regardless of environment type.

3.2.4 Participants' Perceptions of Avatars in Relation to Self

Inspired by Ducheneaut et al. 's [3] work on avatar personalization, this qualitative measure aims at analyzing participants' responses in the post-study survey with respect to pre assigned and selected avatars between the two parts. It focuses on understanding how well participants could relate to their embodied representations of self in VR environments and if so, why (e.g., Why did you choose the avatar you did in part 2? What was it like to be the avatar you were

assigned in part 1? What was it like to be the avatar you chose in part 2? Do you consider the avatar you embodied represented you well?).

3.2.5 Participants' Perceptions of Avatars in Relation to Others

Prior research has shown that avatars impact the way we perceive others in virtual environments, as well as our consequent interactions with them [11, 12]. Kafai [12], for example, reports that "looking good" as an avatar, as established by platform idiosyncrasies, is a way of displaying your higher social status on the platform, making it more likely for other users to engage with you.

In order to understand whether or not such an effect took place in the current study in either condition, we conducted a qualitative analysis of participants' responses in the post-session survey, in which they were asked about their experience of brainstorming with the other person. Examples of these questions are: What was it like to brainstorm with the other person in task 1, when you were both assigned avatars?; (same question for task 2); How do you think the other person felt brainstorming with your avatar in part 1 and 2?

3.2.6 Reflections on the Environments

To understand what impact the two environmental settings may have had on participant's performance in ideation tasks, we compared creativity scores and perceived individual performance with participants' responses in the post-study survey. The responses were analyzed in regard to the following questions: How was it to brainstorm in the environment you were in? Were there aspects of it that you liked/disliked?.

3.2.7 Prior VR Experience and Demographics Check

In the post-session survey, we gathered background information on prior VR experience, demographics, and relationship (e.g., How often do you use social VR?; What do you use social VR for?; What kind of avatars do you use for social VR and what do you like about them?; What is the most important thing to you when customizing an avatar and why?; Please indicate below what your relationship with the other participant was prior to participation in the study).

Chapter 4

Results

4.1 Quantitative Metrics

4.1.1 Chosen Avatars

In part 2, we offered 23 different avatar styles. Of these, we classify 13 as humanoid and 10 as fanciful. In the creative environment condition, 18 out of 20 participants opted for fanciful avatars. A similar pattern was seen in the business environment condition, where 16 out of 20 participants also opted for fanciful avatars (Figure 4.1). We performed a Chi-Square test of Association between environment and avatar choice to see if the environment influenced avatar choice. We found no significant relationship between the two variables (X^2 (1,40) = 0.78, p = .38, phi = .14). These results indicate that, regardless of the environment, participants overwhelmingly preferred fanciful-style avatars.
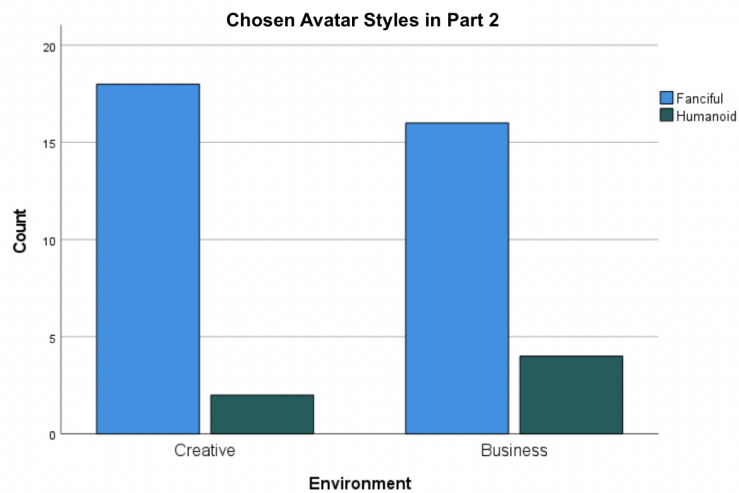
Figure 4.1. Style of avatar chosen in either environmental condition by participants.

4.1.2 Effects of Avatars, Environment, and Prior Relationship on Creativity Scores

Using a mixed-methods ANOVA approach with one within-subjects variable (creativity task), three between-subjects variables (task order, participant familiarity, and environment), and creativity task scores as the dependent variable, we tested to see if the following variables impacted creativity scores: avatars, environment, and prior relationship.

4.1.2.1 Avatars

Because avatar choice was an individual choice and creativity was scored on a group basis, we created a group variable for the number of fanciful avatars in a group (0, 1, 2) and used the group score to compare across the creativity scores. 0 was given to a group where no fanciful avatars were chosen, 1 to where one participant chose a fanciful avatar, and 2 to where both participants chose a fanciful avatar. We found no significant effect of avatars impacting creativity score ($F(2,17) = .87$, $p = .44$). This is likely due to a low sample size. For example, one category (0 fanciful avatars) had only one incident.

4.1.2.2 Environment

We analyzed whether environment, business or creative, had an impact on participants' creativity scores. We found no significant difference on creativity scores between either environment ($F(1,16)=.12$, $p > .05$, partial $\eta^2 = .01$) (Figure 4.2). Meaning, neither environment had an effect on creativity scores.
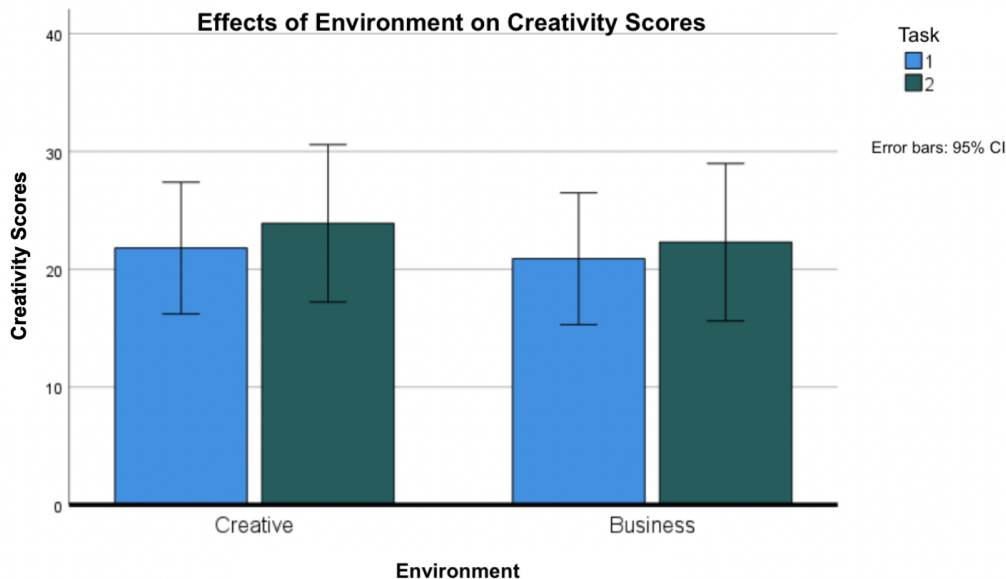
Figure 4.2. Impact of environment on creativity scores.

4.1.2.3 Prior Relationship

Participants were asked to attest to their relationship with the other participant (prior to participation) in the post-session survey. Response choices were: Stranger, Acquaintance, and Friend. 24 participants reported a stranger-level relationship, 8 an acquaintance-level, and 8 a friend-level. Participant pairs largely had an agreement on their relationship to one another, but two pairs had a disagreement where one participant reported acquaintance and the other reported friend. To assess whether prior relationships had an impact on creativity scores, we created a new "prior relationship" variable and assigned a "Yes" or "No" response to participant pairs addressing if they knew each other prior to participation or not. We found that prior relationship had no significant effect on creativity scores ($F_{(1,18)}= .93$, $p > .05$, partial eta squared = .05). Meaning, whether a pair knew each other or not did not affect how well they scored on the brainstorming tasks.

4.1.3 Effects of Task on Creativity Scores

To determine the impact tasks had on creativity scores, we report on the effects of first task vs. second task, task type, and task order below.

4.1.3.1 First Task vs. Second Task

With a paired t-test, we found that scores per group were correlated in that if a group had a higher score in part 1, then they were more likely to have a higher score in part 2. Such results imply that the creativity scores are influenced more so by the group rather than avatars or environment (t= -.92, df= 19, p > .05). Further, there was no significant difference between the scores in task 1 and task 2. Meaning, participant pairs did not perform better on one task than the other.

4.1.3.2 Task Type

A paired t-test revealed that regardless of task order, the energy conservation task produced significantly higher creativity scores than the water conservation task (t= -2.1, df= 19, p< .05). This may imply that the energy conservation task was found to be easier by participants.

4.1.3.3 Task Order

We investigated whether task order, meaning which task came first, affected creativity scores. An ANOVA revealed that there was a nearly significant interaction ($F(1,19)$= 4.4, p = .052, partial eta squared = .22) between task creativity score and task order, such that those who

saw the water task first had significantly lower first tasks scores than those who saw the

energy task first (Figure 4.3)
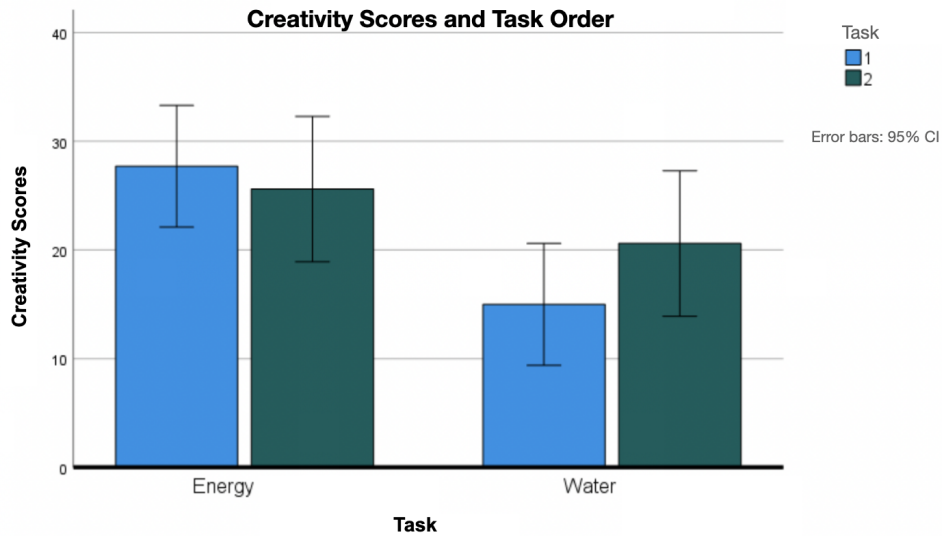
Figure 4.3. Effects of task order on creativity scores.

4.2 Qualitative Results

Qualitative analysis was conducted by reviewing participant's responses to questions in the

post-session survey (see the post-session survey questions under Appendix A).

4.2.1 Perceived Group Performance

30 out of the 40 participants reported feeling more creative in the second part with their

chosen avatars. From their freeform responses, we summarized sentiments into four

categories: (1) increased familiarity with the task, (2) avatars having a positive influence on

brainstorming prowess, (3) the first task ideas bleeding into ideas for the second task, and (4)

perceptions of one task being easier than the other. For familiarity with the task at hand, participants expressed that after having completed the first part of the study, they felt more comfortable going into the second part as they knew what to expect and had more familiarity with their partner:

> "We had more experience with the general objective of the task, and had gotten to know each other a bit from the first interaction." - P024

Participants also expressed an increased feeling of comfort after having picked their avatars in part 2– increased comfort with themselves, and increased comfort with their partner's chosen avatars. This was found to have a positive influence on brainstorming:

> "I felt more empowered to share ideas, since I was able to make a decision on how I would be perceived by the other participant." - P015

> "I was able to have freedom in choosing who I wanted to be and how I wanted to be represented." - P022

> "I was a little bit more on the same wavelength with my partner, especially since we chose the same avatar on accident so we knew we had at least avatar tastes in common." - P026

Self and partner-chosen avatars in part 2 positively influenced participants' ability to generate ideas, attributing to an increased sense of comfort by how they were represented. Embodying an avatar of choice fostered a more collaborative and easygoing space:

> "As I got used to the environment and had the option to choose an avatar, I felt more engaged with the environment and felt more comfortable and creative." - P002

> "I was having more fun and more at ease with my avatar." - P004

> "I felt more empowered to share ideas, since I was able to make a decision on how I would be perceived by the other participant." - P015

37

"I was able to have freedom in choosing who I wanted to be and how I wanted to be represented." - P022

Ultimately, the large majority of participants felt more creative in part 2 with their chosen avatars regardless of environment. For the 10 participants that reported being more creative in part 1, they reported feeling so either due to having more knowledge with the task at hand or feeling that the ideas they generated in part 1 were reusable in part 2.

4.2.2 Perceptions of Avatars in Relation to Self: Embodiment and Musings

Participants reported lower feelings of embodiment with their assigned avatar in either environment during part 1, and increased embodiment with their chosen avatars in part 2. We divided responses to the questions regarding embodiment into 3 main categories: embodied me well, did not embody me well, and indifference/ no opinion. The responses to these questions falling into the given categories can be seen in Figure 4.4.

Part 1		
	Creative environment	**Business environment**
Embodied me well	6	5
Did not embody me well	12	13
No opinion/indifference	2	2
Part 2		
Embodied me well	17	14
Did not embody me well	1	5
No opinion/indifference	2	1

Figure 4.4. Participant opinions on avatar embodiment success in part 1 (top) versus part 2 (bottom).

Participants while embodying the assigned creative environment avatar in part 1 reported

feeling a dislike for the fox, a sense of sterility, indifference, or lack of identification with the

avatar:

> "I felt indifferent, I didn't dislike the avatar, but some level of personality is lost when an aspect of your visual presentation is given to you as a standard unchangeable option, like a uniform." - P018

> "It felt impersonal, like putting a poker chip on a map or board game and saying 'Okay, this represents me.' It felt like its whole purpose was to allow physical presence in the environment and nothing else." - P026

> "I thought the avatar was cute but it was a sterile 'stand in' I wouldn't have necessarily cared much about." - P010,

Some creative environment condition participants, however, reported positive sentiments

about embodying the fox avatar. Such attitudes were less popular, but reported on the feeling

of oneness with one's co-participant or finding the fox to be cute:

> "It sort of had a feeling like my fellow participant and I were going to play some game and we were going to be on the same team." - P002

> "It was cool, we were cute foxes! Kinda felt like we were in a cartoon because of our avatars." - P025

The business environment assigned avatar produced similar sentiments regarding

indifference, restriction, and sterility. Participants reported that the assigned avatar for the

business condition felt generic, like a default stand-in that most felt a lack of embodiment

with. There was also a sense of formality with the assigned avatar in this environment that

was not mentioned in the responses of the creative condition participants:

> "It was ok. It felt very formal to not choose what avatar you could be and to just get the default." - P003

"If I were to use a human-looking avatar, I'd rather prefer to use the one that reflects my gender. Wearing a male avatar felt like it didn't quite represent me." - P027

"It wasn't bad, but it felt restricting in a way. With all the possibilities for customization, having everyone look the same was a little disappointing." - P028

"It felt like the standard 'white dude' character that's always the default." - P028

The assigned avatars in either environment produced a feeling of confinement– having only one, forced-choice option made users feel as though they were choosing a pedestrian stand-in that they failed to resonate with or seamlessly embody. Feelings of embodiment increased in part 2 of the study for both environmental conditions, as highlighted in Figure 4.4. participants felt that they had the opportunity to portray themselves as desired and found more space for creative freedom:

Question: Do you consider the avatar you embodied in part 2 to have represented you well? Why or why not?

"Even though I had to choose the avatar from a limited selection, I felt more represented by the ghost [in part 2] because it had the general vibe that I wanted from an avatar. It wasn't overly quirky, it was unassuming, and I felt like I could project any emotion through it." - P026, creative environment

"I do [feel represented by the avatar I picked in part 2]! I picked the frog as it represented something that I value – humor. I wanted to make my partner laugh when they climbed up the stairs and saw me." - P033, creative environment

"I do feel like the avatar [in part 2] represented me well, since I was allowed to express myself freely." - P015, business environment

"I think it did show off my personality, quirky and a jokester, or that is what I was going for." - P031, business environment

When choosing an avatar, participants reported that ultimately the most important thing when making their choice is to feel represented, which according to our participants is not dependent on likeness. We found that using avatars as means to communicate personality, affect, and uniqueness is more popular as decision-making rationale than choosing an avatar

that looks like oneself. Out of 40 participants, 34 picked non-humanoid, fanciful avatars

citing that such avatars were "fun", "colorful", "stood out from the rest", or represented

something they couldn't be in real life– like a pizza or a frog:

Question: What is the most important thing to you when customizing an avatar? Why?

> "Options and diversity. Being extremely unique. I don't want to see another avatar like mine ever." - P006

> "If this is something that will be used for an ongoing amount of time to an extent I imagine the avatar will become an extension of oneself, or a representation of what one would like to be or feel like. So when choosing an avatar I think it's important to feel comfortable and perhaps that the avatar is relatable." - P013

> "Probably getting to choose the body anatomy size and clothing styles. Like making my body different sizes, feel like a monster or something. Probably has something to do with me being short in real life so I am compensating in VR. Also being weird is fun." - P025

Our results demonstrate a strong preference for the fanciful-styled avatars. The

humanoid avatars, chosen 6 out of the 40 times, were certainly the less popular choice for

participants. Those who did choose the humanoid avatars reported the desire to look like

oneself, blend in, or fit into the environment they were assigned to– especially the business

condition. Regardless, it remains easy to conclude that non-humanoid, fanciful avatars were

largely preferred over the humanoid-style avatars. Participants report that in choosing such

avatars, they achieve that "fun" element that VR affords them, leading them to feel stronger

embodiment and more represented.

4.2.3 Perceptions of Avatars in Relation to Others

To gauge participants' perceptions of their partners' avatars in the brainstorming tasks, we

analyzed responses in the post-session survey to what it was like to brainstorm with their

partners in either part, and how they perceived that their partners felt about brainstorming with them in either part.

Participants reported that brainstorming with their partner in part 1 felt like they were still in a warm-up period, that there was a sense of awkwardness and stiffness. Commentary on avatars included sentiments of impersonalness, awkwardness being the same avatar, or feeling that the other participants' avatars didn't affect collaboration– they were rather more enveloped with the environment and/or the task at hand:

Question: What was it like to brainstorm with the other person in task 1, when you were both assigned avatars?

> "A little difficult because many of the ideas we had for water were already on the board. Them also being the exact same avatar made it a little odd to see when they did the same motions I did." - P010

> "I felt less free to express my ideas and more hesitant to interact with them." - P015

> "It felt impersonal, for lack of a better word. It didn't feel much different than being on a phone call, the avatar didn't really have any meaning because it was chosen arbitrarily." - P026

Moving into part 2, we see more positive responses in regards to partner avatars. Higher levels of enjoyment, engagement, and stimulation were reported from participants. They felt loosened up after having picked an avatar of their choice, and felt an improved sense of interpersonal success in their brainstorming efforts. Although we see no significant difference in ideas generated in part 1 versus part 2, participants perceived their conversations in part 2 to be more natural and flowy:

> "It was a bit more fun and comfortable after we got to choose." - P002

> "The conversation felt more fluid and I was more comfortable expressing our ideas." - P015

"It felt a little more authentic, because we had agency over what we looked like to each other, which I think counts as non-verbal communication. Choosing how to present myself made me feel a little bit more engaged with the virtual space." - P026

In gauging participants' perceptions of how their partner perceived them and their avatar in either part, we found similar trends as we did with participants' responses to what it was like to brainstorm with the other persons' avatar in part 1 and part. Awkwardness, indifference, and discomfort being key descriptors for part 1:

Question: How do you think the other person felt brainstorming with your avatar in part 1?

"Maybe strange because we both had the same avatar." - P012

"I think they felt bored and maybe a little awkward." - P020

"I would say that the other person felt a bit out of place as well, like this wasn't their preferred way (or a bit uncomfortable)." - P033

Moving into part 2, such attitudes were largely assuaged. Participants began to perceive their partners as being more open and comfortable, with increased ease in collaboration. 30 of 40 participant responses implied improved interpersonal relations in part 2, and that their partner's avatar contributed to such:

Question: How do you think the other person felt brainstorming with your avatar in part 2?

"Probably like it was a more human interaction, due to some level of expression where before there was none." - P018

"After we both chose avatars, and ended up choosing the same one, we laughed about that and I feel like my partner felt like they had a little more in common with me." - P026

"I think the other person felt more relaxed as choosing your own avatar provides a sense of silliness depending on what you choose." - P034

Responses to what it was like to brainstorm with one's partner and how one perceived their partner to brainstorm with them revealed that in either case, brainstorming in part 2 was more comfortable and natural than it was in part 1.

4.2.4 Reflections on the Environments

Participants were asked to reflect on their perceptions of the environment they were assigned to post-session. Perceptions between the two different environments differed, with slightly more positive sentiments towards the creative space, namely that the space was "whimsical", "fun", or "cool". Attitudes towards the business environment gravitated towards indifference, boredom, sterility, and task-appropriateness– meaning that a business-like space served the proper functionality for collaborative brainstorming tasks. Such insights were not mentioned by the creative condition participants.

Question: How was it to brainstorm in the environment you were in? Were there aspects of it that you liked/disliked? Why so?

> "I liked the cool chandelier, and the cartoon-magic feel to it." - P025, creative condition

> "It was good, the avatars in part 2 make it more interesting to be sure, and the colors and tones of the environment were not intrusive. The fantasy element definitely gave it some personality." - P018, creative condition

> "The environment matched the task at hand. Would seem like a productive place to get work done." - P008, business condition

> "I liked the city office space, it felt appropriate for what we were doing (and I like those kinds of spaces generally)." - P020, business condition

For both environments, participants took gripes with particular aspects and pointed out what they thought needed improvement. Feelings of restriction, repetitiveness, and distraction were

key complaints for either environment. Several participants found that the environments

missed out on what VR should be able to afford, and that they felt too limited by real-world

physics– implying that otherworldly abilities were expected from the environments and

unfortunately not found:

> "It was nice, but too repetitive. I wish there were objects moving and flying since we were in a VR environment. Being in an area confined by the laws of physics we experience in the real world is boring. I want to live in Harry Potter." - P006, creative condition

> "I liked our environment. The upstairs area where we brainstormed felt a bit containing, but otherwise the downstairs area and surroundings were really cool. I wish we could've sat on furniture." - P033, creative condition

> "Ok. It was fairly sterile, not enough interesting things to look at. A bit cartoonish." - P032, business condition

> "It was terribly boring. It was nice to have a table but the environment was almost distractingly bland." - P035, business condition

Ultimately, neither environment received perfect reviews. The creative space trended towards

slightly more positive sentiments, but both environments share a notable amount of features

that participants would have changed.

4.2.5 Subject Matter Expertise

No participant claimed to have notable expertise in water nor energy conservation. Many

participants claimed their knowledge in either topic came from general awareness of water

and energy conservation, or having a high utility bill in the past leading them to be more

mindful of their personal consumption. No participant reported a higher amount of

knowledge in either topic beyond this.

Chapter 5

Discussion

5.1 General Discussion

The present research investigates how avatar embodiment affects brainstorming and creative success in interpersonal virtual reality scenarios. Participants were given the opportunity in the second part of the study to pick their avatar, after having seen their assigned environment and participating in the first task. As such, this research also investigated how participants use environment and context as a mitigating factor when choosing an avatar. We hypothesized that part 2 would see higher creativity scores than part 1, with creativity scores being the highest in part 2 of the creative environment condition. We also hypothesized that participants would show preference for fanciful styled avatars over business/humanoid styled avatars regardless of environment.

Our quantitative data revealed no significant effects of environment nor avatar on creativity scores. Thus, we reject the formerly mentioned hypothesis. Such results may be due to a low sample size, a key limitation in this study. In short, neither the environment participants were assigned to nor the avatar they embodied in either part had notable statistical effects on creativity performance. Rather, we found significant variance in creativity scores between groups, but this was not due to participants having a relationship prior to participation (i.e., acquaintances or friends), as we found that a former relationship did not have a significant effect on creativity scores. We speculate that this phenomenon may be due to something beyond what the study measured, such as personality type (introversion

vs. extroversion), recent conversations about the topic outside of the study, etc. Future research may consider gathering further information from participants that may impact creativity performance, and hint at why some groups score higher than others.

Other than task type, neither task order nor the first task vs. the second impacted creativity performance. The energy conservation task had significantly higher ideas generated than the water conservation task. Participants reported finding the energy task easier than the water task, indicating that it was a broader topic, and that there were more ways to save energy than to save water. As mentioned, the prompts on either task were an abridged version from an original 15 prompts used by Sun et al. [23] and Won et al. [29]. Upon piloting, we learned that having 7 or more prompts was a hindering factor to fluid conversation. Thus, the list was reduced to 5 to encourage participants to generate more ideas that deviated from the reduced list. In this reduction of the original 15 prompts, it's possible that the energy prompts were unintentionally designed in a way that enabled more successful brainstorming than the water prompts did. Or, simpler: our participants were just more familiar with ways to save energy than to save water. Regardless, we speculate on an extraneous factor influencing higher energy conservation scores not due to any notable expertise in the participants.

Despite our quantitative analysis revealing no significant effect (beyond task type) on creativity scores between part 1 and part 2, our participants reported feeling more creative in part 2 than they did in part 1 regardless of environment or task. Responses in the post-session survey suggest that familiarity contributed to this– familiarity with the environment, the other participant, and the task instructions and goals, suggesting some possible order effects. However, in addition to this was a prevalent sentiment about participant-picked avatars contributing to increased comfort in brainstorming attributed to both self and partner avatars. Having the opportunity to choose one's avatar felt less formal than the previous forced-choice

avatar in part 1– participants felt more represented and at ease with their personal choices which was also noticed by their partners.

Such reflections on part 2 have strong implications for allowing participants to have creative freedom when embodying an avatar. It cannot be ignored that participant enjoyment drastically increases when given the option to choose an avatar one more closely resonates with– which in this study were largely fanciful-style, regardless if in the creative-style or business-style environment. This aligns with the previous in-lab landscape analysis research discussed in chapter 2. When entering either business or creative-styled environments, members of our research group would consistently pick fanciful-styled avatars when they were made available to us– some of us embodying peppers, bananas, or birds. Revealing oneself in any context through means of playful avatar embodiment was a priority for our participants in part 2. The intention of displaying humor, goofiness, uniqueness, and by extension, personality, were are the forefront of participants' rationale for picking the avatars that they did. By doing so, participants foster stronger interpersonal relations by attempting to relate and connect with their partner.

These results highlight missed design opportunities for business-style or productivity-style VR applications, such as Spatial, MeetinVR, Glue VR, etc. Such applications only offer narrow avatar choices limited to humanoid business style or forced likeness (as with Spatial) (see Figure 1.1 for an example).VR applications striving to afford workplace-like environments may be missing the mark when it comes to what avatar options are provided to users. Embodying an avatar of choice in the present study contributed to feelings of higher comfort and enjoyment in comparison to the forced-choice avatar in part 1. While further testing may be needed in order to produce statistically meaningful results, participant reflections compellingly inform us of a strong preference for their chosen avatars,

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which 34 out of 40 times was a non-humanoid, fanciful-style avatar. Alongside these choices was a perceived improvement in creative brainstorming and embodiment. Thus, business or productivity-style VR applications may consider broadening the avatar options offered to users in an effort to improve user experience.

5.2 Limitations

5.2.1 Sample Size

As mentioned, our key limitation in this study was the small sample size. We originally intended to capture 30 participant pairs (60 total participants), but due to unfortunate circumstances this was not feasible. We had experienced a significant delay in hearing back from the IRB for both the preliminary survey conducted by Anya Osborne and for the present study. This placed a several month delay in getting the study up and running. With an upcoming graduation date and the need to finish a thesis on time, we had to scale back our participant sample size to 20 pairs. We also experienced many no-shows and cancellations. Approximately every other scheduled session had a no-show participant.

5.2.2 Spam Accounts and Unqualified Participants

Upon the beginning of recruiting for this study, we experienced an extreme influx of spam bots signing up for the study, limiting spots for viable participants. This lasted several days and required a near complete restructuring of our recruitment process. These spam bots came from our advertisements on Reddit, namely the Subreddit r/samplesize.

Despite asking participants to attest to their United States residency, many non-US based participants signed up for the study erroneously reporting their whereabouts. People

based in the UK, Kazakhstan, and West Africa similarly limited spots for viable participants.

5.2.3 Technical Issues

Another notable limitation in this study was the technical issues we ran into with the wired-in headsets– the Valve Index and the Oculus Rift. Participants who owned these headsets were unable to enter the Mozilla Hubs environments. We found the instructions on how to do this on the Mozilla Hubs website were outdated, thus contributing to unsuccessful attempts in getting wired-in headsets and personal computers to cooperate. These participants were asked to participate on their computers rather than their headsets, which may have affected our data and results.

Chapter 6

Conclusion

In the ideation of this thesis research, we set our sails with a question in mind: what matters when choosing an avatar in interpersonal social VR contexts? The research evolved to not only address this central question, but also what– besides one's own preferences and wishes– influences such choices. Variables like environment, relationship, and situational context all were investigated. Our quantitative analysis revealed no significant effects of avatars, environment, or relationship on creative brainstorming success. However, participants found that their chosen avatars contributed to improved creative brainstorming in part 2.

Future research may consider replicating this study with a few tweaks: larger sample size, better abridgement of the energy and water prompts, and an investigation of extraneous factors (beyond expertise) influencing creativity scores such as personality. Beyond this, further research may investigate using different assessments of creativity besides ideation-based tasks, or consider allowing participants to make their own avatars to see what styles participants conjure– turning the design into less choice-based but freestyle.

Our results also highlight missed design opportunities for social VR platforms, as many platforms offer environment style and avatar style congruence. It may be a wise approach for such platforms to ask what their users want from their avatars, rather than assuming. Or, simply: trust your users (or employees) to embody an avatar that they feel is best for a given scenario. We found that allowing such freedom produces favorable outcomes.

This research just barely taps the surface of all that avatar customization can offer and impact. With the race towards creating the Metaverse, conversations about avatar art and technology are becoming more prevalent than ever. VR affords something that the "real world" struggles to– the ability to create and embody entirely new identities that represent precisely how we want to be perceived.

Appendix

Appendix A: post-session survey questions and answer format

Question	Question response style
What was your participant ID #?	Freeform
What is your age range?	Single answer forced-choice
What is your gender identity?	Freeform
How would you describe your ethnicity?	Freeform
What VR headset did you use today?	Freeform
Please indicate below what your relationship with the other participant was prior to participation in the study	Single answer forced-choice
How long have you been using social virtual reality applications?	Single answer forced-choice
How often do you use social VR?	Single answer forced-choice
If you use social VR, what social VR apps do you use?	Freeform
If you use social VR, what do you use social VR for?	Freeform
If you use social VR, what kind of avatars do you use and what do you like about them?	Freeform
Why did you choose the avatar that you did in part 2?	Freeform
During which task, first or second, do you feel you generated the most creative ideas?	Single answer forced-choice
Why do you think you were more creative in this task?	Freeform
What was it like to be the avatar you were assigned in part 1?	Freeform

What was it like to be the avatar you chose in part 2?	Freeform
What was it like to brainstorm with the other person in task 1, when you were both assigned avatars?	Freeform
What was it like to brainstorm with the other person in task 2, when you both picked your avatars?	Freeform
How do you think the other person felt brainstorming with your avatar in part 1?	Freeform
How do you think the other person felt brainstorming with your avatar in part 2?	Freeform
Do you consider the avatar you embodied in part 1 to have represented you well? Why or why not?	Freeform
Do you consider the avatar you embodied in part 2 to have represented you well? Why or why not?	Freeform
What is the most important thing to you when customizing an avatar? Why?	Freeform
How was it to brainstorm in the environment you were in? Were there aspects of it that you liked/disliked? Why so?	Freeform
How much expertise do you have on water conservation? What is your expertise?	Freeform
How much expertise do you have on energy conservation? What is your expertise?	Freeform
Please upload a photo or selfie of yourself.	Optional image upload
Is there anything else you'd like to share?	Freeform

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