Effects of Display Technology on Avatar Creation in Augmented Reality

Meelad Doroodchi
Dept. Computer Science
Willamette University
Mdoroodchi@willamette.edu

Priscilla Ramos
Dept. Computer Science
Montclair State University
Ramosp3@montclair.edu

Austin Erickson
Dept. Computer Science
University of Central Florida
Ericksona@knights.ucf.edu

Hiroshi Furuya
Dept. Computer Science
University of Central Florida
Furuya@knights.ucf.edu

Damla Turgut
Dept. of Computer Science
University of Central Florida
Damla.Turgut@ucf.edu

Gerd Bruder
Institute for Simulation and Training
University of Central Florida
Gerd.Bruder@ucf.edu

Gregory Welch
Dept. Computer Science
University of Central Florida
Welch@ucf.edu

Abstract

Previous research has established that virtual representations of users in shared or connected environments using virtual or augmented reality (VR/AR) technologies reflect the representational needs of the users [1,2,3]. In this work, we investigated how users customize their avatars based on visibility restrictions that come along in such environments when using an optical see through AR display. We designed a user study (N=20) to evaluate factors including personality, social presence, and visibility in order to determine preferences and changes in avatar attributes such as skin color, clothing, makeup, and hairstyles. We were interested in seeing if display limitations such as transparency, and brightness uniformity affect users' choices. To measure this, we analyzed users' selection of visual attributes while creating their avatars, and their subjective responses using the Microsoft HoloLens 2 AR display.

Study Design

We used a full-factorial within-subjects design in this experiment. We had two factors with two levels each:

- **Environment lighting (2 levels):**
  regular office lighting (200 lux); dim outdoor lighting (2000 lux)
- **Avatar task context (2 levels):**
  formal avatar appearance; casual avatar appearance

20 participants took part in this study: 7 female and 13 male, ages 18 to 55 (mean=23). Each participant completed all four conditions in random order.

Methods

Simulation Development:

Figure 1: Experiment Setup

- Participants had their picture taken to auto-generate an initial 3D avatar representation.
- Participants were presented with a 3D view of their avatar on a Microsoft HoloLens 2 head-mounted display, while also seeing themselves in a mirror.
- Participants were instructed to customize their avatar according to what "situation" their avatars were being put in.
- Participants repeated this process four times; the conditions varied between office lighting and outdoor lighting, and between a formal or casual task context.
- Each participant experienced each condition once, immediately after which they were asked to complete subjective questionnaires to provide feedback on that condition.

Results

Figure 2: Avatar Customization

Figure 3: Full Body VIew of Character Customization

Figure 4: Microsoft HoloLens 2 AR Display

We performed an initial statistical analysis of the results. We analyzed our results with a repeated measures ANOVA at the 5% significance level. We confirmed the assumptions of the parametric tests.

Within Subjects Effects

Cases	Sum of Squares	df	Mean Square	F	p	η_p^2
Lighting	0.800	1	0.800	3.619	0.072	0.160
Residuals	4.200	19	0.221			
Task	0.200	1	0.200	1.357	0.258	0.067
Residuals	2.800	19	0.147			
Lighting ✻ Task	0.200	1	0.200	1.357	0.258	0.067
Residuals	2.800	19	0.147			

Note. Type III Sum of Squares

Figure 5: RM-ANOVA Table on the effect of 'lighting' on 'hair color'

❖ We found a large effect size for the effect of 'lighting' on 'hair color'.
❖ If we ran more participants we would be able to have a significant effect for the combination of these two variables.

❖ The effect of 'task' on 'clothes style' is significant as shown below with p<0.001

Within Subjects Effects

Cases	Sum of Squares	df	Mean Square	F	p	η_p^2
Lighting	0.050	1	0.050	1.000	0.330	0.050
Residuals	0.950	19	0.050			
Task	12.800	1	12.800	46.769	< .001	0.711
Residuals	5.200	19	0.274			
Lighting ✻ Task	0.050	1	0.050	1.000	0.330	0.050
Residuals	0.950	19	0.050			

Note. Type III Sum of Squares

Figure 6: RM-ANOVA Table on the effect of 'task' on 'clothes style'

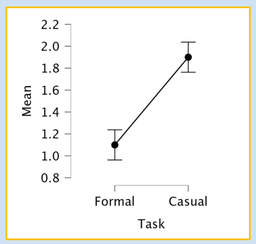

Figure 7: Descriptive Plot on the effect of 'task' on 'clothes style'

Results (Cont.)

❖ The effect of 'task' on 'glasses' is significant as shown below

Task on

Within Subjects Effects

Cases	Sum of Squares	df	Mean Square	F	p	η_p^2
Lighting	0.012	1	0.012	0.106	0.748	0.006
Residuals	2.238	19	0.118			
Task	0.313	1	0.313	6.333	0.021	0.250
Residuals	0.938	19	0.049			
Lighting ✻ Task	0.012	1	0.012	0.192	0.666	0.010
Residuals	1.238	19	0.065			

Note. Type III Sum of Squares

Figure 8: RM-ANOVA Table on the effect of 'task' on 'glasses'

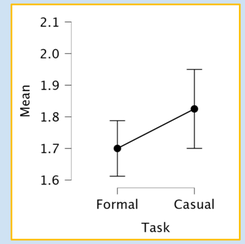

Figure 9: Descriptive Plot on the effect of 'task' on 'glasses'

Post-Hoc Tests

Post Hoc Tests

Post Hoc Comparisons – Lighting ✻ Task

		Mean Difference	SE	t	p_{holm}
Dim, Formal	Bright, Formal	0.100	0.071	1.414	0.331
	Dim, Casual	−0.750	0.127	−5.895	< .001
	Bright, Casual	−0.850	0.127	−6.681	< .001
Bright, Formal	Dim, Casual	−0.850	0.127	−6.681	< .001
	Bright, Casual	−0.850	0.127	−6.681	< .001
Dim, Casual	Bright, Casual	−2.567e−16	0.071	−3.631e−15	1.000

Note. P-value adjusted for comparing a family of 6

Post Hoc Comparisons – Task

		Mean Difference	SE	t	p_{holm}
Formal	Casual	−0.800	0.117	−6.839	< .001

Note. Results are averaged over the levels of: Lighting

Figure 10: Post Hoc Tests on the effect of the Conditions on 'Clothes style'

Conclusion and Future Work

- In our preliminary analysis, the avatar attributes that were affected the most by the conditions were clothes style, hair color, and whether or not the avatar had glasses on.
- Other avatar attributes that were included in the effect size was clothes & skin color
- Proposed future work includes:
  - Investigate interactions between participant appearances and avatars
  - Investigate different virtual environments

Acknowledgments

The support for this work was provided by the National Science Foundation REU program under Award No. 1852002. Any opinions, findings, and conclusions and recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

[1] A. Erickson, G. Bruder, G. Welch, I. Bynum, T. Peck, J. Good. Perceived Humanness Bias in Additive Light Model Displays, Journal of Vision, 2022.
[2] T. Peck, J. Good, A. Erickson, I. Bynum, G. Bruder. Effects of Transparency on Perceived Humanness: Implications for Rendering Skin Tones Using Optical See-Through Displays. IEEE Transactions on Visualization and Computer Graphics (TVCG), 1, pp. 1-11, 2022.
[3] A. Erickson, K. Kim, A. Lambert, G. Bruder, M. P. Browne, G. Welch. An Extended Analysis on the Benefits of Dark Mode User Interfaces in Optical See-Through Head-Mounted Displays. ACM Transactions on Applied Perception, vol. 18, no. 3, 2021.