Exploring Augmented Visual Alterations in Interpersonal Communication

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ABSTRACT

Augmented Reality (AR) glasses equip users with the tools to modify the visual appearance of their surrounding environment. This might severely impact interpersonal communication, as the conversational partners will no longer share the same visual perception of reality. Grounded in color-in-context theory, we present a potential AR application scenario in which users can modify the color of the environment to achieve subconscious benefits. In a consecutive online survey (N=64), we measured the user's comfort, acceptance of altering and being altered, and how it is impacted by being able to perceive or not perceive the alteration. We identified significant differences depending on (1) who or what is the target of the alteration, (2) which body part is altered, and (3) which relationship the conversational partners share. In light of our quantitative and qualitative findings, we discuss ethical and practical implications for future devices and applications that employ visual alterations.

CCS CONCEPTS

• **Human-centered computing** → **Empirical studies in HCI**; *Interaction techniques.*

KEYWORDS

Augmented Reality, visual alterations, interpersonal communication, social acceptability, color-in-context

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1 INTRODUCTION

For centuries, humans have used glasses to level their vision to see reality the way it is. More recently, the idea of embedding Augmented Reality (AR) into glasses added a new layer to this century-old technology. In addition to seeing the existing world in clarity, smart glasses now allow us to "modify our perception and our world" [27]. They can augment the real world with a virtual overlay and allow so-called reality-shifting [36]. Through smartphones, this technology has already found its way into our lives, enriching our reality. Viewed through the smartphone's camera, applications like Pokemon Go [1] allow the user to add animated creatures that blend into their surroundings while other applications allow them to replace faces in real-time [28].

AR technology will not only be used in isolation [4, 17, 37] but could become something we use during social interactions (similar to smartphones). While a first generation of consumer AR glasses has become reality, the societal impact and acceptance of AR glasses are yet to be fully determined. Previous research has already shown that wearing AR glasses alone can impact interpersonal communication, as people today tend to mistrust the technology [25] and feel uncomfortable interacting with it [3, 22, 42]. With our work, we aim to start building a more comprehensive picture and address the important topic of societal impacts of AR glasses. Thus, we aimed to understand the impact a one-sided visual alteration can have on the comfort of both parties (wearer and non-wearer).

To explore how alterations to the perception of objects or even to the communication partners themselves influence the comfort of either person, a concept is needed that provides a reason for executing those alterations. Therefore, we present a concept that justifies and introduces changes to the visual perception, altering an attribute that almost every perceivable object possesses: color. Grounded in color-in-context theory [6], we argue that altering visual stimuli by recoloring existing objects could benefit the user of AR glasses. Color-in-context theory states that perceiving a certain color in a certain context evokes unconscious processes in a person's mind without any intention or awareness [6]. For example, if a person is perceiving a competitor displaying red, the perceiver is tricked into considering the opponent as more dominant, which,

[1] https://pokemongolive.com/en/, Accessed: 11-SEPTEMBER-2020

in turn, impacts their sports performance negatively [13, 18]. Playing with red poker chips makes players feel more dominant and leads them to engage in more risky playing behavior [49]. We argue that controlling which colors we are exposed to is a generic form of visual alteration, representing a set of potential augmentations future AR glasses could provide. We, therefore, present an everyday concept of AR glasses recoloring parts of the users surrounding to induce positive subconscious effects while preventing negative ones.

We utilize this concept of visual color-alterations to explore how comfortable the AR glasses' wearer and their conversational partner are, with one-sided alterations. Analogously to previous work [19, 24, 25], we do not create an artificial scenario in the lab but present the participants with an abstract, but realistic scenario. We then request users to envision themselves in the presented situation. With this approach, we conducted an extensive between-subjects online survey (n=64) to explore how both sides (wearer and non-wearer) would feel about the concept of recoloring objects or parts of either conversation partner. We also suspected that their relationship and whether the colored target area was located on a direct part of the person's body (skin) or the person's clothes/accessories would affect the outcome.

We found that participants generally felt comfortable with the concept and stated that they would use it if available. But also stated that they would not let the AR-HMD (head-mounted display) alone control what they are seeing but would like to be informed and have the last word about it, implicating that participants see the benefits in the concept but are reluctant to trust the AR-HMD. We also found significant effects of the shared relationship as well as the recoloration target, with lesser comfort in recoloring non-wearer compared to the wearer and a detached object. To our surprise, we found that while recoloring parts of the direct body (skin) received the lowest comfort ratings, the wearer showed a significantly lower comfort compared to the non-wearer. We discuss this implied self-stigma towards alterations to a person as well as the ethical implications of one-sided visual alterations.

With this work we make the following contributions:

- The concept of using color-in-context theory in AR to achieve subconscious benefits.
- The quantitive and qualitative findings of an online survey
- Discussion of the found results and the self-stigma regarding visual alterations in AR

2 RELATED WORK

The most relevant related fields of research to our work are (1) acceptance and attitude towards Augmented Reality technology and (2) color-in-context theory.

2.1 Acceptance of AR-HMDs

As Rico et al. [38] revealed, social acceptability of a technology is determined by a multitude of factors including who the person is that accompanies the user. Previous work on AR-HMDs has unveiled that wearing AR-HMDs alone, yields its changes to interpersonal communication. McAtamney et al. [30] found that an active AR-HMDs influenced the quality of interaction and eye-contact between the interlocutors, which was also found by Miller at al. [32]. Koelle et al. [25] explored the acceptance of AR devices in different situations and found that especially the person not wearing the technology (in the following referred to as non-wearer) has a negative view on the AR-HMDs in non-work contexts. In workspace contexts, users are comfortable with the devices, considering them as acceptable work-tools. The authors concluded that knowing the purpose for using an AR-HMDs is crucial to acceptance.

2.2 Acceptance of Action

Research has also found that wearers of AR-HMDs have certain problems interacting with the technology. Serrano et al. [42] explored hand-to-face input with AR-HMDs and found that participants were concerned about using these types of gestures in public places. Trying to tackle this problem of unwanted attention and strong social implications of interaction with AR-HMDs, different approaches have been found. Dobbelstein et al. [3] developed a sensor belt for subtle interaction with AR-HMDs. Hsieh et al. [22] in turn developed haptic gloves to allow interaction with AR-HMDs and found that they were considered unobtrusive and socially acceptable.

While these are key factors that currently holding back the acceptance of AR-HMDs, Koelle et al. [24] conclude from a survey with 51 experts in the field of Augmented Reality that "an alteration in user attitudes as well as an adoption of data glasses is expected until 2026" [24]. They identify usefulness, functionality, usability, and an unobtrusive design as crucial points of long-term adaption. With our work, we contribute to the investigation of societal impacts of AR glasses, by exploring how future functionality of AR-HMDs is perceived by users. To this end, we use visual color alterations based on the color-in-context theory.

2.3 Color-in-Context Theory

Perceiving an object's color is perceiving the light that is reflected or emitted by it [41]. Processing light is an elementary mechanism that evokes processes inside a person's mind without any intention or awareness [6]. Like words that carry different meanings depending on their context [23], the impact of color is determined by its context. A red piece of clothing can make a potential mate appear more attractive [8], while an opponent in a combat sport will appear more dangerous and dominant [10, 20]. Finally, seeing a red progress bar on an IQ-test might diminish the test subject's achievements [11]. In contrast, a blue cooperation logo will make the company appear more competent [26], while a blue piece of meat might indicate that it is rotten. To summarize these effects, Elliot and Maier [6] proposed the *Color-in-context* theory, stating that a certain color stimulus in a certain context will trigger a certain response. This can expand to the whole context the color is perceived in. Even though seeing red on a woman's face makes her appear more attractive, red clothes and accessories [15], or even a red border around her picture [8] can have the same effect.

Some of the responses to certain color stimuli are presumably learned and only appear due to repeated occurrence of the color paired to this particular response. Others, in turn, appear due to biological predispositions, which are reinforced and fortified by social

learning [5]. Maier et al. [29] found that infants had a clear preference for red objects when in a friendly context but opposed red and preferred green objects when in a hostile one, which suggests a context-specific inherent preference. In the West, where red has a generally negative connotation, seeing red impairs performance on IQ-tests [9]. Shi et al. [44] found that the same also happens to people in China, where red has a generally positive connotation. Zhang et al. [50], in return, reported that Chinese stockbrokers, who worked daily with red as a positive sign for stock prices, did not show this effect but had the same effect as green which is associated with sinking stock prices. Despite the unclear origin of these color effects, research has proved their existence. Thus, we found it to be a suitable candidate for our alteration concept.

3 VISION: APPLYING AUGMENTED COLOR ALTERATIONS TO ACCOMPLISH SUBCONSCIOUS BENEFITS

To explore how users would react to the concept of visual alterations in their view while in conversation, we needed to present a clear motivation for executing them. Therefore, we needed a concept whose benefits were universally comprehensible and not based on individual aesthetic preferences, making it comparable between participants. As a broad part of the population might only be vaguely familiar with AR-HMDs and their future application possibilities, we needed the concept to be easy to understand, making it explainable and comprehensible in the scope of a single study. As we wanted to evaluate the difference between altering an object and a person, the concept had to apply to either of them. To not overwhelm the participants, the concept should additionally only induce minor changes or changes in a way that people are familiar with or already know in another context.

In color-in-context theory, we found a scientific proven subconscious mechanism that induced clear, easy to comprehend benefits and disadvantages when triggered. As described in the following, color-in-context describes that seeing a certain color in a certain context triggers subconscious reactions in the AR-HMDs wearer. Our concept, therefore, resolved around altering the coloration of objects and persons to induce positive and prevent negative subconscious effects as will be laid out in the following subsections.

3.1 Employing Color-In-Context Theory in Augmented Reality

In the following, we illustrate our vision on how color-in-context theory could be integrated into future AR-HMDs by describing three scenarios. These depict a person attending a job interview, playing a soccer game, and relaxing in front of their TV. Parts of the following described illustrations are available as videos in the supplementary material to this paper.

3.2 Self Optimization through Color Effects

A person is about to have a job interview. As they enter the room, their AR-HMDs instantaneously recognize their future supervisor's red necktie (see Figure 1(1)). As seeing red would trigger avoidance motivation in the current achievement context [7, 31, 44, 48], the AR-HMDs overlays it with blue to prevent the negative effect. It also colors the walls blue to calm the interviewee [39]. As the interview progresses, the person is asked to write a creative short story. The AR-HMDs colors the pen blue to allow a better creative performance [31].

3.3 Sporting Competition

In the evening the person has an important soccer game, the final game to win the championship. After a foul play, the person is about to shoot the relationship-clinching penalty. The AR-HMD colors the goalkeeper's red jersey blue, making them appear less dominant and giving the player a higher chance of scoring [14] (see Figure 1 (2)). The AR-HMD also colors the person's own shoes and clothes red to make them feel more dominant [49].

3.4 Outside Interpersonal Interaction

As the person comes home, they want to relax in front of the TV and eat something. Trying to lose weight, they are supported by the AR-HMD which colors their plate red to reduce their food intake while watching TV [34] (see Figure 1 (3)). As their coffee got a little cold, the AR-HMD colors the cup in red to make it appear warmer to the person [16]. On TV, a company tries to sell its product by influencing the person through the use of colors [12] but the AR-HMD removes the color stimulus for the user similar to the function of add blocking software today. The person feels a little cold but instead of wasting resources to warm the room, the AR-HMD colors the wall in red to make the room appear warmer [47].

3.5 Summary

The presented scenarios are placed in an imaginary future, where AR-HMDs can recognize a person's context and surroundings. A user is, therefore, enabled to use the technology for influencing their perception to subconsciously achieve certain goals. With the combination of color-in-context theory and AR-HMDs, we found an easy to comprehend concept that can explain why alterations to a person's vision are executed and which benefit they carry. As both, people and objects display color our concept is universally applicable. We additionally argue, that changing the color of an object can be perceived as a comparably minor intrusion to a shared reality, compared to meddling with the structure of things or even going as far as adding new or editing out surrounding visual structures.

4 ONLINE SURVEY

We used the concept described in Section Vision: Applying Augmented Color Alterations to Accomplish Subconscious Benefits to conduct an online survey, exploring how users would react to the concept of visual alterations in their field of view while in conversation. Inspired by prior work done by Koelle et al. [25], we decided to ask participants to imagine themselves in conversation with another person instead of creating an artificial lab scenario, aiming to "rule out potential bias from the artificial situation" [25]. As we wanted to explore how the AR-HMDs *wearer* and *non-wearer* stand to the alterations and to not overwhelm participants, we decided to employ a between-subjects study with *wearer* and *non-wearer* being the levels of the between-subjects factor Point of View (*POV*).

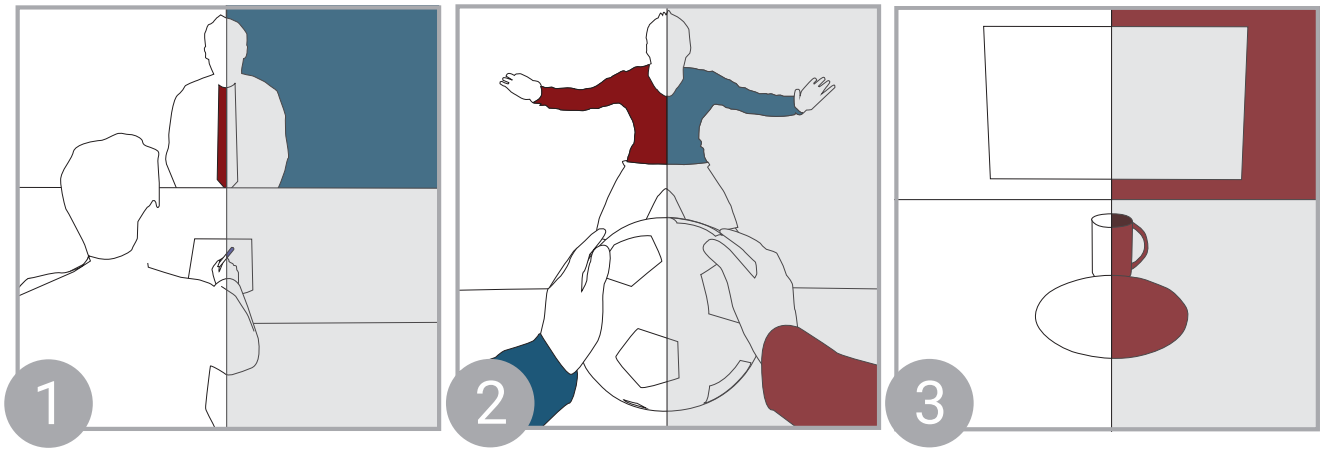


Figure 1: Depictions of (1) a job interview, (2) a soccer match and (3) a living room. Each in its unchanged (left) and augmented coloration (right). The depictions illustrate the scenarios described in section 3.2 to 3.4.

Consequently, each participant only had to imagine themselves as either *wearer* or *non-wearer*.

4.1 Procedure

The survey was structured into three parts. Firstly, to ensure participants had a clear mental construct of the prior non-existing concept they received an extensive introduction.

Introduction
First, participants had to understand how visual alterations could be executed and, secondly, why they could be beneficial to them. Therefore, we textually introduced the concepts of AR-HMDs and color-in-context theory, respectively. We followed up the AR-HMDs explanation by a mock-up video showing how such a device could look and how it could display User Interface elements like Time and Notifications (see Figure 2 (left)) which were inspired by existing devices like Google glass[2]. The explanation of color-in-context theory was followed by a text explaining how the two concepts could be merged and another mock-up video showing a chair being recolored. We added comprehension questions to each section to make sure the participants had understood the concept.

To further give participants practical examples, we created four additional mock-up videos that were derived from the application examples of the concept depicted in Section Vision: Applying Augmented Color Alterations to Accomplish Subconscious Benefits. Each video was introduced by a text section that explained what effect previous work has found and why such a re-coloration could be beneficial to them. In random order, they were exposed to mock-up videos of:

- ... a goalkeeper who's jersey was recolored as their red color made them look more dominant, diminishing the chance to score (see Figure 2)
- ... a plate that was recolored red to assist the user in their dieting efforts (see Figure 2)
- ... a superior who's red tie was recolored to make them appear less dominant and allow the person to be more relaxed around them (see Figure 2)
- ... the own jersey being recolored to feel more dominant and raise the chance of scoring a goal when shooting a penalty (see Figure 2)

Overall, the introduction section took ≈ 12 min and was followed by the two main parts of the study. Both employed *POV* (with the levels *wearer* and *non-wearer*) as between-subject factor. The levels were taken from related work [25, 30]. They describe the *wearer* who is wearing the AR-HMD and is perceiving the visual alterations and the *non-wearer* not wearing an AR-HMD and, therefore, not experiencing the visual alterations.

Part 1: Recoloring parts of *wearer*, *non-wearer* or *object*
The first part of the study was designed to explore if the *relationship* of the conversational partners and the target of the alteration influenced how comfortable the respective individuals felt with the concept of re-coloration. The independent variable *relationship* had three levels (*close person*, *acquaintance*, and *stranger*) describing the relationship between the two. These terms were taken from the work of Sorokowska et. al [46] who utilized them to analyze how different comfort zones varied around the world. The other independent variable *target* consisted of three levels as well ,namely *wearer body*, *non-wearer body*, and *object*. The names self-descriptively point out the alteration's target. Therefore, we used a 3x3 design in which every participant encountered nine conditions.
Depending on the condition, participants were instructed to imagine themselves being in a conversation with either a *close person*, an *acquaintance*, or a *stranger* while imagining a certain part of the scenery as being recolored. To make it easier for participants to imagine the situation and keep track of what is being recolored, we provided an abstract illustration of the respective situation. These were based on the *Humaaans design library* by Pablo Stanley[3]. To

[2]https://developers.google.com/glass/design/ui; Accessed: 16-SEPTEMBER-2020

[3]https://www.humaaans.com/; Accessed: 10-SEPTEMBER-2020

Figure 2: Screenshots from mock-up videos that were shown in the introduction of the study. The picture on the left is a full screenshot from these videos, while the right depicts the parts that show the color augmentation.

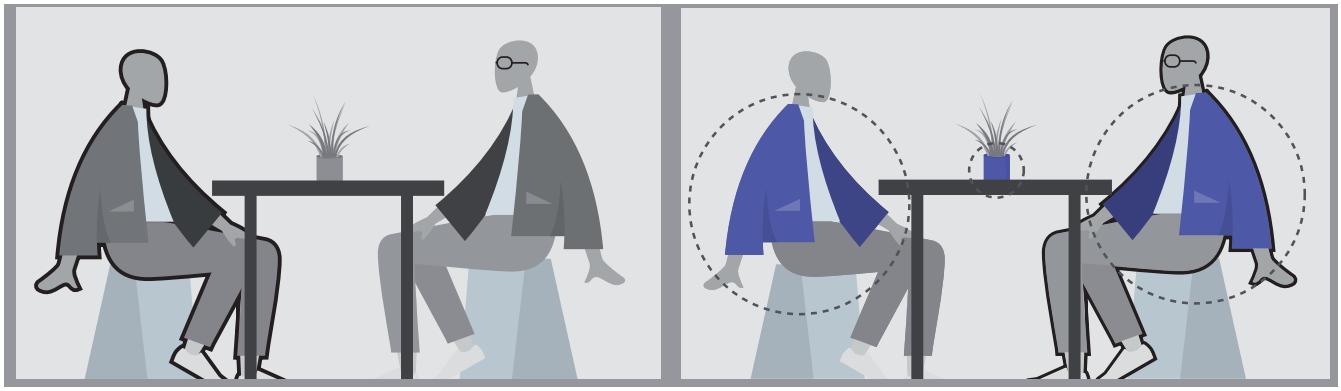


Figure 3: The figure shows depictions that illustrate the situation the participants should imagine to be in. Whom they should imagine to be was highlighted by a black border around the character. On the left, the non-wearers view is shown not perceiving any alterations. On the right, the wearer's view is depicted. Each condition had only one of the colorations that are highlighted by dotted circles for this illustration only.

minimize gender bias, we removed the head hair to make the depicted persons look more androgynous. Participants received a large depiction of what they should imagine seeing and a smaller representation of the view of their opponent, making it easier to assess the situation. Figure 3 (left) illustrates the *non-wearer*'s view while Figure 3 (right) depicts an accumulation of the *wearer*'s view, as in each condition, only one re-coloration was present.

Part 2: Recoloring certain bodyparts

The second part of the study explores how comfortable people are with the concept of altering areas of their own or the other person's body, respectively. We chose an approach inspired by Harrison et al. [19] who highlighted different points of a silhouette resembling a body, asking how comfortable participants would feel if they were touched at this certain point. Analogously, we decided to to ask for comfort in imagining visually altering certain parts of the body. A special focus was put on alterations of the skin and, therefore, the body itself compared to alterations to clothing and accessories. We utilized the same independent variables *relationship* (*close person*, *acquaintance*, and *stranger*) and *target* (*wearer* and *non-wearer*). For this part of the survey, we left out the *target* factors level *object* as it does not apply to the situation we wanted to explore. This resulted in a 3x2 design in which every participant encountered six conditions.

To illustrate the changes to a body, we created the depiction of an androgynous-looking person wearing a typical summer outfit (see Figure 4). This outfit consisted of a t-shirt, shorts, shoes, a watch, and a pair of glasses (depending on the person either Augmented Reality glasses or common prescription glasses). The clothing and accessories organically divided the body into 5 *non-skin* areas. We further divided the body into 5 skin areas, namely Head, Neck Area, Arms, Hands, and Legs.

The participants were instructed to imagine being in conversation with either a *close person*, an *acquaintance*, or a *stranger* (depending on the condition). They were presented with depictions of the above mentioned abstract person either titled "You" or according to the *relationship* level. Participants rated how comfortable they would feel if each body part would be colored independently, as is described in Section Vision: Applying Augmented Color Alterations to Accomplish Subconscious Benefits.

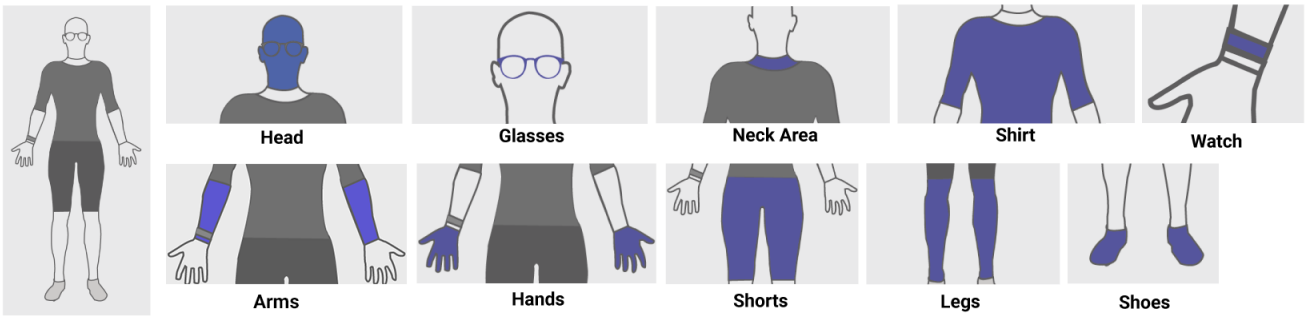


Figure 4: On the left, the depiction of an androgynous body that the participants were asked to imagine being their own. On the right, depictions of the parts that were recolored separately.

General questions and demographics The study ended with several single-item questions about the concept and how much control they would like to have about the alterations. A demographic questionnaire was placed at the end of the study to not prime for stereotype biases [45].

4.2 Measurements

We considered many possible adjectives that could describe how participants feel towards visual alterations and decided to use the scale of comfort. It was previously used as the main metric in Sorokwska et al. [46] on how people felt about others entering their comfort zones. Harrison et al. [19] also used the adjective "comfortable" and argued that it "best captured the multi-dimensional and highly personal nature of touch" [19]. We argue that the same multi-dimensional and highly personal nature applies to the feeling towards the concept of visual alterations. To measure the comfort for a certain visual alteration, we used a 7-Point Likert scale from 1 (very uncomfortable) to 7 (very comfortable). We used this approach in both Part 1 and Part 2.

In Part 1, we also measured *Attitude Towards Using* by using opposite word pairings. Such semantic differentials are an established method of measuring emotional responses in psychology and HCI [24]. For our measurement, we used four word-pairings from the *Attitude Towards Using* subscale of the technology acceptance model [2] on a scale from -2 to +2, corresponding to a 5-Point Likert scale.

In Part 2, participants were asked to rate comfort for each of the 10 individual bodyparts (see Section Procedure). To be able to directly compare all *skin* and *non-skin* areas, we introduced a *surface* score for each area by calculating the mean of all *skin* and *non-skin* areas.

4.3 Participants

We report results of 64 participants (36 male, 26 female, 2 non-binary) aged 18-59 (M=32.89, SD=10.23) that were recruited via Prolific[4]. The study took ≈ 40 min; participants were compensated with 5£ for their efforts. Originally, 86 individuals participated in the study but 22 had to be excluded due to (1) not passing all attention checks we added (in accordance to the Prolifics guide on fair attention checks[5]) throughout the study, (2) not being able to display all videos correctly, or (3) taking less than half the expected time (20min). We nevertheless compensated all participants for their efforts. We recruited US citizens only to avoid confounding variables such as culture [38]. The participants were evenly distributed between the two groups (32 each).

5 RESULTS

In the following, we report our findings. Descriptive and inferential statistics are reported. We focus on the main and interaction effects of the three independent variables *POV* (between-subject), *relationship*, and *target* (both within-subject). For non-parametric data, we used *nparLD* [33] which can even be used with unequal group sizes [1]. ANOVA-type statistics are reported, Bonferroni correction was used for post-hoc tests. Effect sizes were calculated utilizing the formula suggested by Rosenthal [40].
As Part 2 introduced another factor (*surface/body part*), we arrived at one between-subjects and three within-subject factors, which is beyond the limits of nparLD. We, therefore, divided the data per factor into one sub-set per level and executed non-parametric variance analysis (NPVA) on those subsets. Depending on the number of levels, we used Bonferroni adjusted alpha levels. To make the results more readable, we grouped the results of Part 2 per factor and will only report significant results.

5.1 Part 1

For the data of part one, the non-parametric variance analysis (NPVA) revealed a significant main effect on *comfort* of *target* (F=7.76, df=1.8, p<.001, Figure 5a) and *relationship* (F=3.73, df=1.56, p=.03, Figure 5b). We found no significant interaction effects.
A pairwise post-hoc Dunn test showed that participants reported to feel significantly (p=.007, Z=2.83,r=0.14 and p=.005, Z=2.91, r=0.15) less comfortable having the *non-wearer body* (M=4.92, SD=1.95) recolored compared to each *wearer body* (M=5.46, SD=1.70) and *object* (M=5.48, SD=1.66). For *relationship* no statistically significant differences between *close person* (M=5.38, SD=1.79), *acquaintance*

[4]https://www.prolific.co/, Accessed: 10-SEPTEMBER-2020

[5]https://researcher-help.prolific.co/hc/en-gb/articles/360009223553-Using-attention-checks-as-a-measure-of-data-quality, Accessed: 08-JANUARY-2021

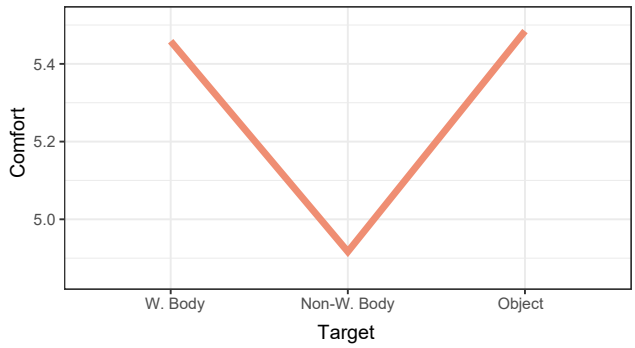


Figure 5: Main effect of *relationship* on *comfort*

(*M*=5.40, *SD*=1.69) and *stranger* (*M*=5.08, *SD*=1.89). There were no other significant differences.

For the Attitude Towards Using (ATT) scores as well as its single items, the NPVA revealed no significant main effects or interaction effects.

5.2 Part 2 - *surface*

The NPVA revealed a significant main effect on *comfort* of *surface* for conversations with each *close person* (F=70.46, df=1, p<.001, Figure 6), *acquaintance* (F=67.32, df=1, p<.001, Figure 6) and *stranger* (F=65.29, df=1, p<.001, Figure 6). As well as a significant main effect for *comfort* of *surface* for each conversation partners bodies, namely *wearer body* (F=68.82, df=1, p<.001, Figure 6) and *non-wearer body* (F=71.38, df=1, p<.001, Figure 6). As we split the data-set into subsets for each level of *relationship* we used Bonferroni adjusted alpha level of .0167 per test (.05/3).

Post-hoc tests showed significant differences between *skin* and *non-skin* on *comfort* for all levels of *relationship* (*close person* [p<.001, Z=6.52, r=0.41], *acquaintance* [p<.001, Z=6.14, r=0.38] and *stranger* [p<.001, Z=6.42 , r=0.40]) and *target* (*wearer body* [p<.001, Z=7.87, r=0.40] and *non-wearer body* [p<.001, Z=7.71, r=0.39]) with Bonferroni adjusted alpha levels. For each of the levels re-coloring *non-skin* was rated as significantly more comfortable than *non-skin* (see Figure 6 (right))

Pairwise comparison has shown significant differences between the specific parts of the body. This can be seen in Figure 6 (left). It should be emphasized that except for Watch and Shorts no significant differences were found between *non-skin* parts of the body. For *skin* parts, the same is true except for Head which shows significant differences in *comfort* compared to all other *skin* parts.

5.3 Part 2 - *POV* and *surface*

Splitting the data by *relationship*, the NPVA revealed an interaction effect for *comfort* between *POV* and *surface* for conversations with each *close person* (F=8.15, df=1, p=.004, Figure 7 (left)), *acquaintance* (F=12.16, df=1, p<.001, Figure 7 (left)), *stranger* (F=11.26, df=1, p<.001, Figure 7 (left)).

Post-hoc tests showed that re-coloration of *skin* has been rated significantly more comfortable for *non-wearer* compared to *wearer* for all for all levels of *relationship* (*close person* [p=.002, Z=-2.96,r=-0.26], *acquaintance* [p<.001, Z=-3.70,r=-0.33] and *stranger* [p<.001, Z=-4.27,r=-0.38]) while having Bonferroni adjusted alpha levels. For mean values and standard derivation see Figure 7 (left). No significant differences where found for *non-skin*.

5.4 Part 2 - *relationship* and *target*

Additionally when splitting the data by *surface*, NPVA revealed an interaction effect for *comfort* between *relationship* and *target* for *skin* (F=6.08, df=1.31, p=.007, Figure 8), *non-skin* (F=7.20, df=1.42, p=.002, Figure 8). Post-hoc tests showed no significant differences.

5.5 Additional Questions

After finishing Part 1 and Part 2 of the study, participants rated multiple single-item questions. The exact wording of the questions can be found in the supplemental material.

Participants agreed (*M*=5.50, *SD*=1.65) when asked if they would activate a re-coloration feature given they owned an AR-HMD and slightly disagreed (*M*=3.56, *SD*=1.96) when asking if they would deactivate such feature.

When asked how much control they wanted to have over the re-coloration, they slightly disagreed with trusting the AR-HMD to change their surrounding without notifying them (*M*=3.86, *SD*=2.14). Contrary, they agreed (*M*=5.92, *SD*=1.50) with wanting to be informed before a re-coloration is executed. They even agreed (*M*=5.56, *SD*=1.77) to be willing to approve every re-coloration before taking effect.

The participants also stated that they would be willing to spend an average of 111.14 $ (*SD*=132.82) to activate the re-coloration function on a AR-HMD they owned.

5.6 General Participant Statements

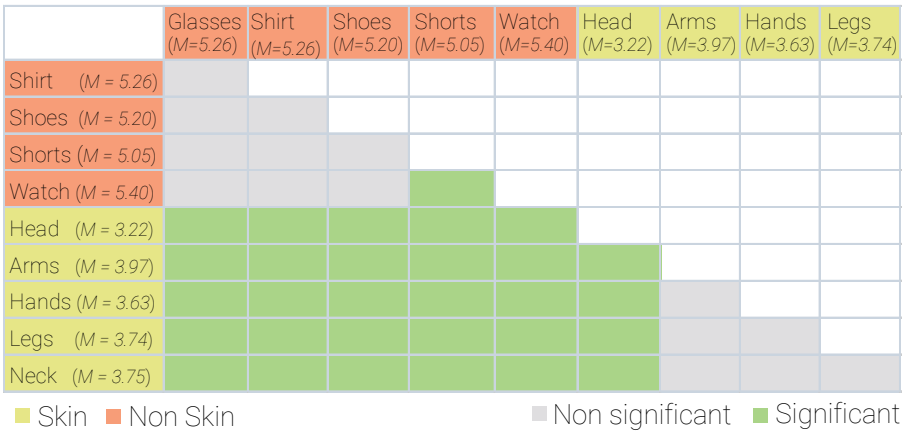
Participants were able to voice chances and concerns that they see in using visual color augmentations via additional open statements. As others [21] already discussed many ethical concerns with regard to AR technology, we focused on the concerns voiced about visual alterations.

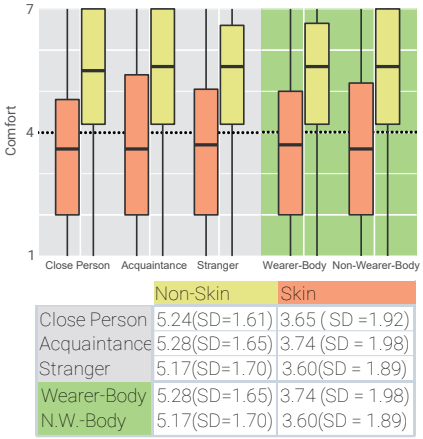
Positive

Many participants named the color alterations displayed in the introduction and the later parts of the story as positive application scenarios. Another common theme was the alteration of the surrounding world according to their own preferences. Altering the physical properties and colors of objects, perceived as unpleasant or distracting to the respective participant's eye or removing them altogether. Additionally, the theme of altering the general appearance of the surrounding world was described as filters known from social media applications. Making a weathered day look warm-tinted or "making colors pop more". Many participants also mentioned the benefit of having additional information displayed in the field of view. Recurring themes were Navigation, News, Information about Weather, the general world around them, Emails, and Notifications.

Negative

A great part of concerns focused on how they and other people might be altered in an abusive manner. Participants voiced concerns

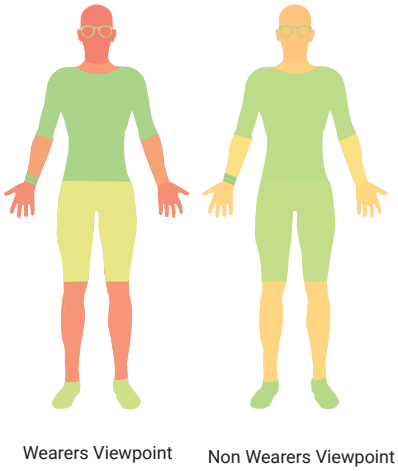




	Non-Skin	Skin
Close Person	5.24(SD=1.61)	3.65 (SD =1.92)
Acquaintance	5.28(SD=1.65)	3.74 (SD = 1.98)
Stranger	5.17(SD=1.70)	3.60(SD = 1.89)
Wearer-Body	5.28(SD=1.65)	3.74 (SD = 1.98)
N.W.-Body	5.17(SD=1.70)	3.60(SD = 1.89)

Figure 6: On the left, depiction of the results of pairwise comparison between the *body parts*. On the right, main effects on *comfort* divided by *relationship* and *target*.

		Non-Skin	Skin
Close Person	Wearer	5.31 (SD=1.48)	3.13 (SD=1.77)
	Non-W.	5.18 (SD=1.73)	4.17 (SD=1.93)
Acquaintance	Wearer	5.28 (SD=1.56)	3.06 (SD=1.63)
	Non-W.	5.29 (SD=1.75)	4.43 (SD=2.08)
Stranger	Wearer	5.12 (SD=1.69)	2.88 (SD=1.57)
	Non-W.	5.23 (SD=1.72)	4.33 (SD=1.90)



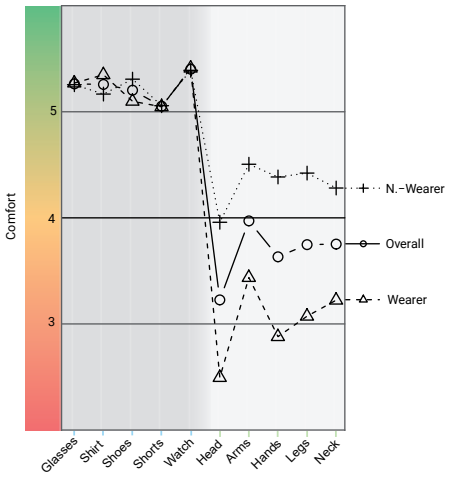


Figure 7: (Left) Interaction effect between *POV* and *surface*. (Middle) *Comfort* for each *wearer* and *non-wearer* depicted as a heatmap. (Right) Mean values for *comfort* of each bodypart overall and divided by *POV*.

that visual alterations could suppress the ability of self-expression by alterations to their clothes. One also stated that skin-color could be altered to change one's ethnicity. Multiple participants described attacks to self-determination by displaying them naked or deep-faking generally "inappropriate image[s] over whoever they wanted". Some participants also referred to the examples given in the study, stating that some of the advantages given might be unfair, especially in sports competition. Some also were concerned about some colors being changed that carry a meaning. For example, altering the colors of traffic lights or warning signs.

6 DISCUSSION

In this section, we describe and discuss the implications and limitations of the presented survey.

6.1 General Comfort

Overall, all conditions were rated towards comfort on a 7-point Likert scale (5.x on a 7 point scale). As participants additionally stated that they would use such a concept, we can conclude that this concept was well received. However, we have to keep in mind that this could potentially change depending on the type of alteration. Therefore, we used a generic application scenario (coloring) to show some potentially inherent differences to alteration which could be even further exaggerated through different types of alterations.

We found that when faced with the concept of altering parts of the person that belong to the body (skin), participants felt significantly less comfortable than when recoloring worn objects. We argue that this might, for one, be grounded in the novelty of such an approach, as they might not be used to seeing skin recolored. On the other hand, all body-parts can be dressed and recolored in this way as the clothes change the perceived color too. Another

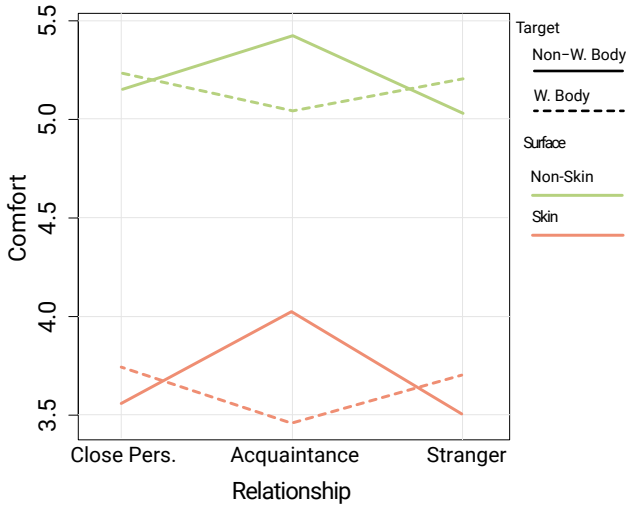


Figure 8: Interaction Effect between *relationship* and *target* for *skin* and *non-skin*

explanation might be the intrusion into the person's personal space. Altering the body itself might be perceived as a larger intrusion into the person's self-identity. The head was the only part of the body that has shown significant differences when comparing how skin parts were rated. The result seems less surprising when considering that the head is commonly tattooed least, meaning there is already a predisposing societal stigma against altering one's head area, as it has a large influence on the appearance a person and might influence how they are treated by society[6].

Even though people showed high levels of comfort in the concept of coloring (worn) objects, participants stated that they would like to be informed and have the final saying in which alterations are executed. This shows that while seeing the benefits in the alterations, they also mistrust the system to not work in their best interest or to act as a moral instance.

6.2 Relationship

In Part 1, we found a significant main effect on the relationship between the two conversational partners, but post-hoc tests showed no significant differences when they were close, acquainted, or strangers to each other. Nevertheless, the second part revealed an interaction between who is the target of re-coloration (the wearer's or the non-wearer's body) and the relationship. Here, being acquainted seems to have a special standing compared to being close or being strangers. While in those cases, the re-coloration of the wearer's body was rated as slightly more comfortable, this difference is turned around and expanded for the acquaintances. This pattern can be observed in both skin and non-skin body parts. We were not able to find a suitable explanation but report this interesting effect that should be examined more closely in future work.

[6]https://www.bbc.com/news/newsbeat-50478621, Accessed: 10-SEPTEMBER-2020

6.3 Concerns

Today, many of the critically voiced alterations are already applicable, or in the realms of possibility, to videos using artificial intelligence. Fake videos that, for example, display a person with another face or replace a whole body, created by so-called deep-fake networks, already pose a problem as the human eye might not be able to distinguish them from real videos. We found that people are alarmed about visual alterations interfering with their self-expression (e.g., by changing clothes), self-identity (e.g., through changes in skin color) and self-determination/agency (e.g., changing them to perceived to be nude or ridiculing them through ridiculous clothing).

As this technology comes closer to becoming a reality, the discussion of what should and what should not be done becomes more urgent. The concerns voiced in our study substantiate that. It has to be discussed what is and what is not acceptable and which changes to reality we are willing to accept to reap the benefits of the new technology.

6.4 Comfort Gap

Surprisingly, we found that the level of comfort for altering colors was mainly influenced by the perspective (wearer, non-wearer) rather than by the target. This means that participants who were imagining being the wearer reported lower comfort scores for altering parts of the skin independent of the target (self or other). Additionally, we found that participants who imagined themselves to be the non-wearer reported higher acceptance scores for alterations towards oneself or the other. This means that the non-wearer, in our online survey, felt more willing towards alterations while the wearer felt more conservative towards alterations. To a degree, these findings contradict those by Koelle et al. [25] who found that the wearer of AR-HMDs in interpersonal communication is generally more comfortable with the situation.

Our findings imply a certain stigma towards the usage of AR technology. Analogously to feeling insecure when executing hand-to-face gestures [42] in public, the unfamiliar act of altering parts of the human body could cause the wearer to feel less comfortable. They perceive themselves as the source of an extraordinary, maybe morally questionable, happening and feel insecure about what others could think of them. This might go as far as experiencing fear of getting caught, as they feel like committing a socially unacceptable act of changing a person in their private display of the world. The fact that the wearer is held back when altering a person brings us to the discussion about whether this is justified.

The ability to change the visual perception of another person is something that we already have. We could just use our imagination and imagine a variety of alterations perceived as good or even bad. However, having this now be amplified in its fidelity through technology raises the question: Do I have the right to change the visual appearance of another person even if it is only for my personal use? There are two sides to this argument which are either grounded in the freedom of thoughts (as long as you do not share this information and by that harm the other individual, you can imagine/do whatever you want) or in the dignity of the individual (every human has the individual right of self-expression and should have control of his or her visual appearance). We do not want to

take a position in this argument but rather raise this upcoming issue and present valid points for each side.

Pro Alteration: A point could be made that the only person perceiving the alterations is the person wearing the glasses. The alterations only influence the person themselves and, therefore, only concern them. The alterations become part of their private subjective reality. Limiting what you are allowed to change could be equated with limiting how a person is allowed to see the world. Drastically spoken, outlawing certain alterations could therefore come close to Orwell's "thought police" [35].

Con Alteration: Displaying who one is and how they want to be perceived by the outside world is a fundamental part of self-expression and can be expressed, for example, via clothes [43]. Participants in our study stated that they were alarmed about visual alterations interfering with their self-expression (e.g., by changing clothes), self-identity (e.g., through changes in skin color), and agency over the own body (e.g., changing them to perceived to be nude or ridiculing them through ridiculous clothing). Even though only perceivable to the wearer, it nevertheless could be regarded as an intrusion into the target's personal rights, denying their self-expression, robbing them of their identity, and violating their agency over their own body. The argument that alterations to another person only have an influence on the wearer and, therefore, only concerns them could be countered by the fact that if allowed, the targeted person has to live with the fear that every person wearing an AR-HMD could be potentially violating their personal rights. This, in turn, would harm not only the person altered but everyone facing an AR-HMD. A participant stated their opinion on alterations in the following way:

> *"As a woman, I'm very uncomfortable with the idea that augmented reality might change something about my body. In this study, it's just a color, but what if this technology could be used to change the appearance of parts of my body without my consent? I think that would absolutely happen in the real world and I would not be okay with it."*

6.5 Limitations

As the technology referred to is not yet available, we could not measure reactions to the technology itself but only to the abstract concept. This, in combination with the novelty factor of the AR-HMD technology, might have had a significant impact on our findings.

Even though we were trying to present a situation as abstractly as possible to not bias the participants, we had to clarify the rather complex concept by opening with concrete examples and presenting imagery coupled with specific benefits during the study. We also only investigated color alterations and not the general concept of visual alterations. These points together could negatively influence the generalizability of our findings. Additionally, we used comfort as the main metric for our study, while applicable to most interpersonal communication, situations may arise in which the metric is not the decisive factor in deciding whether or not execute alterations. This includes, for example, sports competition, where the competitor would have no interest in the wearer getting an advantage, and a low level of comfort in this competitor could be even advantageous for the wearer. Also while avoiding certain biases, the androgynous avatar might induce distortions, as males and females might have different associations of different body regions.

We also made a distinction between objects and parts of the participant's bodies but disregarded possible differences between objects. Some objects detached from the body might still be part of the self-identification of a person (e.g., a person's car or smartphone) and could be regarded as an analog to a worn object. Previous work [25] also has shown that knowing the action of an AR-HMD makes it more acceptable for bystanders. To evaluate what the *non-wearer* is thinking, we had to let them in into the functionality of the AR-HMD, which in turn might have influenced the survey's result.

7 CONCLUSION

In this work, we presented the concept of Augmented Reality recolorations to achieve subconscious benefits based on color-in-context theory [6]. We also present quantitative and qualitative results from an online survey (N=64) utilizing this concept to explore which impact a one-sided visual alteration can have on both parties' comfort in interpersonal communication (wearer and non-wearer). On the one hand, participants overall showed high comfort levels with the concept of these visual alterations, stating that they would use such a function. On the other, they stated that they would like to be informed and even have the last word if an alteration is executed. This implies that they see the benefits in the concept but mistrust AR technology to act unsupervised. We report a significant effect of the conversational partners' relationship and the target of alterations, with the partners being more comfortable with recoloring the wearer's body and detached objects than the non-wearers body. We also found that participants were more uncomfortable with alterations to parts of the direct body (skin) than worn objects. Surprisingly, we found a comfort gap in who perceives these alterations to the body (the wearer being significantly less comfortable with recolored skin than the non-wearer) but not who the alteration target is (wearer body or non-wearer body). These findings imply a certain stigma towards the usage of AR technology. We present points for both sides of the argument of the ethical discussion about alterations to a person's body, basing the counterarguments on concerns voiced in our survey. Our research, therefore, provides the concept of color alterations in AR and first findings and implications on how users perceive visual alterations in interpersonal communication.

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REFERENCES

[1] Mark Colley, Marcel Walch, Jan Gugenheimer, Ali Askari, and Enrico Rukzio. 2020. Towards Inclusive External Communication of Autonomous Vehicles for Pedestrians with Vision Impairments. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems* (Honolulu, HI, USA) *(CHI '20)*. Association for Computing Machinery, New York, NY, USA, 1–14. https://doi.org/10.1145/3313831.3376472

[2] Fred D Davis. 1985. *A technology acceptance model for empirically testing new end-user information systems: Theory and results.* Ph.D. Dissertation. Massachusetts Institute of Technology.

[3] David Dobbelstein, Philipp Hock, and Enrico Rukzio. 2015. Belt: An Unobtrusive Touch Input Device for Head-Worn Displays. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems* (Seoul, Republic of Korea) *(CHI '15)*. Association for Computing Machinery, New York, NY, USA, 2135–2138. https://doi.org/10.1145/2702123.2702450

[4] Brian L. Due. 2015. The social construction of a Glasshole: Google Glass and multiactivity in social interaction. *PsychNology J.* 13 (2015), 149–178.

[5] Andrew J Elliot. 2015. Color and psychological functioning: a review of theoretical and empirical work. *Frontiers in Psychology* 6 (2015), 368.

[6] Andrew J. Elliot and Markus A. Maier. 2012. *Color-in-Context Theory.* Vol. 45. Elsevier, Amsterdam, The Netherlands. 1–59 pages. https://doi.org/10.1016/B978-0-12-394286-9.00001-9

[7] Andrew J. Elliot, Markus A. Maier, Arlen C. Moller, Ron Friedman, and Jörg Meinhardt. 2007. Color and psychological functioning: The effect of red on performance attainment. *Journal of Experimental Psychology: General* 136, 1 (2007), 154–168. https://doi.org/10.1037/0096-3445.136.1.154

[8] Andrew J Elliot and Daniela Niesta. 2008. Romantic red: red enhances men's attraction to women. *Journal of personality and social psychology* 95, 5 (2008), 1150.

[9] Andrew J Elliot, Vincent Payen, Jeanick Brisswalter, Francois Cury, and Julian F Thayer. 2011. A subtle threat cue, heart rate variability, and cognitive performance. *Psychophysiology* 48, 10 (2011), 1340–1345.

[10] Roger Feltman and Andrew J Elliot. 2011. The influence of red on perceptions of relative dominance and threat in a competitive context. *Journal of Sport and Exercise Psychology* 33, 2 (2011), 308–314.

[11] Timo Gnambs, Markus Appel, and Bernad Batinic. 2010. Color red in web-based knowledge testing. *Computers in Human Behavior* 26, 6 (2010), 1625–1631. https://doi.org/10.1016/j.chb.2010.06.010

[12] Gerald J Gorn, Amitava Chattopadhyay, Tracey Yi, and Darren W Dahl. 1997. Effects of color as an executional cue in advertising: They're in the shade. *Management science* 43, 10 (1997), 1387–1400.

[13] Iain Greenlees, Alex Leyland, Richard Thelwell, and William Filby. 2008. Soccer penalty takers' uniform colour and pre-penalty kick gaze affect the impressions formed of them by opposing goalkeepers. *Journal of sports sciences* 26, 6 (2008), 569–576.

[14] Iain A Greenlees, Michael Eynon, and Richard C Thelwell. 2013. Color of soccer goalkeepers' uniforms influences the outcome of penalty kicks. *Perceptual and motor skills* 117, 1 (2013), 1–10.

[15] Nicolas Gueguen and Celine Jacob. 2014. Clothing color and tipping: Gentlemen patrons give more tips to waitresses with red clothes. *Journal of Hospitality & Tourism Research* 38, 2 (2014), 275–280.

[16] Nicolas Guéguen and Céline Jacob. 2014. Coffee cup color and evaluation of a beverage's "warmth quality". *Color Research & Application* 39, 1 (2014), 79–81.

[17] Jan Gugenheimer, Evgeny Stemasov, Julian Frommel, and Enrico Rukzio. 2017. ShareVR: Enabling Co-Located Experiences for Virtual Reality between HMD and Non-HMD Users. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems* (Denver, Colorado, USA) *(CHI '17)*. Association for Computing Machinery, New York, NY, USA, 4021–4033. https://doi.org/10.1145/3025453.3025683

[18] Norbert Hagemann, Bernd Strauss, and Jan Leißing. 2008. When the referee sees red.... *Psychological science* 19, 8 (2008), 769–771.

[19] Chris Harrison and Haakon Faste. 2014. Implications of Location and Touch for On-Body Projected Interfaces. In *Proceedings of the 2014 Conference on Designing Interactive Systems* (Vancouver, BC, Canada) *(DIS '14)*. Association for Computing Machinery, New York, NY, USA, 543–552. https://doi.org/10.1145/2598510.2598587

[20] Russell A. Hill and Robert A. Barton. 2005. Red enhances human performance in contests. *Nature* 435, 7040 (2005), 293. https://doi.org/10.1038/435293a

[21] Bjørn Hofmann, Dušan Haustein, and Laurens Landeweerd. 2017. Smart-glasses: Exposing and elucidating the ethical issues. *Science and Engineering Ethics* 23, 3 (2017), 701–721.

[22] Yi-Ta Hsieh, Antti Jylhä, Valeria Orso, Luciano Gamberini, and Giulio Jacucci. 2016. Designing a Willing-to-Use-in-Public Hand Gestural Interaction Technique for Smart Glasses. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems* (San Jose, California, USA) *(CHI '16)*. Association for Computing Machinery, New York, NY, USA, 4203–4215. https://doi.org/10.1145/2858036.2858436

[23] Walter Kintsch and Praful Mangalath. 2011. The construction of meaning. *Topics in Cognitive Science* 3, 2 (2011), 346–370.

[24] Marion Koelle, Abdallah El Ali, Vanessa Cobus, Wilko Heuten, and Susanne CJ Boll. 2017. All about Acceptability? Identifying Factors for the Adoption of Data Glasses. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems* (Denver, Colorado, USA) *(CHI '17)*. Association for Computing Machinery, New York, NY, USA, 295–300. https://doi.org/10.1145/3025453.3025749

[25] Marion Koelle, Matthias Kranz, and Andreas Möller. 2015. Don't Look at Me That Way! Understanding User Attitudes Towards Data Glasses Usage. In *Proceedings of the 17th International Conference on Human-Computer Interaction with Mobile Devices and Services* (Copenhagen, Denmark) *(MobileHCI '15)*. Association for Computing Machinery, New York, NY, USA, 362–372. https://doi.org/10.1145/2785830.2785842

[26] Lauren I Labrecque and George R Milne. 2012. Exciting red and competent blue: the importance of color in marketing. *Journal of the Academy of Marketing Science* 40, 5 (2012), 711–727.

[27] Nicola Liberati and Shoji Nagataki. 2015. The AR glasses'"non-neutrality": their knock-on effects on the subject and on the giveness of the object. *Ethics and information technology* 17, 2 (2015), 125–137.

[28] Luming Ma and Zhigang Deng. 2020. Real-Time Face Video Swapping From A Single Portrait. In *Symposium on Interactive 3D Graphics and Games* (San Francisco, CA, USA) *(I3D '20)*. Association for Computing Machinery, New York, NY, USA, Article 3, 10 pages. https://doi.org/10.1145/3384382.3384519

[29] Markus A. Maier, Petra Barchfeld, Andrew J. Elliot, and Reinhard Pekrun. 2009. Context Specificity of Implicit Preferences: The Case of Human Preference for Red. *Emotion* 9, 5 (2009), 734–738. https://doi.org/10.1037/a0016818

[30] Gerard McAtamney and Caroline Parker. 2006. An Examination of the Effects of a Wearable Display on Informal Face-to-Face Communication. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Montréal, Québec, Canada) *(CHI '06)*. Association for Computing Machinery, New York, NY, USA, 45–54. https://doi.org/10.1145/1124772.1124780

[31] Ravi Mehta and Rui Juliet Zhu. 2009. Blue or red? Exploring the effect of color on cognitive task performances. *Science* 323, 5918 (2009), 1226–1229.

[32] Mark Roman Miller, Hanseul Jun, Fernanda Herrera, Jacob Yu Villa, Greg Welch, and Jeremy N Bailenson. 2019. Social interaction in augmented reality. *PloS one* 14, 5 (2019), e0216290.

[33] Kimihiro Noguchi, Yulia R Gel, Edgar Brunner, and Frank Konietschke. 2012. nparLD: an R software package for the nonparametric analysis of longitudinal data in factorial experiments. *Journal of Statistical Software* 50, 12 (2012), 23 pages.

[34] Genschow O., Reutner L., and Wänke M. 2012. The color red reduces snack food and soft drink intake. *Appetite* 58, 2 (2012), 699–702. https://doi.org/10.1016/j.appet.2011.12.023

[35] George Orwell. 2017. *1984 & Animal Farm.* Text Publishing, Melbourne, Australia.

[36] Isabel Pedersen and David Blakesley. 2013. Ready to wear: A rhetoric of wearable computers and reality-shifting media.

[37] Xukan Ran, Carter Slocum, Maria Gorlatova, and Jiasi Chen. 2019. ShareAR: Communication-Efficient Multi-User Mobile Augmented Reality. In *Proceedings of the 18th ACM Workshop on Hot Topics in Networks* (Princeton, NJ, USA) *(HotNets '19)*. Association for Computing Machinery, New York, NY, USA, 109–116. https://doi.org/10.1145/3365609.3365867

[38] Julie Rico and Stephen Brewster. 2010. Usable Gestures for Mobile Interfaces: Evaluating Social Acceptability. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Atlanta, Georgia, USA) *(CHI '10)*. Association for Computing Machinery, New York, NY, USA, 887–896. https://doi.org/10.1145/1753326.1753458

[39] L. D. Rosenstein. 2011. Effect of Color of the Environment on Task Performance and Mood of Males and Females with High or Low Scores on the Scholastic Aptitude Test. *Perceptual and Motor Skills* 60, 2 (2011), 550–550. https://doi.org/10.2466/pms.1985.60.2.550

[40] Robert Rosenthal, Harris Cooper, and L Hedges. 1994. Parametric measures of effect size. *The handbook of research synthesis* 621, 2 (1994), 231–244.

[41] Tim Schilling, Alexandra Sipatchin, Lewis Chuang, and Siegfried Wahl. 2019. Looking through 'rose-tinted'glasses: The influence of tint on visual affective processing. *Frontiers in Human Neuroscience* 13 (2019), 187.

[42] Marcos Serrano, Barrett M. Ens, and Pourang P. Irani. 2014. Exploring the Use of Hand-to-Face Input for Interacting with Head-Worn Displays. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Toronto, Ontario, Canada) *(CHI '14)*. Association for Computing Machinery, New York, NY, USA, 3181–3190. https://doi.org/10.1145/2556288.2556984

[43] Deirdre Shaw, Gillian Hogg, Elaine Wilson, Edward Shiu, and Louise Hassan. 2006. Fashion victim: the impact of fair trade concerns on clothing choice. *Journal of Strategic Marketing* 14, 4 (2006), 427–440.

[44] Jiaxin Shi, Chao Zhang, and Feng Jiang. 2015. Does red undermine individuals' intellectual performance? A test in China. *International Journal of Psychology* 50, 1 (2015), 81–84. https://doi.org/10.1002/ijop.12076

[45] Margaret Shih, Todd L Pittinsky, and Nalini Ambady. 1999. Stereotype susceptibility: Identity salience and shifts in quantitative performance. *Psychological science* 10, 1 (1999), 80–83.

[46] Agnieszka Sorokowska, Piotr Sorokowski, Peter Hilpert, Katarzyna Cantarero, Tomasz Frackowiak, Khodabakhsh Ahmadi, Ahmad M Alghraibeh, Richmond Aryeetey, Anna Bertoni, Karim Bettache, et al. 2017. Preferred interpersonal distances: a global comparison. *Journal of Cross-Cultural Psychology* 48, 4 (2017), 577–592.

[47] Nancy j. Stone and Anthony j. English. 1998. Task type, posters, and workspace color on mood, satisfaction, and performance. *Journal of Environmental Psychology* 18, 2 (1998), 175–185. https://doi.org/10.1006/jevp.1998.0084

[48] Ayumi Tanaka and Yuki Tokuno. 2011. The effect of the color red on avoidance motivation. *Social Behavior and Personality: an international journal* 39, 2 (2011), 287–289.

[49] Femke S. Ten Velden, Matthijs Baas, Shaul Shalvi, Paul T Y Preenen, and Carsten K W De Dreu. 2012. In competitive interaction displays of red increase actors' competitive approach and perceivers' withdrawal. *Journal of Experimental Social Psychology* 48, 5 (2012), 1205–1208. https://doi.org/10.1016/j.jesp.2012.04.004

[50] Tengxiao Zhang and Buxin Han. 2014. Experience reverses the red effect among Chinese stockbrokers. *PloS one* 9, 2 (2014), e89193.