

Exploring the Use of Real-Time Camera Filters on Embodiment and Creativity

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ABSTRACT

Virtual representations of ourselves can influence the way we feel and behave. While this phenomenon has been explored heavily in the realms of virtual reality and gaming, little is known about the level of impact increasingly pervasive real-time camera filters can have on how people feel, think, and behave. The prevalence and popularity of these technologies have surged, coupled with greater usage of online communication tools. Motivated by a desire for self-improvement in an age of regular video-based online communication, we conducted a user study to investigate the potential for real-time camera filters to influence emotions, support embodiment illusions, and consequently impact cognitive performance by applying it to the domain of creative thinking.

CCS CONCEPTS

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

KEYWORDS

self-perception, camera filters, real-time, embodiment, creativity,

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1 INTRODUCTION

The use of video-based online communication has grown over the last decade and has surged due to the need for remote work during the COVID-19 pandemic [31]. Beyond connecting individuals online, many video conferencing platforms offer the unique ability to digitally manipulate visuals during conversations. For instance, the look of one's environment can be changed with the use of virtual backgrounds. Additionally, a growing number of platforms provide real-time camera filters (e.g. Zoom [33] and Snap Camera [28]), which present an accessible avenue for manipulating one's appearance. This is particularly interesting as they not only enable us to alter how others perceive us, but also allow us to change how we perceive ourselves. While filters have originally been designed for entertainment purposes, little is known about how they can be leveraged constructively for productivity scenarios.

Many studies, particularly in the domain of virtual reality (VR) and gaming have shown that the digital representations of ourselves can impact our sensory perception, alter our behaviour, and even impact our cognitive abilities [2, 12, 18, 24]. While the use of camera filters in the context of video-based communication is considerably different from the scenarios previously studied in VR research, we also observe promising parallels between them. More importantly, their simplicity of use and the multiplicity of situations during which such filters could potentially be applied, motivates us to investigate the potential of this technology for similar applications.

In this paper, we contribute a preliminary investigation into the potential impact and use of real-time camera filters in the context of creativity. As a motivation, we present a survey (174 responses) on people's experiences with video-based online communication. We then conduct a remote user study with 21 participants comparing participants' experience of a *no-filter* condition (A) to real-time camera filter conditions, *inventor* (I) and *child* (C). Subjects' perceptions of embodiment and mood were captured to investigate what underlying psychological processes and mechanisms may underpin filter effects. Divergent thinking tasks were conducted to investigate the potential impacts filters may have on creative cognitive ability. We summarize our findings and discuss ideas for future research in this direction.

2 RELATED WORK

For our investigation into the effects of real-time camera filters, we consider prior works relating to embodiment illusions, self-perception, and creativity.

2.1 Embodiment Illusions & the Proteus Effect

Research has shown that the brain's representation and perception of the body is malleable. Our experience of having a body, or our sense of embodiment [21], can be manipulated with the use of physical props or virtual reality (VR). The Rubber Hand Illusion [5] demonstrated that one can have the feeling of embodiment over a visible fake rubber hand when it is physically stroked in time with one's real unobserved hand. In VR, an embodiment illusion can extend from a virtual limb to a full-body avatar. The strength of such illusions is influenced by multiple factors including one's sense of ownership, agency and location of an avatar [9]. Multi-sensory integration, including visuo-tactile [27] and visuo-motor techniques, such as seeing one's movement in a virtual mirror [10], is used to enforce and heighten this illusion. Changes can also be made to the mental representation of one's face. This is referred to as the enfacement illusion [11, 30].

Embodying an avatar in VR has been demonstrated to have powerful effects on people's behaviors and abilities in many contexts. It has been shown to help boost physical expressivity [18], manipulate the severity of stereotype threat [24], and improve problem solving abilities [2]. In a study by Guegan et al. [12], engineering students who embodied "inventor" avatars in VR demonstrated greater fluency and originality of ideas in a collaborative brainstorming task compared to neutral- and no-avatar conditions. The Proteus Effect [32], the phenomenon wherein people's behaviors conform to their digital self-representations, is seen as a driving mechanism behind these changes in performance [12]. This is further supported by the self-perception theory [4] that people may infer their internal states or characteristics from external cues. However, while the implications of altering self-perception via the embodiment illusion in VR is strongly established, the use of real-time camera filters presents a novel avenue for exploration.

2.2 Technology-Mediated Creativity

Creativity is defined as the ability to discover novel and useful solutions to a given problem [1, 26]. It is often mapped to divergent thinking abilities [14, 16]. As a popular topic of study in psychology and cognitive science, many approaches have been developed to measure and assess one's creative thinking abilities [14, 16, 19, 25].

In human-computer interaction (HCI), the prospect of augmenting one's creative abilities has spurred many unique research efforts [8, 15]. Nakazato et al. [22] investigated how changing the facial appearance of pairs of people, either through expression or similarity between them during video calls impacts the outcome of collaborative brainstorming. In online crowdsourced environments, computational priming via the assumption of different roles coupled with affective stimulation via images was studied as a means to boost creativity, and was found to be potentially helpful when one runs out of ideas [23]. *Avatar-mediated brainstorming tools* [6, 13, 20] is an emerging class of creativity support tools. While avatars and creative idea generation were explored from the angle

of embodying someone else [12], it has also been proposed that self-similar avatars in VR can offer a creative boost by increasing feelings of self-identification and positive affect [20]. In contrast to these works, we perform a novel investigation into the potential for real-time camera filters to alter self-image, by allowing subjects to see themselves as an inventor-like figure or as a child.

3 CONCEPT & MOTIVATION

As mentioned, studies have shown that virtually embodying someone who we perceive as having greater abilities than our own may have a positive impact on our own capabilities. Ongoing research, particularly in VR, continues to study the acceptance of different manipulations to a self-avatar and their subsequent "attitudinal, social, perceptual and behavioral effects" [9]. Building on this, and taking inspiration from how virtual real-time mirror reflections in VR can drive a sense of embodiment of a virtual avatar [10], we explore the potential for increasingly pervasive real-time camera filters to produce a similar illusion in the context of online video calls. As it is still unknown to what degree real-time camera filters can support a sense of embodiment, particularly when used on their own, we conduct a study to investigate this concept. We also extend our study to explore its applicability to augment cognition in the realm of creative thinking.

3.1 Online Survey of Online Communication

The onset of the COVID-19 pandemic quickly unearthed the need to rely on online communication tools. We were interested in understanding people's experiences with using online video-based communication for work and conducted an online survey. There were a total of 174 respondents (96 males, 76 females, 2 undisclosed), whose ages ranged from 17 - 80 ($M = 43.5$, $SD = 14.80$). They included people working in different sectors (e.g. finance, health, science and technology, education), such as accountants, bankers, physicians, therapists, software designers and developers, team leads, scientists and researchers, teachers and students. We asked questions regarding the types of online communication tools and features they use, the types of calls they engage in, and their experiences using the various available features. People predominantly used their laptops (91.9% of all respondents) to hold video-calls, followed by mobile devices and tablets (33.7% and 12.2% respectively). The top five most common types of calls people engaged in were *information sharing*, *status updates*, *planning/decision making*, *problem solving/brainstorming*, and *team building*.

Participants were asked to report their habits around watching the video streams of others as well as watching their own self-view. The majority of people have self-view enabled and occasionally look at themselves. Given the feature to turn off one's camera/video-stream, most people reported keeping their cameras on for most of the time or all of the time. Reasons for looking at one's self-view are summarized in Figure 1 (right). The survey highlighted that in the context of online communication, there is the potential for one's self-view to serve as a channel for helpful input (from system to user). Given that people are able to see a live video stream of themselves during video calls, real-time filter effects may be able to play a constructive role based on the Proteus effect.

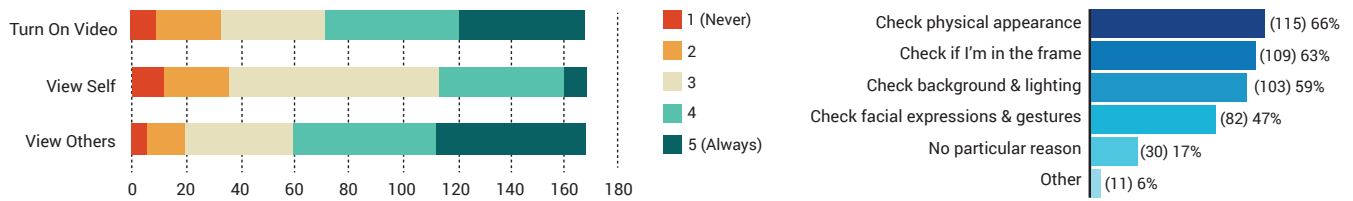


Figure 1: Results from the online communication survey. Left: summary of use of different features (1 = Never, 5 = Always). Right: reasons respondents have for checking their own self-view as a percentage of all respondents. Note: the responses of 7 participants were dropped for this analysis due to contradicting answers (reported *Turn On Video* = 1 but *Viewing Self* > 1).

3.2 Real-Time Camera Filter Experiences

Real-time filters face unique challenges with regards to embodiment. During a regular video conferencing session, the illusion of embodiment can only be supported by an image on a two-dimensional screen. This parallels the experience of looking at virtual mirror reflections in immersive VR [10]. However, in contrast to standard immersive VR experiences facilitated using head-mounted displays (HMDs), it is not possible to support the illusion at any viewing angle. Instead, the illusion is limited to the size of the display and can be dispelled when a person looks down at their own physical bodies in the real physical space. Despite this limitation, we were motivated to study the impact of filters on cognition in the creativity domain. Filters are highly accessible and scalable, and many activities including brainstorming can be done without requiring people to divert their gaze from the screen. Furthermore, as outlined earlier, evidence from VR studies suggest that manipulating one's digital self-image can have notable impacts on cognition.

4 USER STUDY

In this study, we conducted an online experiment over Zoom to explore the effects of real-time filters on creativity. In particular, major cognitive and affective factors, such as mood and embodiment, were examined to understand potential underlying mechanisms and processes. While we considered investigating filters in group settings, as they may yield stronger effects, we decided to first study the applicability of filters on oneself to understand the effects of self-image manipulation with real-time camera filters.

4.1 Conditions

Each participant experienced three different filter conditions: a no-filter, **adult condition (A)**, an **inventor¹ filter condition (I)**, and a **child² filter condition (C)**. An example of these conditions are pictured in Figure 2. These filters were selected since inventors and children are stereotypically creative thinkers, lending themselves to the Proteus effect [32], and embodying these characters in VR has been shown to positively impact creativity [12] and mood [29] respectively. The specific filters were also selected since they do not completely mask a person's facial features. Rather, they manipulate facial features in a way that the person is still recognizable.

¹Mad Scientist by Charles Hamblen: <https://www.snapchat.com/unlock/?type=SNAPCODE&uuiid=f341b6ab08254b8bb0e46ffc02409280>

²Baby by Snap Inc.: <https://www.snapchat.com/unlock/?type=SNAPCODE&uuiid=69a3ac3fe3bb4007ba514afda7d3a97d>

4.2 Apparatus

The study was conducted remotely. Each subject was required to have Snap Camera [28] and Zoom [33] installed. To participate in the study, they connected with the study coordinator via a password-protected Zoom call, and selected Snap Camera as their camera input. On the call, subjects were asked to run both applications simultaneously, and when instructed, enable or disable the specified camera filters. Each session was recorded, and surveys were issued using Google Forms and Qualtrics. Subjects were instructed to perform all study activities on a single screen.

4.3 Procedure

The study was approved by the review board of the local university. Subjects were recruited via emails and public communication platforms, and each subject was paid with a \$25 Amazon gift card as a thank-you for their participation. Each participant was required to sign a consent form, as well as answer a pre-survey comprising basic demographic questions. The study took approximately 75 min for completion per participant.

The study followed a within-subject repeated measures design. Participants experienced three counterbalanced conditions sequentially within one session. The overall study protocol is pictured in Figure 2. Each trial consisted of a *setup/orientation*, *creativity assessment*, and *survey* phase. To begin, subjects were asked to apply one of the three filter options: *No-Filter* (A), *Inventor* (I), or *Child* (C). To orient subjects with the respective filters, the study-coordinator both announced and performed a predefined set of physical actions for the subject to copy (e.g. "shrug your shoulders", "touch the top of your head", "raise your eyebrows up and down"). This was motivated by the literature on visuo-tactile and visuo-motor synchrony techniques in VR [9]. An additional 20 seconds were given for each subject to continue to familiarize themselves with their camera-stream. During the *creativity assessment* phase, subjects completed a verbal Alternate Uses Task (AUT) [14] for two distinct objects (e.g. broom, water bottle, paper clip, pizza box, plastic fork, rubber band). For each item, they had two minutes to think of as many unique and unusual uses for this object as they could. They were instructed to say these aloud. This was followed by a Verb Generation Task (VGT) [25], where they were cued to say a verb aloud that could be associated with a provided noun. Objects for the AUT and noun sets for the VGT were altered between conditions. After this, they were given an additional 20 seconds to look at their camera image. Finally, subjects were asked to complete a survey that

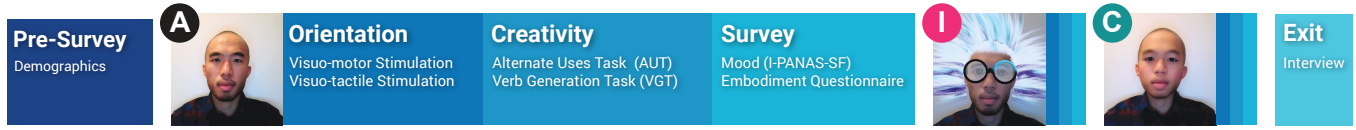


Figure 2: Each participant experienced all three filter conditions in three separate trials. From left to right: no-filter/adult (condition A), the inventor filter (condition I), and the child filter (condition C). Conditions were counter-balanced between participants. The images were used with consent from the depicted subject.

comprised questions about their brainstorming experience, mood (I-PANAS-SF) [17] and embodiment (following the standardized questions proposed in [9]). Subjects were invited to take a short break before proceeding to the next trial. At the conclusion of all three trials, subjects were asked to openly provide comments about their overall experience in a semi-structured interview process.

5 RESULTS

We summarize our findings from the study below with respect to mood, embodiment and creativity.

5.1 Participant Demographics

The study was completed by 21 participants (14 female) aged 18 to 31. They comprised 14 undergrad and graduate students, 3 engineers, an entrepreneur, a project manager, and a program director. One was unemployed. 18 were native English speakers. The participants were generally already familiar with the use of real-time camera filters (Median = 4).

5.2 Embodiment

For each trial, participants answered 17 7-point Likert-scale questions based on the standardized questionnaire proposed by Gonzalez-Franco and Peck [9]. Responses could range from *strongly disagree* (-3) to *strongly agree* (+3). From [9], we asked questions on *body ownership* (1-5), *agency* (6-9), *tactile sensations* (10-11), *location* (14-16) and *appearance* (17-20). Wordings for some questions were slightly adapted to match the context of this study. Higher scores for each axis indicate greater degrees of embodiment. According to [9], *body ownership* is how much a person feels they own the

avatar body and *agency* is the feeling of control over it. The other factors either enhance or detract from the embodiment illusion – the feeling that one’s body has been substituted by the avatar body.

The computed total embodiment score [9] was on average highest for condition A, followed by C and I (see Figure 3). A Friedman test was used to compare the total embodiment scores for all conditions ($\chi^2(2) = 16.65, p < 0.001$), and Wilcoxon matched-pairs signed rank tests yielded significant differences in the medians across groups I-A ($Z = -3.74, p < 0.001$) and C-A ($Z = -3.52, p < 0.001$). Regarding the individual embodiment factors, the Friedman test detected a significant effect of filter condition for *body ownership* ($\chi^2(2) = 28.92, p < 0.001$), *agency* ($\chi^2(2) = 11.11, p < 0.01$), *tactile sensations* ($\chi^2(2) = 12.25, p < 0.01$), *location* ($\chi^2(2) = 10.48, p < 0.01$) and *appearance* ($\chi^2(2) = 8.43, p < 0.05$). Wilcoxon matched-pairs signed-rank tests yielded significant differences in the medians across groups I-A: *body ownership* ($Z = -3.30, p < 0.001$), *agency* ($Z = -1.98, p < 0.01$), *tactile sensations* ($Z = -1.56, p < 0.01$), *location* ($Z = -2.21, p < 0.01$), and *appearance* ($Z = 2.47, p < 0.01$), and C-A: *body ownership* ($Z = -3.30, p < 0.001$), *agency* ($Z = -1.77, p < 0.01$), *tactile sensations* ($Z = -1.74, p < 0.01$), *location* ($Z = -2.61, p < 0.01$), and *appearance* ($Z = 1.89, p < 0.05$) (see Figure 3). We note that the condition A scored lower for appearance; this was expected since these questions assumed the use of avatars, which would logically be perceived as separate entities (e.g. Q17. "It felt as if my real body was turning into an avatar body" would yield a lower score for an accurate camera image over a less realistic filter condition). Overall, these observations suggest that real-time camera filters may not be able to induce as high levels of embodiment as one’s unmodified video image, and feelings of embodiment may differ the most with respect to *body ownership*.

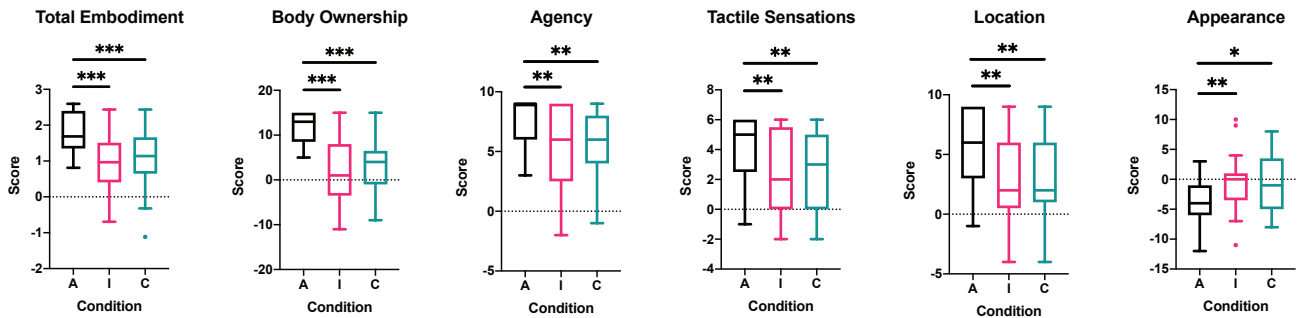


Figure 3: No-filter condition A significantly differed from the filter conditions I and C in total embodiment and the related factors from [9]. I and C were not significantly different from each other on these axes ($P < 0.001 = *$, $P < 0.01 = **$, $P < 0.05 = *$).**

5.3 Mood

Prior research indicates that positive emotions are linked to higher performance in creativity [7]. To understand the potential emotional impact of the different filter conditions, study participants were asked to complete the International Positive and Negative Affect Schedule Short Form (I-PANAS-SF) [17], comprising 10 different emotions. Subjects rated the intensity of the emotion on a 5-point Likert scale (1 = “Very slightly or not at all” and 5 = “Extremely”). The conditions did not differ greatly for the net positive affect score (means: A=17, I=17.5, C=15.5) and negative affect score (means: A=7.4, I=7.3, C=8.3). A subset of the emotion ratings are shown in Figure 4. C made participants feel more *Ashamed*, with only 52% reporting 1 (Very slightly or not at all) vs. 76% for A and 67% for I. They also felt less *Alert* (rating > 4: A=52%, I=62%, C=43%), *Determined* (rating > 4: A=62%, I=67%, C=48%), *Active* (rating > 4: A=62%, I=71%, C=52%), and *Attentive* (rating > 4: A=67%, I=62%, C=57%). In the child condition, participants felt less inspired as 29% reported 1 in contrast to only 10% for A and I. Generally, similar emotional tendencies exist between A and I, where they tend to score higher on the positive emotions but lower for the negative emotion of shame. These responses indicate that real-time camera filters may trigger different emotions in some, but more research is needed to understand the underlying reasons.

5.4 Creativity

Subjects completed two activities pertaining to creativity: the Alternate Uses Task (AUT) and the Verb-Generation Task (VGT). Prabhakaran et al. [25] proposed that semantic distances between pairs of text positively correlate with creativity. AUT results were analyzed using SemDis [3], a novel web-based tool that computes semantic distances between brainstorming prompts and corresponding ideas to assess creativity. Higher mean SemDis scores between two texts indicate they are more distantly associated concepts and thus indicate more creative solutions. SemDis cleans the data by

removing special characters and numbers as well as removes filler and stop words. A distinct score is calculated per prompt and response. A score per trial was calculated by taking an average of the scores per item, and then the average of these. A plot of these scores is shown in Figure 5, left. While Fluency (i.e. number of ideas generated) is typically of interest for the AUT, there were no considerable differences between conditions for this since the activity was tightly time-capped. For the VGT, semantic distances between each noun-verb pair were calculated using latent semantic analysis (LSA) based on the gensim Word2Vec model (16 words per trial, 48 pairs in total). We averaged the 16 scores from each trial to create a single score representing a participant’s performance in the corresponding filter condition. A plot of these scores is shown in Figure 5, right. As the order of conditions were counter-balanced, our preliminary findings suggest that there may be a slight tendency for higher creativity in the I and C conditions; however more participants would be needed for more conclusive results.

6 DISCUSSION & LIMITATIONS

Participants were asked to share their comments on the experience during the exit interview at the conclusion of the study. Participants had varied preferences for the filters. Given their generally playful look, one participant imagined it could help spark more lively discussion in creative work sessions. On the topic of inhibition, some participants felt that the filters acted as “masks” that liberated them from feelings of self-consciousness and judgement - making it easier to produce more creative ideas. However, others expressed feeling more self-conscious (particularly with the child filter) and felt that it detracted from their creative output. Generally, these comments suggest that the use of such filters may only suit a subset of workplace cultures, and that the option to select one’s own filter would be favored in practice.

Occlusion and extreme head angles can disrupt the filters. Additionally, some participants mentioned that they felt they did not

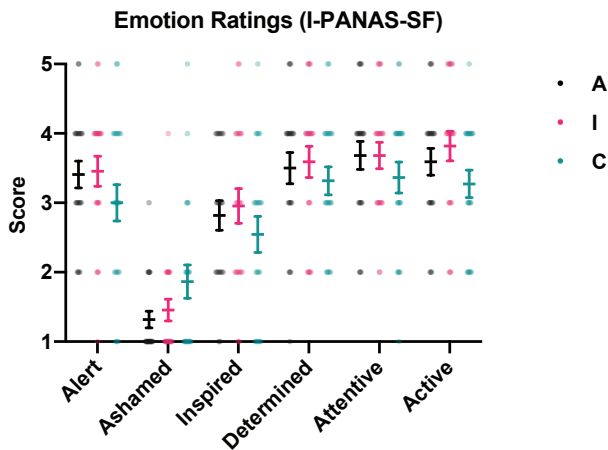


Figure 4: Subset of emotion ratings by the study participants in the I-PANAS-SF mood assessment. The mean and SEM bars show the subtle differences between the conditions.

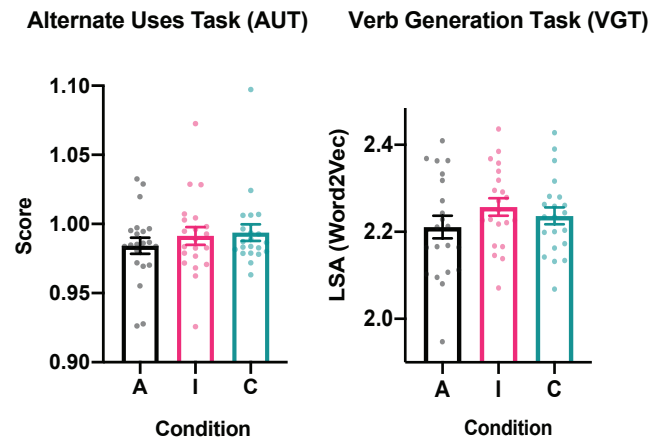


Figure 5: Participants performance on the AUT and VGT. Semantic distance scores for both tasks were slightly higher for the filter conditions I and C.

look at their camera stream much, either because they prefer to look away when thinking, prefer not to look at themselves, or prefer to look at their conversation partners. These are potential hurdles for using real-time camera filters, as they can weaken the impact of the illusion. Nevertheless, the tendency of the results suggest that the orientation period during which they were instructed to deliberately look at their camera stream may have been enough to make a slight shift. As such, future works in this space should likely carefully integrate similar orientation phases.

As limitations to our study, our sample size was small (21 participants). Also, since the VGT relies solely on providing verbs, language fluency may be a confounding factor. However, the majority of participants were native English speakers (18 of 21), and repeated measures were taken per trial. All in all, our preliminary results suggest that filters may have an impact on some people with regards to embodiment, mood and creativity. We see this as an indication for the potential for real-time camera filters to impact cognition, making it a fruitful direction for further research.

7 CONCLUSION

We performed a novel investigation into the potential impacts of changing one's digital self-image with the use of real-time camera filters in a video-calling scenario. In our user-study with 21 participants, we compared the effects between two different filters, an inventor filter (I) and a child filter (C) against a no-filter condition (A). Participants applied the different filters in a Zoom call, and were asked to complete different creativity tasks as well as different surveys. The results of our preliminary study show that while participants had varied responses to the different conditions with respect to affect and embodiment, they as a whole showed a slight increase in their creativity scores with the virtual camera filters applied. Consequently, we believe that research into the constructive and productive use of real-time camera filters warrants further investigation. In light of the surge in usage of video-based online communication tools due to the COVID-19 pandemic, we believe that the self-view in video calling platforms may serve as a useful channel for stimulation and improvements in cognition.

As we learned that some people have the tendency to avoid looking at their camera image frequently, it would be interesting to explore whether the use of real-time filters by all members in a collaborative video-calling session would amplify any effects. Additionally, we would like to increase the number of participants, study the impact of different filter parameters (e.g. realism), and examine how this approach compares to VR. Another interesting idea would be to consider the possibilities of real-time filters as assistive technology. Filters could be designed to counter personal limitations, such as an inability to maintain eye-contact due to autism, or mask involuntary tremors due to Parkinsons. We see this wide array of potential applications and extensions to this work as an opportunity worthy of further investigation. Deeper exploration into the use of real-time camera filters is particularly interesting since this approach is highly customizable and scalable.

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