

Using Internet Studies to Assess the Impact of Self-Focused Mixed Reality on Perception, Affect, and Behavior

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ABSTRACT

Self-focused mixed reality (MR) technologies (such as video filters and smart mirrors) are growing in popularity. It is in the best interest of end-users if these technologies and accompanying design features are evaluated for their impact on user's perception, affective experiences, and behavior. Methodologies that enable these evaluations would help designers navigate the effect of increased or augmented self-attention on their design goals. In this paper, we present a recent online MR study methodology used to assess the impact of self-focused MR in a health behavior context. We present challenges and opportunities for evaluating the role of objective self-awareness and self-focused attention in future MR studies.

CCS CONCEPTS

• **Human-centered computing** → **Interaction design theory, concepts and paradigms**; • **Computing methodologies** → **Mixed / augmented reality**.

KEYWORDS

mixed reality; augmented reality; self-awareness; vicarious reinforcement; health behavior; online study

1 INTRODUCTION

Self-focused mixed reality technologies such as web-camera video filters (e.g., Snapchat Lenses [4] and AR effects on Instagram [1]) and smart mirrors (e.g., MIRROR home gym [2]) have grown in popularity in recent years. These technologies layer digital information on top of a user's self-reflection. Research in psychology highlight that heightening self-focused attention (SFA) can affect a user's level of objective self-awareness (OSA), which has implications for perception, affective experiences (emotions, feelings, and moods), and behavior. OSA occurs when an individual places attention on themselves, viewing themselves as a social object. SFA is suggested to result in a comparison of one's "actual state" and "desired state," followed by an experience of negative affect resulting from the awareness of a discrepancy between the two (OSA theory; [14]). This experience may lead to behavior changes to reduce the discrepancy; however, it may also lead to avoidance of the SFA-inducing experience. While UX design features increasing SFA can have positive, persuasive design implications (for behavior change designers), it can also result in causing negative affect for a

user without the designer's intent or awareness. To further discuss the occurrence of increased SFA in MR applications, it's helpful to understand the perceptual mechanisms that cause SFA. Gestalt figure-ground perceptual principles are often cited for determining automatic focusing on the self [7]. These principles describe that for a perceptual field divided into parts, the smaller parts will be figural against a background and attract attention. Research suggests that making self figural increases self-focused attention [13]. According to the figure-ground principle, any designed environment that makes the self distinctive may heighten the user's SFA.

While external-focused MR design features may impact SFA levels (such as third-person vs. first-person self-embodiment), this paper focuses on applications that augment one's self reflection, such as with AR video filters. A few studies on self-representation [16] and spatial presence [8] explored self-focused MR and suggested an impact on perceptions and behavior. However, self-focused MR studies often lack a control group to compare self-focused features to.

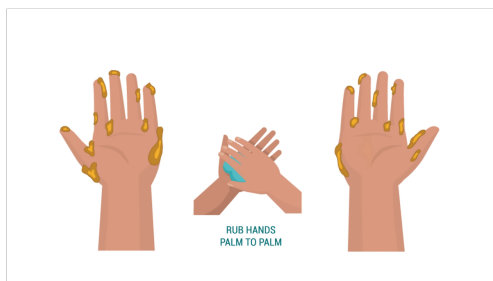
This paper describes a method used in a recent study where we utilize a control condition to evaluate the impact of self-focused MR. We discuss challenges and opportunities to expand methods for measuring the effect of self-focused MR in internet studies.

2 SELF-FOCUSED AR WEB-BASED EXPERIMENT

We conducted a web-based between-subjects experiment (n=355) to explore the relationships between self-focused MR, health perceptions, emotions, and hand hygiene behavior intentions during COVID-19. Experimental conditions were compared with a control to explore the impact of self-focused MR layered with various reinforcement (reinforcement that occurs from observing others' behavior and the results) [Figure 1] as described below:

No mirror self-focus or vicarious reinforcement (control condition). In the control condition, we displayed an animation of proper hand-washing following standards outlined by WHO [10].

Reinforcement. In the reinforcement condition, the hand-washing animation was accompanied by an additional animation showing germs disappearing from a pair of illustrated hands. These animations were synced with hand-washing animation. For example, the thumb cleaning animation segment was paired with germs disappearing from the thumbs.



(a) Reinforcement condition.



(b) Mirror condition.



(c) Avatar mirror reinforcement condition.



(d) Direct mirror reinforcement condition.

Figure 1: The experimental condition interface designs used to investigate individual and combined used of mirror self-focused attention and vicarious reinforcement.

Mirror. The mirror condition utilized the participant's web camera to display their self-reflection. The hand-washing animation was layered on top of the viewer's reflection. This reflection was shown in real-time.

Mirror reinforcement: avatar. In the avatar mirror reinforcement condition, participants view an animation showing germs disappearing from a pair of illustrated hands layered on top of the user's mirror reflection.

Mirror reinforcement: direct. The direct mirror reinforcement condition visualizes germs directly on the participant's hands. Instructions at the beginning of the animation direct participants on where to place their hands. The hand-washing animation is displayed in between their hands. As the animation progresses, the user sees the germs disappear from the reflection of their own hands.

2.1 Study Design

The design of the study allowed us to evaluate potential beneficial and adverse reactions to self-focused AR. The study and evaluation consisted of four phases:

1. *Recruitment and setup.* We recruited participants via a crowdsourcing platform, Prolific [3]. A pre-screener verified (1) access to an acceptable browser and (2) that camera permissions worked adequately.

2. *Online experiment web-application.* All conditions displayed the same information about COVID-19, such as how it is spreads and preventative measures as described by the U.S. Centers for Disease Control and Prevention [5] and World Health Organization (WHO) [10]. Next, participants viewed an animation detailing proper hand hygiene steps described by WHO [10].

3. *Post-study questionnaire.* Questionnaire measures were adapted from Schwarzer [11] and Li [9], focusing on health perceptions that predict health-related behavior and fear control mechanisms that negate health communication efforts.

4. *Verification.* We used these screenshots to ensure that the web application displayed participant's mirror reflections back to them and that those in conditions that required specific hand positions followed the instructions provided.

2.2 Results

The results provided insights into the impact of self-focused MR on indicators of health behavior intentions. With significance established at $P < .05$, when comparing the direct mirror reinforcement condition to the control, reinforcement, or mirror conditions, we found significantly higher levels of perceived threat susceptibility and severity. Levels of severity also differed from the avatar condition. An effect of direct mirror reinforcement on intention when mediated by threat severity ($b = .06$, 95% CI= [.02, .12], SE = .02) and fear ($b = .07$, 95% CI= [.01, .16], SE = .04). The Extended Parallel Process Model (EPPM) [15] warns that heightened fear levels could result in fear control mechanisms such as message minimization. In our study, we found a negative effect of the direct mirror reinforcement condition on message minimization with severity as the mediator ($b = -.07$, 95% CI= [-.16, -.008], SE = .04). In summary, we found layering germs directly on a user and their disappearance in response to proper hand hygiene to result in higher levels of behavioral intentions through increased perceived threat severity and fear. We did not find higher levels of message minimization resulting from the increase in perceived threat severity.

3 KEY CHALLENGES, LIMITATIONS, AND FUTURE WORK

Due to the lack of self-focused MR evaluations in HCI work but the growing use of features that could affect it, we predict that methodologies that produce in-depth explanations will be valuable for researchers and designers. We propose that future internet self-focused MR studies should consider the following:

1. *Validation in MR Internet Studies.* Conduction online MR evaluations increase the pool of potential participants and allow for rapid testing of features. However, MR internet studies present the challenge of validation. In our study, we utilized screenshots to validate that participants followed instructions. Screenshot validation proved to be effective, but the development of an AI-based validation method may save researchers time in the future.

2. *Instructions for Interactions in Non-Moderated MR Internet Studies.* Providing instructions to those in the interactive conditions also displayed a challenge. In the post-study questionnaire, a few participants communicated doubts that they followed the instructions correctly. While reviewing the screenshots, we noticed that many participants “practiced” washing their hands along with the animation displayed, although this was not part of the instructions. Future internet MR studies should utilize moderated pilot studies to assess how participants interact with the application according to expectations.

3. *Measuring SFA.* Our study did not measure SFA directly; however, it might be beneficial to record these values in future work. Quantifying the effect of designs on SFA would provide data that allows for comparing features within a study and between studies. Researchers could adopt a method called the pronoun test [6], which SFA studies in psychology often utilize. Study participants fill in blanks within a paragraph with pronouns. Those who are provided with self-focus stimuli beforehand typically use more self-referential pronouns [6, 12]. MR researchers may adapt these in post-study questionnaires or develop novel means of measuring SFA.

4. *Privacy in MR Internet Studies.* Privacy within MR internet studies utilizing cameras is of concern considering the potential invasiveness of a study conducted in one’s living environment. In our case, we required camera use both for the design intervention and for participation validation. To address potential concerns and prepare participants, we asked participants to be aware of their background before starting the study. The HCI community should consider developing guidelines for augmenting one’s self-reflection (and their environment) and collecting that image data from home environments.

4 CONCLUSION

In this paper, we have shared a recent internet study methodology for self-focused MR evaluations. We argued for the expansion of methods to evaluate the relationships between design features, self-focused attention, perception, affect, and behavior. While this study focused on self-focused MR, we hope that this work sparks a conversation within the general MR community. Design strategies aimed at components of presence such as self-embodiment and social communication can also heighten SFA. While MR experiences become more embedded in everyday life, we must consider

how heightened SFA can improve lives and how we can design to mitigate any harmful effects.

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