

# Hide and Seek: Choices of Virtual Backgrounds in Video Chats and Their Effects on Perception

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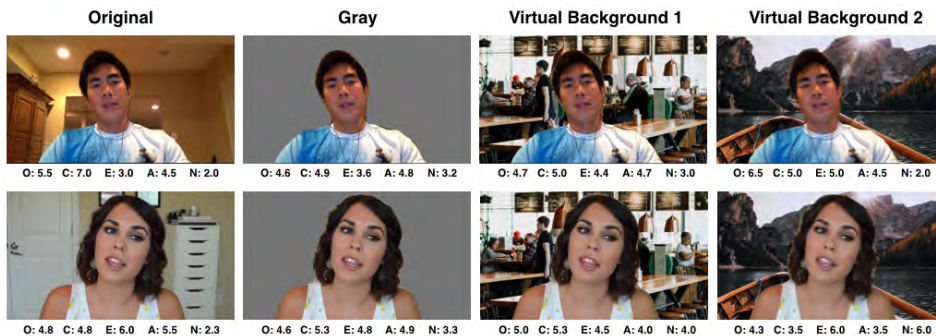


Fig. 1. Examples of videos with original and virtual backgrounds and Big Five personality traits ratings in our study. ("O" represents Openness, "C" represents Conscientiousness, "E" represents Extraversion, "A" represents Agreeableness, and "N" represents Neuroticism.)

In two studies, we investigate how users choose virtual backgrounds and how these backgrounds influence viewers' impressions. In Study 1, we created a web prototype allowing users to apply different virtual backgrounds to their camera views and asked users to select backgrounds that they believed would change viewers' perceptions of their personality traits. In Study 2, we then applied virtual backgrounds picked by participants in Study 1 to a subset of videos drawn from the First Impression Dataset. We then ran a series of three online experiments on Amazon Mechanical Turk (MTurk) to compare participants' personality trait ratings for subjects (1) with the selected virtual backgrounds, (2) with the original video backgrounds, and (3) with a gray screen as a background. The selected virtual backgrounds did not change the personality trait ratings in the intended direction. Instead, virtual background use of any kind results in a consistent "muting effect" that mitigates very high or low ratings (i.e., compressing ratings to the mean level) compared to the ratings of the video with the original background.

CCS Concepts: • **Human-centered computing** → **Human-computer interaction (HCI)**; *HCI theory, concepts and models*; Empirical studies in HCI.

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## 1 INTRODUCTION

The COVID pandemic and resulting mandates (e.g., social distancing) have shifted work and social lives online in much of the world. The attempt to replace in-person communication with video-mediated alternatives (e.g., Zoom, Google Meet, Microsoft Teams, Skype, FaceTime) has caused a sudden and dramatic increase in the use of these applications. By the end of 2019, there were a total of 10 million registered users on Zoom, one of the main video conferencing platforms. According to the company's annual report in June 2020, the total active accounts exceeded 300 million within just a few months after the pandemic outbreak [49, 59]. On top of that, the transition to working from home (WFH) has blurred the boundary between work and personal spaces for many. The rapid migration triggered various challenges, occupying users' mind with how to manage self-presentation while preserving a comfortable degree of privacy in video chats. One way to address the issue is with one of the several video conferencing tools which provided virtual background features allowing people to control what they reveal in their video backgrounds. While some research [1, 40] has investigated how people form impressions based on physical appearance or their surrounding environments [28], how the use of virtual backgrounds affects people's perceptions of others in video-mediated communication remains understudied. This drives the two fundamental inquiries of the present research:

- *RQ1: What are users' motivations and considerations when they apply virtual backgrounds in video conferencing to manage self-presentation?* This research question motivated Study 1.
- *RQ2: How does the use of different virtual backgrounds influence how individuals are perceived during video conferencing?* This research question motivated Study 2.

To address these research questions, we conducted two user studies. In Study 1, we implemented a web prototype that allowed users to apply different virtual backgrounds to their camera views in real-time. We then conducted an online study to examine how people select virtual backgrounds under various scenarios and to understand the motivations of their choices. We also asked participants to select backgrounds that they believed would change viewers' perceptions of their personalities. Our study results suggest the selections of virtual backgrounds were influenced by interpersonal relationships and perceived closeness with conversational partners as well as the desire to control their self-presentation.

In Study 2, we selected 15 virtual backgrounds based on the results from the first study and applied them to videos from the First Impression Dataset. We then ran three waves of online experiments on Amazon MTurk to compare participants' ratings for subjects in the videos when presented in three forms: with the selected virtual backgrounds, with the original video backgrounds, and with a gray screen as background. Our results suggested that the selected virtual backgrounds did not necessarily change personality trait ratings according to participants' expectations. Instead, covering up the original background with a virtual background results in a consistent "muting effect" mitigating very high or very low ratings for confederates on a video-mediated communication platform.

The contributions of this paper are as follows:

- Identifying people's motivations and considerations for selecting virtual backgrounds in video chats.
- Discussing the effects of virtual backgrounds on viewer's impressions toward the speakers in the videos based on our empirical evidence as well as prior related theories.

## 2 BACKGROUND AND RELATED WORK

### 2.1 Why Would Users Choose to Use Virtual Backgrounds? (RQ1)

While video conferencing, users are not only conversing, but also, providing a view into their personal spaces [34]. Previous literature has identified users' concerns about revealing their physical environments in video calls if they were not "camera-ready." By exposing personal spaces to conversational partners, users perceived a sense of intrusion or loss of privacy or were otherwise dissatisfied in their degree of control over self-presentation. Furthermore, the extent to which users felt comfortable revealing their physical environment was moderated by their relationships with others. In the following sections, we review users' concerns and discuss how they may drive motivations to apply virtual backgrounds.

**2.1.1 Privacy.** In 2020, individuals across the world have established new social norms to account for unprecedented circumstances—for the first time in recent memory, a large percentage of work-related activities took place in personal spaces [12]. Nonetheless, users may not always be ready or willing to expose their physical environment to their audience. Existing literature on video-mediated communication has consistently revealed major privacy concerns related to one's physical environment (e.g., an untidy room) or appearance (e.g., messy hair) [10, 30, 42, 43, 47]. The extent to which users will willingly expose their personal spaces can depend on their current physical location, temporal aspects, the affordances of a communication medium, and the relationships with others on the video call [10, 42, 46]. Despite these concerns, users typically report feeling obligated to be present in front of a camera when engaging in group conversations through video-based communication platforms [35, 43], resulting in a conflict between the desire to preserve a degree of privacy and the intention to communicate face-to-face. Therefore, instead of turning off one's camera, using a virtual background is one simple, sensible solution.

**2.1.2 Self-presentation.** Individuals' desire to present an "ideal self" through computer-mediated communication (CMC) is well-documented [17, 26, 33, 55]. The technology affordances of each platform offer users the ability to control different aspects of self-presentation. Users can prepare themselves prior to a synchronous interaction (e.g., by selecting an avatar or a profile picture ahead of time). On top of that, when users are aware that others on a CMC platform have never met them in person, users may leverage platform-specific affordances to shape an ideal first impression. With video-based communication systems, selective self-presentation may be more challenging, given that users are engaging in real-time interactions. Regardless, participants still make some efforts toward impression management through simple practices, such as tidying up the room ahead of time, choosing specific streaming angles, and hiding things from the camera view [45]. With virtual backgrounds, users have another option for selective self-presentation.

**2.1.3 Social closeness.** Compared to other types of computer-mediated mediums, video-based communication platforms create a higher degree of intimacy among users [11, 42]. As a result, users' relationships with those they interact within video calls are critical factors determining the degree to which they feel comfortable revealing their physical environment. With family members and close others, revealing one's personal spaces is considered beneficial to bonding [11, 34]. However, when it comes to work or customer service interactions (e.g., doctor appointments), even applying blur filters may fail to satisfy the need of users to preserve privacy [30, 41]. Additionally, team members'

concerns about their presentation of themselves and their environment during videoconferencing can serve as a source of distraction and can reduce the efficiency of teamworking [31]. Recent work has also found that participants in video calls engaged in some degree of selective self-presentation to impress ordinary friends, colleagues, or acquaintances to compensate for the loss of nonverbal cues, but not when interacting with close others [45].

## 2.2 What are the Effects of Virtual Backgrounds on Person Perception? (RQ2)

Given individuals' motivations to control their self-presentation, perhaps by applying a virtual background, we also ask what the potential effects of applying virtual backgrounds might be on person perception. Considering a virtual background as a form of environmental cue, we review literature on how individuals process information from the physical environment.

*2.2.1 Information Processing of Environmental Cues.* Two mainstream theories posit competing views on how we process external cues from our surroundings. On one hand, Ecological Perception Theory [21–23] suggests humans' perceptual organs and sensory systems are "evolved machines" which automatically pick up information from the environment and process them to make rational sense. That is, what individuals learn about their environments is based on these "filtered" views pre-processed by their sensory systems. On the other hand, Perception Sensation Theory [19, 20] propose that our sensory systems pick up random and fragmented pieces of information from the environment and deliver them all to higher-level cognitive systems. As a result, we learn about the external world through complete, big pictures being put together in our brains.

Given these theories, there are at least two possible routes for virtual backgrounds to influence viewer's perceptions of speakers during video conferencing. Based on Ecological Perception Theory, users may only tune into relevant information to evaluate their conversational partners and overall conversing experiences. For instance, a viewer might focus heavily on others' facial expressions in order to judge their reactions toward a proposed opinion or the quality of a conversation [4, 44, 50]. In this case, if a viewer selectively attends to the virtual background used in a video call, the visual content of the background may play a critical role in the user's judgments. Conversely, considering the view of Perception Sensation Theory, any random cues from a video call may directly or indirectly influence users' perception. In this regard, applying a virtual background may either offer an additional source of information about the video conferencing experience; or, it may deprive the viewer of the rich information provided by the speaker's original physical environment.

The contexts of virtual interaction and collaboration introduce an additional layer of complexity to information processing of environmental cues. First of all, users are not sharing the same space with their conversational partners. While attending to others in a video call, users may experience other sources of cues and distractions in their own environment. As a result, informative cues from others' environment may not be as influential. Furthermore, on-screen interaction with conversing confederates is a less "rich" experience, compared to face-to-face interaction. Therefore, the effect of environmental cues may not be as salient. Last but not least, recent research has revealed attending virtual conferences can be more cognitively demanding than in-person meetings [36, 39]. This may leave users limited cognitive bandwidth to attend to the background and other heuristic cues in their conversational partners' environment. All in all, the effect of applying virtual backgrounds in video conferencing may differ from how environmental cues influence human perception in a physical world. However, to our knowledge, the effects of virtual backgrounds on person perception have not been empirically tested, nor have these potential differences been systematically examined. To address this research gap, we investigate the effect of virtual backgrounds on individuals' perceptions toward speakers in videoconferencing chats.

**2.2.2 Person perception based on environments.** People consciously and unconsciously leave traces that reflect their values, interests, experiences, and personalities in the spaces around them [28, 56–58]. For example, an office worker’s personality is reflected in the types of items (e.g., photos of family and friends) which are used to decorate and generate the ambiance of his/her/their space. For instance, those people who are high in openness tend to display artwork [57] and have stylish personal living spaces [28]. Compared to introverts, extraverts have more decorated workspaces that are perceived as inviting [28]. Spaces perceived as highly inviting tend to have an open desk and chair arrangement [38]. In turn, observers may use these traces to form impressions about the occupants. Personal characteristics (e.g. gender, ethnicity, and personality) can be inferred by observing features in the physical environments [27, 28, 56]. Background scenes influence emotional judgements in humans [5, 6, 48]. However, it remains unclear to what extent environmental cues in the background of a video chat influence the perception of a speaker’s personality traits, nor how different virtual backgrounds would affect this perception.

### 2.3 Summary of Literature Review

Synthesizing the above literature, we posit that users’ motivations and considerations for applying virtual background can be influenced by multiple factors, including privacy concerns, intention for self-presentation, and the relationship with conversational partners. Based on research on physical environments, there is reason to believe that viewers’ perceptions of the speaker may indeed be affected by virtual backgrounds, since they may be processed as environmental cues which facilitate evaluation toward others. However, little research addresses this question. To address this research gap, we conducted a two-stage study. First, in an online survey (Study 1) we addressed RQ1. We investigated participants’ motivations and considerations as *users* to select virtual backgrounds under various scenarios. We also asked participants to select virtual backgrounds that they felt would affect person perception. Next, in Study 2, we conducted three online experiments (Studies 2a, 2b, and 2c) asking participants to serve as *evaluators*, rating the personalities of speakers in videos while presenting their physical environment (i.e., original background), applying virtual backgrounds, or using a plain gray screen as background (answering RQ2).

We designed the scenarios in Study 1 to address different degrees of **social closeness**. Per our literature review, individuals’ concerns for privacy, intention for impression management, and relationship ties can all be influenced by their perceived social closeness with others. Synthesizing former literature [3, 16, 51], we operationalized different degrees of social closeness as interpersonal relationships, from which we derived the scenarios to address in Study 1 (see Figure 2 for a conceptual illustration). Given the burgeoning development of new social networking applications as well as the context of the COVID-19 pandemic, we added one specific scenario to address people who have only met online.

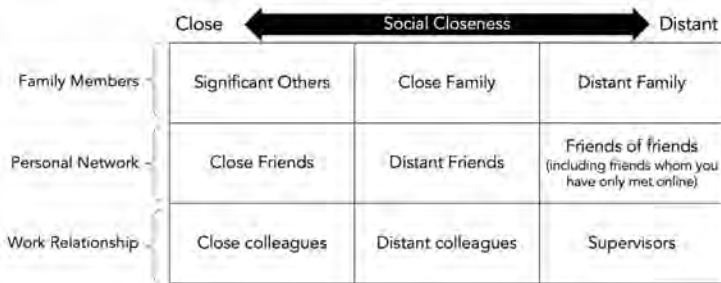


Fig. 2. Operationalization of social closeness to various interpersonal relationships and scenarios



### 3 STUDY 1: SELECTION OF VIRTUAL BACKGROUND (RQ1)

In the first study, we examined how users select virtual backgrounds under different scenarios. We asked users what motivates them to adopt virtual backgrounds and how they apply these backgrounds for self-presentation purposes. Specifically, we investigated how users' relationships with their conversational partners influence the above decision-making processes.

#### 3.1 Method

Study 1 consisted of two tasks presented online via a Qualtrics survey. First, we asked participants to select which virtual backgrounds they would use in video-based communication with different audiences. Second, we asked them to select backgrounds that in their judgment would give the impression of different personality traits. The study was approved by the Institutional Review Board (IRB) of the researchers' affiliated university.

**3.1.1 Participants.** The online survey was distributed through the participant pool of the researchers' affiliated university. We collected responses from  $N = 65$  student participants (78% female). The mean age of respondents was 20 years. While student participants would not normally be considered the most representative sample of users who regularly engage in video conferences, we chose this population for two reasons. First, the task (asking them to upload their picture on a virtual background to elicit realistic responses) was one that required a certain amount of trust and was thus less appropriate to ask of crowdsourced workers [60]. Second, the students in our sample had recently transitioned to online learning, which meant that they had recently gained considerable experience with videoconferencing software for class. In addition, these students were mostly separated from immediate family and were also applying to internships and jobs using videoconferencing software given the ongoing pandemic, so they were likely to find multiple of the proposed scenarios relevant.

**3.1.2 Procedures.** The online survey consisted of three parts. First, participants reported their use of video-based communication technology, including how often they engaged in video calls and the video conferencing platforms they most often used. They also described their recent video chat experiences in open-ended responses. Next, to perform the virtual background selection tasks, participants visited a study website created by the researchers. On the study website, participants could click on each virtual background and preview how they looked while applying the background in real-time (See additional details in Section 3.1.3). We note that we did not require participants to use the preview function, but offered it to make participants' decision-making more resemble the actual process of selecting virtual backgrounds. Whether they previewed themselves with different virtual backgrounds or not, participants could directly download images from the study website after selecting their preferred images for virtual backgrounds. They then uploaded these selected images to the online survey and reported their reasons for selecting certain backgrounds.

**3.1.3 Scenarios to Elicit Motivations for Using Virtual Backgrounds.** In Task 1, participants read 10 different scenarios, presented in random order. Each featured a specific type of relationship between conversational partners (see Table 1 for descriptions of the ten scenarios). Relationships included (1) a significant other, (2) a close family member, (3) a distant family member, (4) a close friend, (5) a distant friend, (6) a close colleague/classmate, (7) a distant colleague/classmate, (8) a supervisor, (9) a friend of a friend, and (10) people they have only met online. Participants then chose the virtual backgrounds they would use in each scenario and also reported what their motivations would be in applying a virtual background in such a video call. In Task 2, participants were asked to select virtual backgrounds that would best represent each of the Big Five personality traits of an individual (i.e., openness, conscientiousness, extraversion, agreeableness, and neuroticism) [28, 29].

**3.1.4 Virtual Background Prototyping Tool.** Virtual backgrounds are categorized differently on different royalty-free image websites; for example, Pixabay [3] lists 20 categories from "Animals" to "Vacation" while Pexels [1] and Unsplash [2] allow images to be searched by tags. To establish cross-cutting categories, two authors first reviewed the three image collections and independently generated categories. They then discussed and agreed on six categories including abstract, interior, nature, public spaces, workplaces, and funny. Then we randomly selected 15 images for each category. The main consideration in choosing images was for each category to have a variety of images. For example, the interior category contains images of different rooms (e.g. office room, living room) with various styles (e.g. cozy, modern). However, we were aware that participants might not be able to find an appropriate background for completing the tasks in Study 1. Thus, we also allowed users to upload their own virtual backgrounds through our web prototype in study 1. We found that only 2 out of all participants uploaded any personal virtual backgrounds, implying that 97% of participants in Study 1 could satisfactorily complete the tasks with our selected virtual backgrounds. A link to the original study website can be accessed here: <https://eric-cornellvel.github.io/CamVirtualBG/>.

On the website, the images of virtual background were presented in the six categories described above. For each category, we offered 15 images on the study website. To implement virtual backgrounds in the preview window on the study website —so that participants could examine how they looked like when applying each virtual background —we built a prototype utilizing *bodypix*, a deep-learning-based computer vision technique to remove or change the background of the videos. The stimulus website also allowed participants to take a screen capture and download their previews. Participants then uploaded these images to the online survey in response to the two virtual background selection tasks. To protect participants' confidentiality, their faces were automatically blurred from the preview images. Figure 3 presents a screenshot of the study website used in the online survey. All stimulus materials can be found at the following link: [https://osf.io/jzpkc/?view\\_only=2795169ea86e4c3fa802c499399c3fc9](https://osf.io/jzpkc/?view_only=2795169ea86e4c3fa802c499399c3fc9).

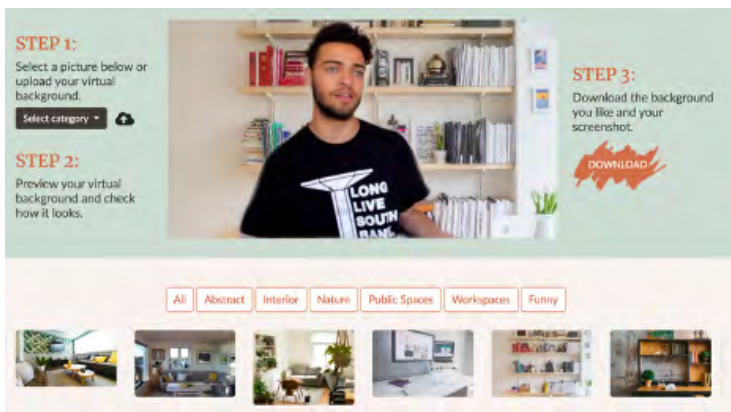


Fig. 3. Screenshot of the stimulus website in Study 1

Table 1. Ten scenarios described in Study 1

Relationship type	Description of the scenario
Significant other	It's a casual Friday night, and you are bored at home in your pajamas. Just at this moment, you receive a video call from your significant other (spouse / girlfriend / boyfriend). You pick up the call and start to chat.
Close family	It's a lovely afternoon, and you are not doing much. You receive a video call from your close family members. You pick up the call to catch up with them.
Distant family	It's a lovely afternoon, and you are not doing much. You receive a video call from your family members who are NOT close with you. You pick up the call to catch up with them.
Close friend	It seems like a great night for hanging out, and your friends who are close with you shares the same mind. S/he is calling through a video chat, and you pick up the call immediately.
Distant friend	You ran into a friend who is not close with you a few days ago, and thought it will be great to hang out later. You take the initiative and give the friend a video call.
Close colleague	You have been working with a colleague/classmate who is close with you on a big project for quite a while, and you two have become close throughout the collaboration. Today, you have yet another virtual meeting to discuss about the project.
Distant colleague	You recently teamed up with colleagues/classmates who are NOT close with you to work on a temporary project. Today, you all will do a kick-off meeting through video conferencing.
Supervisor	It's a busy Monday morning, and you are about to do your weekly check-in with your supervisor to plan for this upcoming week.
Friend of friend	Your friend introduced you to someone with mutual interests. You have not yet met them, but now you are going to have a video call with the friend of your friend.
Person you met online only	You recently met a person online through an online game community. Though you guys have only met online, you thought it will be cool to video chat while you both are catching up the recent game you played.

**3.1.5 Measurement.** In Study 1, we recorded participants' *selected backgrounds* according to each scenario. In addition, we asked participants to select from five potential *motivations* for using a virtual background: (1) "To hide something in the background" (2) "To share your work and profession" (3) "To share something fun" (4) "To represent my identity and intended self-image" (5) "To initiate a conversation with the other person." Participants responded to which extent each of the five incentives motivated them in selecting each background using 7-point Likert scales (1 = Not at all; 7 = A whole lot).

To the best of our knowledge, there is no existing measurement scale addressing users' considerations for the use of virtual backgrounds. Therefore, we pulled together a list of themes emerging from our literature review to assemble the five questions we measured using the Likert scales. Given the exploratory nature of the present study, we also allowed participants to elaborate additional motivations for applying virtual backgrounds in each scenario using open-ended text responses.

## 3.2 Results

**3.2.1 Motivations to apply virtual background.** Test results of repeated-measures ANOVA suggested the degree to which participants were motivated to use virtual backgrounds in order to hide



something ( $F_{(9,612)} = 14.47, p < .001$ ), show professionalism ( $F_{(9,611)} = 5.25, p < .001$ ), share something fun ( $F_{(9,611)} = 19.80, p < .001$ ), and initiate a conversation ( $F_{(9,611)} = 6.55, p < .001$ ) was significantly affected by their relationship with their conversational partners. However, whether they were likely to use virtual backgrounds to represent their identities did not dependent on the relationship type ( $F_{(9,612)} = 1.16, p = .315$ ). We followed up the significant main effect with two contrast tests. First, we tested whether *personal* (significant other, close family, distant family, close friend, distant friend) versus *work* relationships (close colleague, distant colleague, supervisor) would influence participants' motivations to use virtual backgrounds. Contrast test results showed that participants were significantly more likely to use virtual backgrounds to hide something in the background ( $t_{(495)} = -5.09, p < .001$ ) and to show professionalism ( $t_{(495)} = -5.46, p < .001$ ) when speaking to work partners. Conversely, participants were significantly more motivated to use virtual backgrounds to share something fun ( $t_{(495)} = 8.71, p < .001$ ) and to initiate a conversation ( $t_{(495)} = 5.13, p < .001$ ) when speaking to their personal connections. The second contrast tested whether perceived closeness of participants' conversational partners influence the motivations to use virtual backgrounds by dividing relationship types into two groups: *close* (significant other, close family, close friend, close colleague) and *distant* (distant family, distant friend, and distant colleague). When interacting with close others, participants showed significantly greater intentions to use virtual backgrounds to share something fun ( $t_{(435)} = 7.32, p < .001$ ). On the other hand, participants were significantly more likely to apply virtual backgrounds to hide something in the back ( $t_{(435)} = -8.08, p < .001$ ) and to show professionalism ( $t_{(435)} = -2.48, p = .014$ ) when interacting with people in the distant group. Figure 4 shows motivations to use virtual background by the 10 scenarios described to participants.

**3.2.2 Selection of virtual background depending on interpersonal relationships.** Using repeated-measures ANOVA, we again saw that the various relationships between participants and the conversational partners described in the task had an significant effect on their choices of virtual background types ( $F_{(9,640)} = 7.97, p < .001$ ). We followed up the significant main effect with the same two contrast tests as above: (1) personal vs. work relationships, and (2) socially close vs. distant groups. When interacting with individuals at work, participants were significantly more likely to use virtual background showing an image of *work space* ( $t_{(518)} = -7.53, p < .001$ ) or *interior* ( $t_{(518)} = -4.93, p < .001$ ). On the other hand, when speaking with individuals in their personal network, participants showed a significantly stronger tendency to use *funny* images ( $t_{(518)} = 7.37, p < .001$ ) or photos of *nature* ( $t_{(518)} = 2.64, p = .008$ ) as virtual backgrounds. In the second contrast test, participants were significantly more likely to adopt a *funny* background when their conversational partners were perceived as socially close ( $t_{(453)} = 6.42, p < .001$ ). Conversely, when speaking with less familiar acquaintances, participants tended to use images of still scenes, including *interior* ( $t_{(453)} = -2.52, p = .012$ ), *nature* ( $t_{(453)} = -2.91, p = .004$ ), and *public space* ( $t_{(453)} = -2.86, p = .004$ ). Figure 5 shows background types selected in each of the ten scenarios.

**3.2.3 Selection of virtual background to self-present personalities.** We used a Chi-squared test to examine whether conversational scenarios can effectively predict the frequency of each background type selected for video chats. Test results show that participants' background selection differed significantly according to the type of personality they intended to self-present ( $\chi^2 = 144.70, p < .001$ ). We then followed up on the significant main effect with post-hoc tests. Participants were significantly more likely to use a *nature* background to represent personalities of neuroticism ( $\chi^2 = 16.02, p = .014$ ) and agreeableness ( $\chi^2 = 10.71, p = .09$ ). To present a conscientious personality, participants tended to select background images of *work spaces*, *interior spaces*, or *public spaces* ( $\chi^2 = 77.08, p < .001$ ). On the other hand, extraversion was most likely to be represented by *funny* or *abstract* images ( $\chi^2 = 52.51, p < .001$ ). The selection of background images for openness

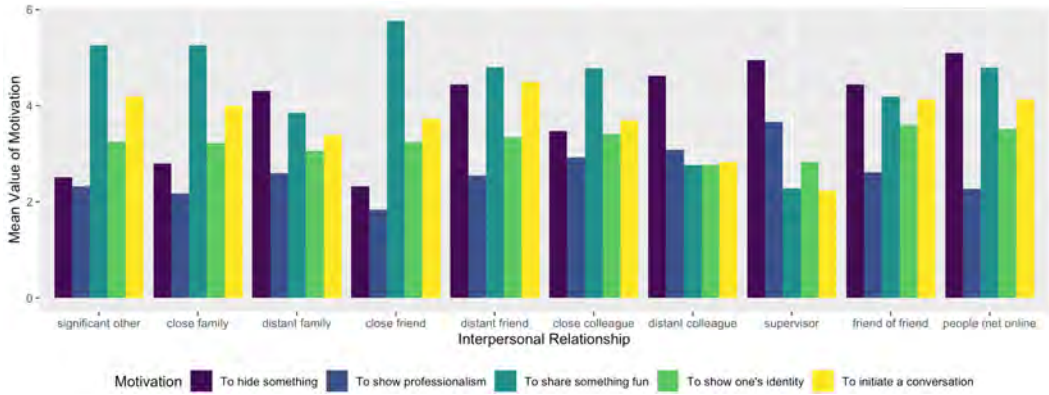


Fig. 4. Motivations to apply virtual backgrounds during video calls. The y-axis represent the mean values (on 7-point Likert scales) of each motivation for applying virtual backgrounds in the 10 scenarios.

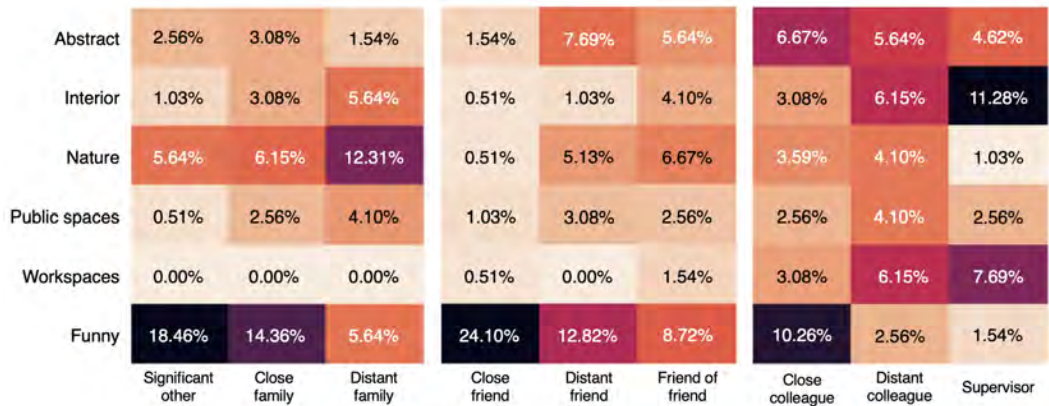

















Fig. 5. Selection of virtual background types depending on interpersonal relationships with one's conversational partners.

personality was more diverse, and no particular image type stood out, although on visual inspection we speculate that all three images might represent a large space or sense of depth.

We took a more granular look and examined individual images selected to represent each personality type. Table 2 represents the most selected virtual backgrounds for each of the Big Five Personalities based on our survey responses. There was a surprising amount of convergence on the most chosen images, given that there were 90 images in total. Specifically, for each of the top images, we performed a one-sample t-test comparing the likelihood of a top image being chosen to the likelihood of an image being randomly drawn from all the available options. In results, all of the topmost selected images for each personality type were chosen significantly more likely than by chance, while all top 2 and 3 selections occurred marginally more likely than by chance. Additionally, we also see some emerging themes across participants' selected images from a qualitative and visual standpoint. For instance, participants tended to select images that contained bookshelves to represent conscientious individuals, while cool color tones were favored

for neuroticism images. Together, participants' responses suggested that their choices of virtual backgrounds tended to converge for the representation of each personality type.

Table 2. Top selected images and their summary statistics

	Openness	Conscientiousness	Extraversion	Agreeableness	Neuroticism
Image 1					
Category	Nature	Interior	Abstract	Nature	Nature
Count	17	6	10	9	9
Percentage	26.15%	9.23%	15.38%	13.85%	13.85%
$t_{(64)}$	4.56	2.24	3.16	2.95	2.95
$p$	<.001	.028	.002	.004	.004
Image 2					
Category	Nature	Interior	Abstract	Nature	Nature
Count	4	4	6	4	4
Percentage	6.15%	6.15%	9.23%	6.15%	6.15%
$t_{(64)}$	1.68	1.68	2.24	1.68	1.68
$p$	.098	.098	.028	.098	.098
Image 3					
Category	Public space	Public space	Funny	Interior	Nature
Count	4	4	5	3	4
Percentage	6.15%	6.15%	7.69%	4.62%	6.15%
$t_{(64)}$	1.68	1.68	1.98	1.34	1.68
$p$	.098	.098	.052	.186	.098

**3.2.4 Qualitative responses.** Participants were also asked to explain their reasons for their selection of images for the 10 scenarios using open-ended text. Two research assistants read participants' written responses and coded the data inductively based on Grounded Theory [24], looking for emerging themes rather than testing any specific hypothesis. In the first round of coding, each research assistant went through the data individually and summarized each response using short phrases. Afterward, the two research assistants regrouped to discuss the initial coding results, observed recurring concepts, and categorized them into cohesive themes.

In reviewing responses, we noticed participants selected images that were funny, aesthetically pleasing, and related to their personal experiences. However, rationales differed based on the degree of perceived social closeness with the conversational partners described. With high degrees of social closeness (significant others or close friends) participants favored funny, silly images, and their considerations for image selection were rather self-centered. That is, participants were likely to state reasons such as "I like this picture," "I am interested in the image," or "I can relate to that..." As social closeness decreased, participants' attention shifted to their conversational partners and the background's role in initiating a conversation, stating "I think s/he (the conversational partner) will like that," or "We have gone to somewhere like this" as reasons for image selection. When interacting with those who were not close with them, participants were concerned about how to initiate and stay focused on the conversation. As a result, they prized images that were clean, neutral, and simple in order to present an "appropriate" impression; for example, "I haven't seen my distant family for a long while, so I don't want to make them think that I'm a weirdo."

### 3.3 Discussion

Study 1 results showed participants' motivations and considerations for the selection of virtual backgrounds depended on the perceived closeness with their conversational partners. Participants' concerns for privacy were also demonstrated in Study 1. In particular, participants used virtual backgrounds to hide their physical environment when interacting with others at work or with individuals they felt less close with. Furthermore, participants were only inclined to use certain background types (i.e., funny and abstract) when they interacted with close others.

Building on these findings, we investigated whether participants' convergent intuitions about how backgrounds would affect personality ratings would be accurate when tested on a new set of participants. Building on these findings, we next investigated whether participants would rate individuals applying distinct virtual backgrounds differently in Study 2.

## 4 STUDY 2: EVALUATION OF USERS APPLYING VIRTUAL BACKGROUND (RQ2)

We built our second study around the *First Impression* dataset [8, 9], derived from a previous study that extracted 10,000 short clips (each featuring a unique actor speaking for 15 seconds) from job interview videos on YouTube. Participants in these former studies were asked to rate actors in the videos on the short form of Big Five Personality inventory [29] and describe how likely they would be to hire each actor viewed in the video, using 7-point Likert scales. Each video was rated five times. We note that the original studies did *not* prevent repeated participation on MTurk.

We randomly extracted 50 videos from the First Impression dataset. To these videos, we added virtual backgrounds derived from participants' responses to the second task of Study 1, in which they selected virtual backgrounds to convey each of the Big Five personality traits. We used the top three most selected images for each of the Big Five personality types and applied the resulting 15 virtual backgrounds to 50 unique videos randomly selected from the first impressions dataset. With the 50 randomly selected clips from the dataset, we created 15 more versions with each of the virtual backgrounds. This means that there were 16 versions of each video had, the original version + 15 versions with different virtual backgrounds.

We used the original First Impressions study as a template to design our MTurk HIT template (see Figure 6). In each study, we presented MTurk participants with a random selection of five job interview videos, either presented with a virtual background or with its original background. After each video, participants rated their perceptions of the Big Five personality traits for each speaker.

We note that we collected a new set of responses to the original background, instead of using the First Impression dataset responses as ground truth. First, we wanted to exclude raters from repeated participation. Second, we considered that various contextual factors have changed since the original study was first conducted almost 10 years ago. Table 3 shows ratings of the Big Five Personalities when actors were presented in front of their original backgrounds in the original study compared to the present study (compiling data across Study 2a, 2b, and 2c). Overall, ratings for Openness, Conscientiousness, Extraversion, and Agreeableness in the present study shifted positively, while ratings for Neuroticism remained largely the same.

After analyzing data from the first round of this study (Study 2a), we conducted two follow-up studies (Study 2b and 2c) for confirmatory and exploratory purposes.

### 4.1 Study 2a: Discovering the "Muting" Effect of Virtual Background

**4.1.1 Participants and Procedures.** We recruited  $N = 160$  participants through MTurk to conduct Study 2A. We set the following screening criteria for recruitment on MTurk: (1) HIT approval rate greater than 98%, (2) approved HITs greater than 500, and (3) MTurk worker's location within the United States. 62.5% of participants in Study 2a were male. The largest age group of participants



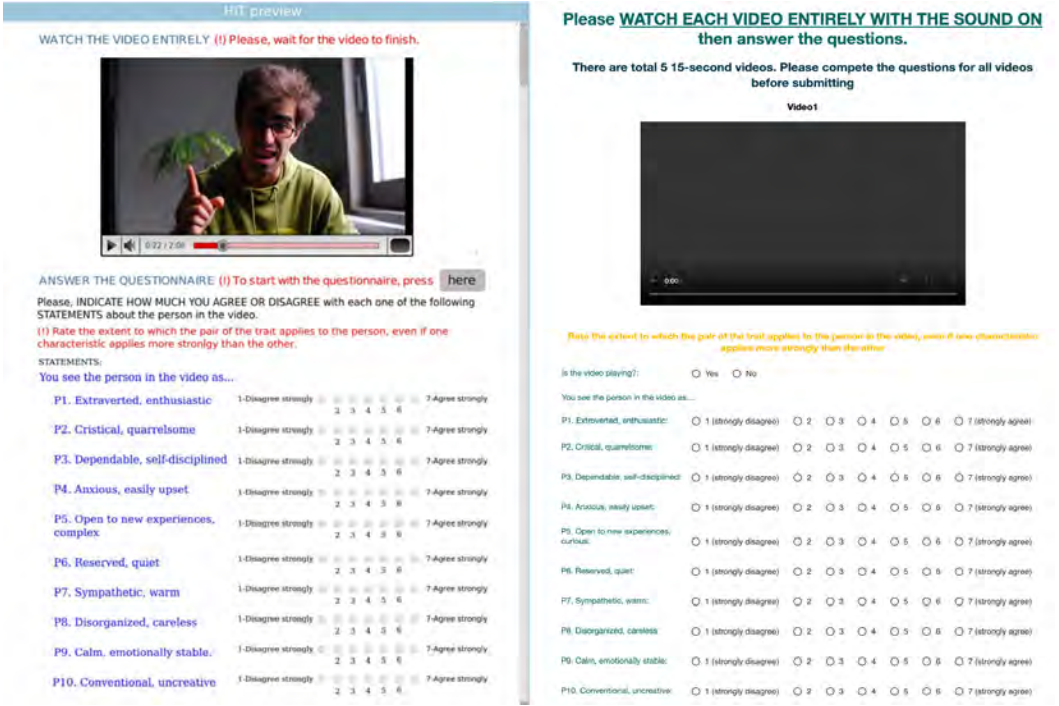


Fig. 6. Design of MTurk HIT templates in the First Impression study (left) and in the present study (right).

Table 3. Descriptive statistics and distributions of ratings in the First Impression dataset (coded in red in the plots) and the present study (coded in green in the plots)

Statistics	Openness	Conscientiousness	Extraversion	Agreeableness	Neuroticism
The First Impression $M \pm SD$	3.80 $\pm$ 1.08	3.61 $\pm$ 1.09	3.12 $\pm$ 1.11	3.83 $\pm$ .94	3.37 $\pm$ 1.21
The present study $M \pm SD$	4.63 $\pm$ 1.40	5.06 $\pm$ 1.35	4.59 $\pm$ 1.79	4.85 $\pm$ 1.14	3.13 $\pm$ 1.10
Distribution plots					

(40.6%) falls under the age range of 25 - 34 years old, followed by 35.0% in the 35-44-year-old range. Participants who consented to participate were randomly assigned five videos with and without virtual backgrounds. They viewed the first video and then rated the speaker in that video, and repeated this process to view and rate five different videos in total. Participants did not see repeated videos of the same speaker, nor did they see the same virtual background applied to different videos. Finally, participants answered a few basic demographic questions.

**4.1.2 Measurement.** After viewing each video, participants first responded to a validity question, asking them whether the video played properly or not. In Study 2a, 6 out of the 800 videos (0.75%)

did not display properly to participants. We excluded data entries from these cases before proceeding to our analysis. Next, participants rated the speaker in each video by responding to the short form of Big Five personality inventory [29]. The short form includes ten items of 7-point Likert questions (Strongly disagree = 1, Strongly agree = 7), capturing each of the Big Five personalities with two questions. Openness scores were measured by "open to new experiences, curious" and "conventional, uncreative" ( $M = 4.73, S.D. = 1.30$ ). Conscientiousness was measured by "dependable, self-disciplined" and "disorganized, careless" ( $M = 4.95, S.D. = 1.24$ ). Extraversion was measured by "extroverted, enthusiastic" and "reserved, quiet" ( $M = 4.69, S.D. = 1.50$ ). Agreeableness was measured by "critical, quarrelsome" and "sympathetic, warm" ( $M = 4.78, S.D. = 1.22$ ). Neuroticism was measured by "anxious, easily upset" and "calm, emotionally stable" ( $M = 3.31, S.D. = 1.19$ ).

**4.1.3 Results.** For all analyses, we investigated how ratings for each personality type differed when actors were presented in front of their original backgrounds (*original rating*) versus when they were presented along with virtual backgrounds (*rating with background*). We began our analysis by looking at the correlation between original ratings and ratings with virtual backgrounds. We asked whether there was a significant direct effect of virtual background type (i.e., the type of personality a background is intended to emphasize) on ratings for actors. To test the direct effect of background type, we fit a linear mixed effect model using the lmer package in R, including the background type and time order of the response as fixed variables, and the actor's and the participants' unique Ids as random factors. We report all analyses below.

We found no significant main effect of virtual background on ratings (Openness:  $F = .66, p = .657$ ; Conscientiousness:  $F = .87, p = .498$ ; Extraversion:  $F = .74, p = .593$ ; Agreeableness:  $F = .17, p = .973$ ; Neuroticism:  $F = .79, p = .555$ ). That is, the type of virtual background used *per se* cannot directly predict participants' ratings for individuals shown in video chats. However, the correlations between the ratings of the original videos versus ratings of videos with virtual backgrounds were rather weak (Openness:  $r = .21, p < .001$ ; Conscientiousness:  $r = .19, p < .001$ ; Extraversion:  $r = .46, p < .001$ ; Agreeableness:  $r = .16, p < .001$ ; Neuroticism:  $r = .19, p < .001$ ), suggesting that ratings for actors did change after applying virtual backgrounds to the video. Therefore, we suspected that applying virtual backgrounds might still influence ratings, but that this relationship might be moderated by other variables.

As mentioned above in our literature review, gender can be one of the demographic features that inform individuals' perception towards others in computer-mediated communication (e.g., [27]). Additionally, research in organizational behaviors has repeatedly revealed the effect of gender matching on evaluation [13, 18]. Given the exploratory nature of the present study, we were motivated by these references to conduct some post hoc analyses with our data. Therefore, we tested whether there were any significant interactions between background type and the original rating of an actor, the gender of an actor, and the congruence between the gender of an actor and his/her rater (i.e., whether the gender of an actor is the same as the participant who rated the video). To test each of the interaction effects, we again fit a linear mixed model using the lmer package in R. For each model, we included one of the abovementioned interaction terms as well as time order of the response as fixed effect, and we also adopted the actor's and the participants' unique Ids as random factors. Results showed a significant two-way interaction between background types and original ratings (see Table 4 for summary statistics). Specifically, compared to ratings with no background (i.e., using background type = no background as the reference level to fit the linear mixed effect model), we found that ratings with *any* virtual background differed significantly from the original ratings (i.e., ratings with no background). However, there was no significant difference between the different background types. The interaction term was further probed by the Johnson-Neyman technique, which tested the statistically significant region of each interaction term (Openness:



[1.30, 6.67],  $p < .05$ ; Conscientiousness: [.35, 5.33],  $p < .05$ ; Extraversion: [.28, 8.25],  $p < .1$ ; Agreeableness: [3.12, 6.58],  $p < .05$ ; Neuroticism: [2.23, 19.40],  $p < .05$ ).

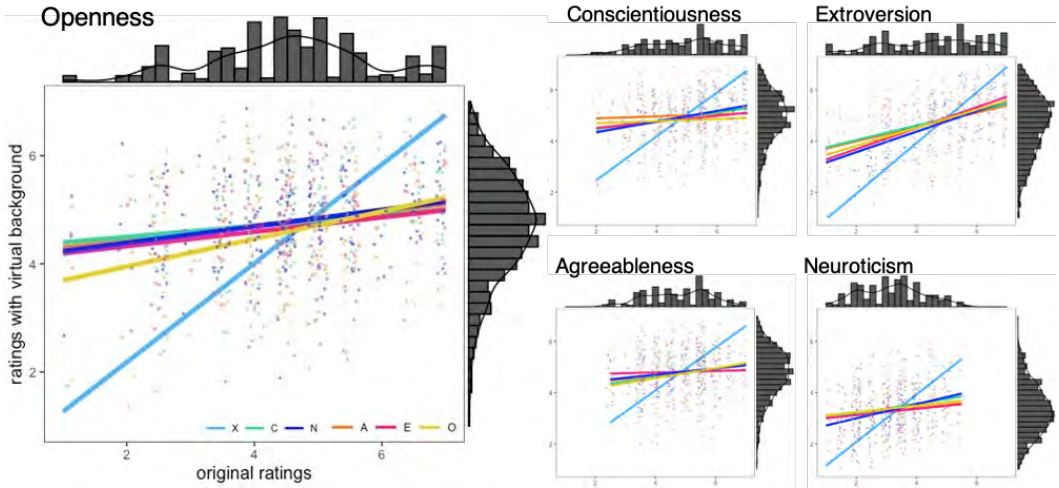


Fig. 7. Two-way interaction between original ratings and virtual background types. (X: Original Background, O: Openness, C: Conscientiousness, E: Extraversion, A: Agreeableness, N: Neuroticism)

As shown in Figure 7 and in Table 4, for actors with very high or low original ratings (their personality scores were either lower than the lower-bound or higher than the upper-bound of the statistically significant regions), their new ratings with virtual backgrounds differed significantly from ratings with no background. More specifically, actors with very low original ratings tended to receive higher ratings when applying virtual backgrounds, while those with particularly high original ratings were rated with lower scores after applying virtual backgrounds. These findings are also reflected on the difference in distributions of original ratings and of ratings with virtual background. As shown on the upper edge of each sub-figure in Figure 7, participants' original ratings are more sparse and spread widely across the 7-point scale. Conversely, the distribution of ratings with virtual backgrounds shows a central tendency (as shown on the right edge of each sub-figure in Figure 7), such that more participants tend to rate actors in the videos around the group means. As a result, we see fewer ratings on the two extremes (highly positive or highly negative). The same patterns appear across ratings of all five types of personality scores.

We tested interaction terms of other variables, but participants' gender, actors' gender, and gender congruence did not significantly moderate the effect of virtual backgrounds on new ratings (all test results have  $p > .562$ ).

**4.1.4 Discussion.** In Study 2a, we revealed a "muting" effect of virtual backgrounds on actors' ratings. In particular, actors with significantly high original ratings (i.e., original ratings greater than the upper bound of the statistically significant region) received lower ratings when applying virtual backgrounds. Conversely, actors with significantly low original ratings (i.e., original ratings lower than the lower bound of the statistically significant region) were rated more positively after applying virtual backgrounds. For actors with personality scores closer to the group mean (i.e., original ratings fall within the statistically significant region), the muting effect of virtual background was not significant. In summary, we observed extreme ratings of actors' personality scores being "muted," or in other words, being shifted toward the group means when applying

Table 4. Study 2a: Statistics of Two-way Interaction Term of Background Type \* Original Ratings

Personality	Variable	<i>F</i>	effect size ( $\eta_p^2$ )	p-value
Openness	Original Rating * Background type	9.98	.07	< .001***
	Original Rating	21.00	.30	< .001***
	Background type	10.11	.07	< .001***
	Time order	.01	< .01	.936
	Worker $\tau$ = .31			
	Actor $\tau$ = .27			
	$R^2_{\text{marginal}}$ = .088, $R^2_{\text{conditional}}$ = .429			
Conscientiousness	Original Rating * Background type	9.47	.07	< .001***
	Original Rating	20.20	.26	< .001***
	Background type	8.13	.06	< .001***
	Time order	.89	.02	.349
	Worker $\tau$ = .34			
	Actor $\tau$ = .16			
	$R^2_{\text{marginal}}$ = .082, $R^2_{\text{conditional}}$ = .403			
Extraversion	Original Rating * Background type	10.91	.07	< .001***
	Original Rating	78.51	.60	< .001***
	Background type	11.05	.07	< .001***
	Time order	.0001	< .01	.481
	Worker $\tau$ = .29			
	Actor $\tau$ = .30			
	$R^2_{\text{marginal}}$ = .248, $R^2_{\text{conditional}}$ = .506			
Agreeableness	Original Rating * Background type	5.96	.24	< .001***
	Original Rating	17.97	.04	< .001***
	Background type	5.71	.04	< .001***
	Time order	2.8781	.06	.09
	Worker $\tau$ = .36			
	Actor $\tau$ = .13			
	$R^2_{\text{marginal}}$ = .062, $R^2_{\text{conditional}}$ = .386			
Neuroticism	Original Rating * Background type	6.45	.05	< .001***
	Original Rating	26.66	.06	< .001***
	Background type	6.77	.01	< .001***
	Time order	.02	< .01	.889
	Worker $\tau$ = .29			
	Actor $\tau$ = .10			
	$R^2_{\text{marginal}}$ = .076, $R^2_{\text{conditional}}$ = .345			

virtual background. We observed the muting effect of applying virtual backgrounds on all Big Five personalities, regardless of participants' age, gender, and gender congruence between the raters and the actors. However, different types of virtual background did not demonstrate different patterns in influencing participants' personality scores. Given that the muting effect is highly statistically significant and consistent across individuals and personality types, we aimed to investigate what

leads to this phenomenon. Therefore, we conducted a follow-up study, Study 2b, to confirm our observations in Study 2a and to learn more about the mechanism of this muting effect.

## 4.2 Study 2b: Understanding the "Muting" Effect of Virtual Background

As mentioned above, the motivation to conduct Study 2b was to replicate our initial findings and attain further insights into why and how the muting effect was formed. Prior to the launch of Study 2b, we proposed some potential causes for the muting effect. As per the Ecological Perception Theory [21, 23], participants might tune into the information offered by images of virtual backgrounds, and thus, they might be consciously influenced by backgrounds in videos when determining the ratings for actors' personalities. On the other hand, Perception Sensation Theory [19, 20] suggests that individuals need each and every piece of information from the original videos to evaluate the actors comprehensively. Hence, participants might rate all actors more neutrally (i.e., with personality scores leaning toward the group mean) when they are aware that virtual backgrounds are covering up part of the videos, and thus that part of the information they could use to evaluate each actor has been lost. To determine whether raters noticed that the backgrounds were virtual and whether they were *consciously* referring to the virtual backgrounds as a source of information to facilitate their judgments, we specifically asked participants in Study 2b to self-report whether their judgment for each actor was influenced by the background and whether they perceived each background shown in the video to be real or virtual.

*RQ2a: How does the degree of perceived influence of background moderate the effect of applying virtual backgrounds on the perception toward others' personalities?*

*RQ2b: How does the degree of perceived realness of background moderate the effect of applying virtual backgrounds on the perception toward others' personalities?*

**4.2.1 Participants and Procedures.** We adopted the same recruitment criteria as in Study 2a to obtain a sample size of  $N = 160$  on MTurk for Study 2b. 60.6% of participants in Study 2b were male. The primary age groups sampled were 25 - 34 years old (40.6%) and 35 - 44 years old (33.1%).

In Study 2b, we used the same 50 videos as in Study 2a, and each participant followed the same procedure to view and rate five unique videos, either with or without virtual backgrounds. After rating all five videos, participants were asked to reflect whether the backgrounds in the videos influenced their ratings for each actor. Finally, they were asked to report whether they perceived each background in each video as real or virtual. We placed the questions of perceived realness at the end of the study to prevent any priming effect that might affect participants' ratings for actors.

**4.2.2 Measurement.** We used the validity check question from Study 2a to ensure we only included data where participants could view a video properly. In Study 2b, all videos were displayed properly to the participants, and thus, no data was excluded from the analysis. Participants' ratings for actors were again measured by the short form of Big Five personality inventory [29] (Openness:  $M = 4.66$ ,  $S.D. = 1.19$ ; Conscientiousness:  $M = 4.87$ ,  $S.D. = 1.20$ ; Extraversion:  $M = 4.67$ ,  $S.D. = 1.44$ ; Agreeableness:  $M = 4.70$ ,  $S.D. = 1.20$ ; Neuroticism:  $M = 3.37$ ,  $S.D. = 1.21$ ). Participants reported whether backgrounds in videos influenced their ratings for actors on a 3-point scale (-1 = no influence, 0 = not sure/maybe, +1 = have a influence,  $M = -.49$ ,  $S.D. = .81$ ) and one open-ended question asking participants to describe the influence of backgrounds, if any. Last, we asked whether participants viewed the background in each video as real (=1), not sure/maybe (=0), or virtual (= -1) on a 3-point scale ( $M = -.66$ ,  $S.D. = .72$ ).

**4.2.3 Results.** Fitting to the same linear mixed effect model, we again observed a significant two-way interaction between background types and original ratings, replicating the muting effect of virtual backgrounds on all personality types found in Study 2a. We again tested the interaction terms

Table 5. Study 2b: Statistics of Two-way Interaction Term of Background Type \* Original Ratings

Personality	Variable	<i>F</i>	effect size ( $\eta_p^2$ )	p-value
Openness	Original Rating * Background type	5.56	.04	.001***
	Original Rating	37.41	.40	< .001***
	Background type	5.65	.04	< .001***
	Time order	.24	< .01	.624
	Worker $\tau = .58$			
	Actor $\tau = .34$			
	$R^2_{\text{marginal}} = .103, R^2_{\text{conditional}} = .414$			
Conscientiousness	Original Rating * Background type	3.16	.02	.008**
	Original Rating	38.54	.41	< .001***
	Background type	2.79	.02	.017*
	Time order	2.47	.05	.124
	Worker $\tau = .10$			
	Actor $\tau = .39$			
	$R^2_{\text{marginal}} = .103, R^2_{\text{conditional}} = .388$			
Extraversion	Original Rating * Background type	3.91	.03	< .001***
	Original Rating	55.46	.52	< .001***
	Background type	5.01	.03	< .001***
	Time order	.04	< .01	.852
	Worker $\tau = .24$			
	Actor $\tau = .29$			
	$R^2_{\text{marginal}} = .210, R^2_{\text{conditional}} = .465$			
Agreeableness	Original Rating * Background type	9.41	.07	< .001***
	Original Rating	11.64	.18	.001**
	Background type	8.39	.06	< .001***
	Time order	.41	.01	.527
	Worker $\tau = .34$			
	Actor $\tau = .18$			
	$R^2_{\text{marginal}} = .059, R^2_{\text{conditional}} = .414$			
Neuroticism	Original Rating * Background type	7.67	.05	< .001***
	Original Rating	18.36	.27	< .001***
	Background type	7.20	.05	< .001***
	Time order	.34	< .01	.633
	Worker $\tau = .27$			
	Actor $\tau = .15$			
	$R^2_{\text{marginal}} = .065, R^2_{\text{conditional}} = .349$			

with the Johnson-Neyman technique and found that actors with original ratings lower than the lower-bound of the statistically significant region were again rated more positively when applying virtual backgrounds, while those with ratings higher than the upper-bound of the statistically significant region were again rated more negatively when using virtual backgrounds (Openness: [2.62, 6.41],  $p < .05$ ; Conscientiousness: [-2.36, 4.36],  $p < .10$ ; Extraversion: [4.20, 10.70],  $p < .1$ ; Agreeableness: [4.39, 5.87],  $p < .05$ ; Neuroticism: [-6.16, 4.02],  $p < .05$ ). We then tested whether

the effect of applying virtual backgrounds differed by the extent of perceived realness and perceived influence of backgrounds, but neither of these moderators showed a significant interaction effect (p-values greater than .05 for all test results).

### 4.3 Study 2c: Testing the "Muting" Effect with a Gray Screen

Based on findings in Study 2b, we learned that participants were not *consciously* taking into account the content of virtual backgrounds to evaluate perceptions toward others in video conferencing. The "muting effect" was *not* affected by whether participants believed themselves to be influenced by the use of virtual backgrounds nor by whether they perceived the backgrounds as real or virtual. We proposed that participants did not use virtual backgrounds at all when assessing speakers in videos, but instead, interpreted the presence of virtual backgrounds as removing cues to personality traits [52]. In other words, participants were less confident in rating participants very high or low in personality traits, because they were missing information. To confirm this hypothesis, we then asked whether simply removing the information from the background completely would have the same effect on person perception as the use of virtual backgrounds. To address this inquiry, we conducted Study 2c by replacing the original background in each video with a gray screen. Figure 8 shows one of the videos used in Study 2c, with the original background replaced by a gray screen.

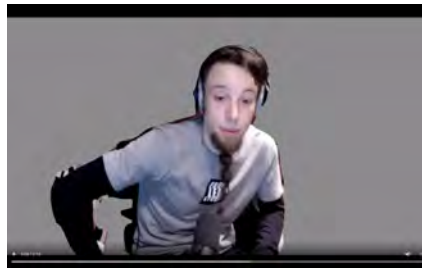


Fig. 8. An example of replacing the original background and applying a gray screen to a video in the present study's task.

**4.3.1 Participants and Procedures.** Again, we conducted Study 2c entirely online through MTurk.  $N = 30$  participants were recruited for this study. 50.8% of participants were male, and the largest age group was again 25 - 34 years old (38.0%), followed by 35 - 44 years old (34.8%). We used the same set of videos as in Study 2a and 2b, but replaced the original background with the same gray screen (50% white and 50% black). The experiment procedure was identical to that of Study 2a and 2b, where each participant viewed five 15-second videos of candidates speaking in job interviews. Through this data collection process, each video was rated by three different participants.

**4.3.2 Measurement.** Similarly, participants rated each candidate using the short scale of the Big Five Personality Inventory immediately after they viewed each video (Openness:  $M = 4.67$ ,  $S.D. = 1.27$ ; Conscientiousness:  $M = 4.92$ ,  $S.D. = 1.23$ ; Extraversion:  $M = 4.66$ ,  $S.D. = 1.48$ , Agreeableness:  $M = 4.74$ ,  $S.D. = 1.21$ ; Neuroticism:  $M = 3.34$ ,  $S.D. = 1.21$ ). As in Study 2b, the questionnaire in Study 2c also asked participants to reflect whether their evaluation of actors in the videos was influenced by the background ( $M = -.52$ ,  $S.D. = .81$ ). Again, we also asked participants to report whether they encountered any technical issues to ensure we only include valid data. In Study 2c, all videos were displayed properly to the participants, and thus, no data were excluded from the analysis.

Table 6. Study 2c: Statistics of Two-way Interaction Term of Background Type \* Original Ratings

Personality	Variable	<i>F</i>	effect size ( $\eta_p^2$ )	p-value
Openness	Original Rating * Background type	18.18	.11	< .001***
	Original Rating	44.25	.46	< .001***
	Background type	19.53	.50	< .001***
	Time order	2.27	.46	.134
	Worker $\tau = .12$			
	Actor $\tau = .18$			
	$R^2_{\text{marginal}} = .243, R^2_{\text{conditional}} = .425$			
Conscientiousness	Original Rating * Background type	7.82	.04	.006**
	Original Rating	33.70	.40	< .001***
	Background type	8.57	.04	.004**
	Time order	.47	< .01	.546
	Worker $\tau = .23$			
	Actor $\tau = .09$			
	$R^2_{\text{marginal}} = .150, R^2_{\text{conditional}} = .347$			
Extraversion	Original Rating * Background type	17.44	.08	< .001***
	Original Rating	80.49	.62	< .001***
	Background type	14.67	.07	< .001***
	Time order	16.56	.08	< .001***
	Worker $\tau = .31$			
	Actor $\tau = .22$			
	$R^2_{\text{marginal}} = .361, R^2_{\text{conditional}} = .562$			
Agreeableness	Original Rating * Background type	10.00	.04	.002**
	Original Rating	23.59	.09	< .001***
	Background type	8.62	.03	.004**
	Time order	.06	< .01	.506
	Worker $\tau = .27$			
	Actor $\tau = < .01$			
	$R^2_{\text{marginal}} = .098, R^2_{\text{conditional}} = .285$			
Neuroticism	Original Rating * Background type	9.9984	.04	.002**
	Original Rating	18.0285	.10	< .001***
	Background type	8.6174	.03	.004**
	Time order	.0645	< .01	.800
	Worker $\tau = .27$			
	Actor $\tau = < .01$			
	$R^2_{\text{marginal}} = .098, R^2_{\text{conditional}} = .285$			

**4.3.3 Results.** Results of Study 2c revealed the muting effect even when applying a blank gray screen as the background. Across ratings for the Big Five personality traits, we again saw significant interaction effects between the original personality scores and background types applied in the video (see Table 6 for summary statistics). That is, actors with more extreme original ratings (i.e., either highly positive or highly negative scores in a personality trait) were rated more neutrally after applying a gray background. Aside from the visual outputs of the interaction diagrams, the findings are further supported by running Johnson-Neyman tests to look at the statistically



significantly regions of each interaction effect (Openness: [1.30, 6.67],  $p < .05$ ; Conscientiousness: [.35, 5.33],  $p < .05$ ; Extraversion: [.28, 8.25],  $p < .1$ ; Agreeableness: [3.12, 6.58],  $p < .05$ ; Neuroticism: [2.23, 19.40],  $p < .05$ ).

Furthermore, the muting effect generated by a gray screen was similar to that produced by other virtual background types. In testing the interaction term between ratings with a gray screen and ratings with other virtual background types, the interaction terms were not significant for all personality ratings. Similar to Study 2b, there was also no significant three-way interaction between original ratings, background type, and perceived influence of background in the video.

#### 4.4 General Analysis

**4.4.1 Validation of data and analytic approaches.** After completing all data collection processes, we conducted a general analysis for all three phases of Study 2. We first checked the similarity of data across the three studies (i.e., participants ratings for the Big Five Personalities of each actor did not significantly differ across Study 2a, 2b, and 2c) using a one-way ANOVA with Tukey's HSD post-hoc tests. As shown in Table 7, participants' ratings for all personality types across the three studies remain consistent, showing no significant ANOVA test result nor did the post-hoc Tukey's tests indicate any pairwise significant difference between any of the two studies.

Table 7. One-way ANOVA and Tukey's HSD testing similarity of ratings across Study 2a, 2b, and 2c

Personality ratings	Compare all 3 studies		Pairwise: Study 2a vs. 2b		Pairwise: Study 2a vs. 2c		Pairwise: Study 2b vs. 2c	
	$F(df=2)$	$p$	$t$	$p$	$t$	$p$	$t$	$p$
Openness	.73	.481	1.18	.462	.67	.777	.14	.989
Conscientiousness	1.41	.245	1.20	.451	.70	.763	1.52	.277
Extraversion	2.31	.099	.22	.973	2.08	.091	1.93	.127
Agreeableness	2.31	.099	.22	.974	2.08	.091	1.93	.127
Neuroticism	.50	.605	1.00	.570	.34	.931	.33	.939

Table 8. One-way ANOVA comparing ratings by background images of the same background types

Background type	Ratings for all personalities		Ratings for Openness		Ratings for Conscientiousness		Ratings for Extraversion		Ratings for Agreeableness		Ratings for Neuroticism	
	$F$	$p$	$F$	$p$	$F$	$p$	$F$	$p$	$F$	$p$	$F$	$p$
Openness	1.26	.285	.76	.471	.36	.696	.61	.545	.36	.701	.70	.498
Conscientiousness	2.67	.693	.54	.583	1.65	.193	.70	.498	1.38	.253	.62	.538
Extraversion	.72	.488	.32	.730	1.00	.368	.27	.762	1.80	.167	.71	.491
Agreeableness	.96	.383	.34	.709	1.71	.182	.82	.440	.65	.524	.67	.513
Neuroticism	.31	.737	1.18	.308	.39	.676	.81	.447	1.24	.291	.29	.752

Additionally, we verified whether applying images of the same background types yielded similar ratings for actors' personalities. That is, we assessed whether our approach of combining images of the same background types and examining the muting effect by *background types*, instead of by *individual images*, was justifiable. Accordingly, we performed two series of ANOVA with Tukey's HSD tests. First, we tested whether ratings for *all* of the Big Five Personalities differed significantly by background images of the same background types. Following, we further examined whether ratings for *each personality* differed significantly by background images of the same background types. As shown in Table 8, the fact that ratings of the same background type did not significantly differ by background images justified our rationale to group and look at images of the same background type together (see summary statistics for Ratings for Openness, Conscientiousness, Extraversion, Agreeableness, and Neuroticism). Additionally, the fact that ratings for all personalities

also did not differ significantly by images of the same background type supported our previous findings that background types did not have a significant main effect on personality ratings (e.g., applying an Openness type of image did not significantly improve one's Openness scores), but the effect of virtual backgrounds should be examined along with actors' original ratings: what we highlighted as the "muting" effect across Study 2a, 2b, and 2c.

**4.4.2 Re-examination of the muting effect.** Given the above data validation, we proceeded to perform a univariate analysis controlling time order to re-examine the muting effect of virtual backgrounds across all three parts of Study 2. Again, we observed significant interaction effects between the use of virtual backgrounds and the original personality scores, suggesting that actors originally rated with more extreme scores (extremely positive or negative) for each of the Big Five personalities were then evaluated more neutrally (with personality scores shifted toward the group means) when they applied a virtual background. However, the different types of images used in the background did not significantly moderate the muting effect, nor did they differ significantly from applying a grey screen to replace the original background.

The muting effect was further probed by the Johnson-Neyman technique to examine statistically significant regions of the interaction terms, showing that the use of virtual background "mutes" each personality in a different fashion. Speakers with extremely high or low ratings in *Openness*, *Agreeableness*, and *Neuroticism* all received more neutral scores when applying virtual backgrounds. That is, negatively rated actors received higher scores while positively rated individuals were rated lower than before. However, the muting effect on *Conscientiousness* only took place on highly conscientious individuals. By contrast, the muting effect of virtual background on *Extraversion* was also one-sided, but only those with extremely low extraversion scores received an increase in ratings after applying virtual backgrounds. Highly extroverted individuals were not affected. Figure 9 shows the statistically significant regions of the muting effect on each type of the Big Five personalities.

**4.4.3 The effect of original background.** In the final part of our analysis, we further discussed the impact of original backgrounds in our present findings. Though we did not directly ask participants to rate the backgrounds alone, we highlighted that the effect of original backgrounds has been addressed in the "muting" effect. Specifically, for videos that received lower ratings with the

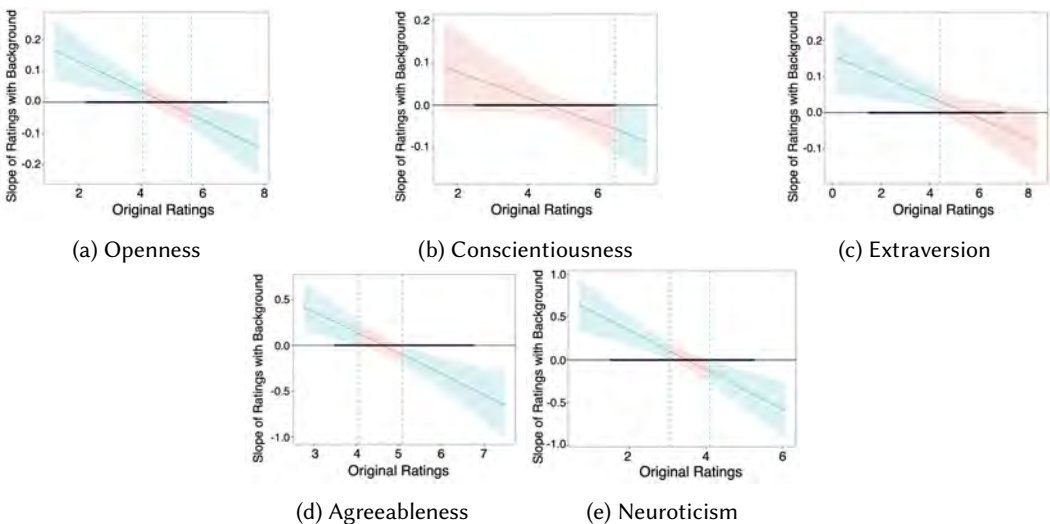


Fig. 9. General analysis: Statistically significant regions of the muting effect (The cyan regions represent statistically significant regions, while the red regions represent non-significant)

original backgrounds, we saw increases in personality scores after applying virtual backgrounds. Conversely, for videos that received higher ratings with original backgrounds, we found decreases in personality scores after applying virtual backgrounds. In other words, by showing the significant interaction term between original ratings and background type, we indicated that the effect of virtual backgrounds on person perception is dependent on the original backgrounds (i.e., what we termed as the “muting” effect).

To further explore the effect of the original backgrounds, we conducted a simple slope analysis by categorizing actors into three groups: *low original ratings* (ratings with original backgrounds below  $M - 0.5S.D.$ , consisting of 33% of the data), *mid original ratings* (ratings with original backgrounds between  $M \pm 0.5S.D.$ , consisting of 34% of the data), and *high original ratings* (ratings with original backgrounds greater than  $M + 0.5S.D.$ , consisting of 33% of the data). Figure 10 shows changes in ratings after applying virtual backgrounds for the three groups. In alignment with what we found with the “muting” effect, participants with low original ratings yielded positive rating changes ( $M = 1.50, SD = 1.43$ ), while those with high ratings in their original backgrounds resulted in negative rating changes ( $M = -1.11, SD = 1.31$ ). Actors with original ratings at the medium level saw minimum changes in ratings after applying virtual backgrounds ( $M = .16, SD = 1.25$ ). Across the three groups, there are no significant differences in rating changes when applying different background types.

We followed up these results with pairwise comparisons among all background types for each of the three groups. That is, for actors with low, medium, and high ratings with original backgrounds, we compared mean differences in ratings between any two of all virtual background types used in the study. In Figure 11, we showed the 95% confidence intervals of all pairwise tests for each of the three groups. Red bars in the figure denote statistically significant ( $p < .05$ ) pairwise test results, and yellow bars denote marginally significant ones ( $p < .1$ ). As shown in the illustration, we saw positive mean differences for the group with low original ratings, while all the positive results were pairwise comparisons between no background vs. other virtual background types. Conversely, the group with high original ratings produced negative mean differences, while statistically or marginally significant pairwise results were those comparing no background to other virtual background types. For actors with medium original ratings, there was no significant pairwise test results. All in all, our further examination shows the effect of original backgrounds has been captured by what we previously saw in the “muting” effect.

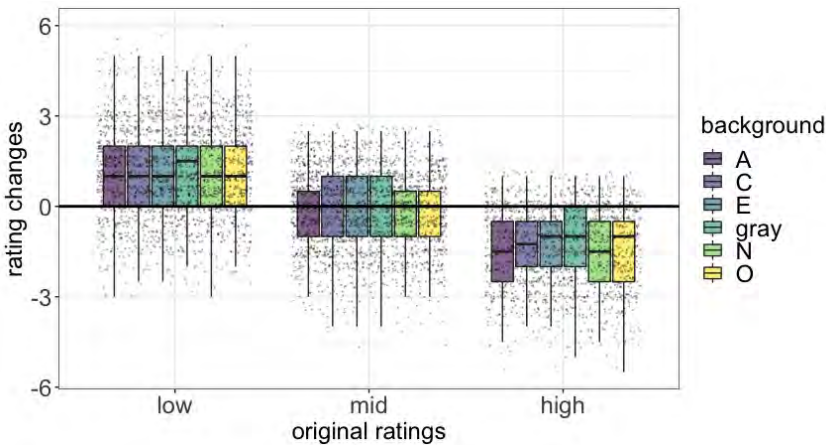


Fig. 10. Ratings changes after applying virtual backgrounds (A: Agreeableness, C: Conscientiousness, E: Extraversion, gray: Gray background, N: Neuroticism, O: Openness)

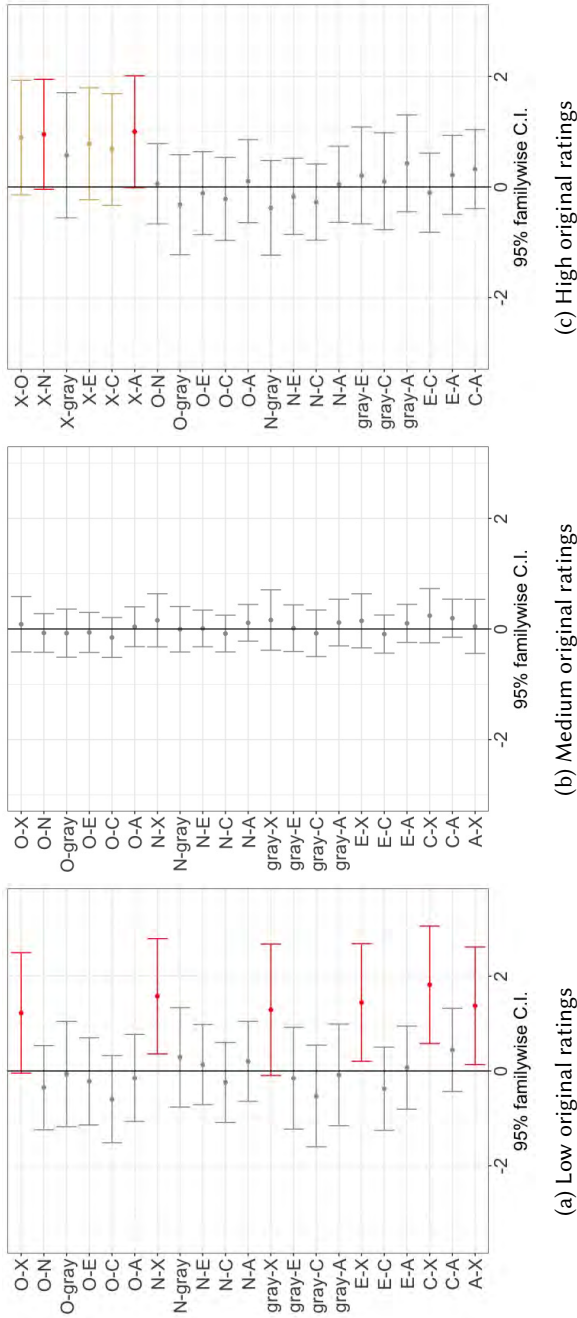


Fig. 11. Pairwise comparison of ratings with different background types for actors with low, medium, and high ratings with original backgrounds. Red bars denote statistically significant ( $p < .05$ ) and yellow bars denote marginally significant ( $p < .1$ ). (A: Agreeableness, C: Conscientiousness, E: Extraversion, gray: Gray background, N: Neuroticism, O: Openness)

## 5 GENERAL DISCUSSION



Fig. 12. The same virtual background can have different effects on the perceptions of people, depending on their different original ratings

### 5.1 Same Virtual Background Affects Perceptions Differently

Aligning with Goffman’s theory of self-presentation, [25], people often add filters or otherwise manipulate photos or videos before sharing them in order to manage the impressions they make on others. Applying virtual backgrounds in video chats is another method of self-presentation. Based on the results of Study 1 participants felt that selecting different virtual backgrounds could affect viewers’ perceptions of specific personality traits. However, based on the results of Study 2, the selected virtual backgrounds did not change personality trait ratings in the way they were intended to do. Instead, covering up the original background with virtual background resulted in a consistent “muting effect” that mitigated very high or very low ratings, as shown in Figure 12. These results imply that people with low original ratings of personality traits with their original backgrounds can utilize virtual backgrounds to change their perceived personality positively. Perhaps ratings of people in videos with poor lighting or a messy room would be more positive after applying a virtual background. However, for people who have positive ratings of personality traits with their original backgrounds, applying virtual backgrounds might lead to lower ratings. Although further research is needed on whether the muting effect applies when the video is viewed by conversational partners who are not strangers (e.g. friends and colleagues), our study results indicate that people tend to use different virtual backgrounds with different conversational partners and that the same virtual background could increase or decrease ratings.

### 5.2 The Muting Effect of Virtual Background

A major finding of the present research concerns the muting effect of virtual backgrounds. Based on our empirical evidence as well as additional literature review, we posit that the muting effect can be understood through at least three perspectives. Two theories of information processing for environmental cues can help explain the muting effect. Based on the Ecological Perception Theory, we expect that informative cues from the environment are processed selectively. In this regard, once participants realized a background was not real (i.e., the background did not provide

direct information about a speaker in the video), they may then consider the background as a less useful piece of information for evaluating the actor. Secondly, the Perception Sensation Theory suggested that evaluative judgments are formed holistically through all available information. Individuals grasp each and every piece of information from the environment to make decisions and judgments. As a result, when candidates applied virtual backgrounds, their viewers (i.e., the participants) no longer had full access to all the information they could utilize to evaluate these characters. Therefore, both theories suggested that participants experienced a certain degree of information loss when viewing actors applying virtual backgrounds. As a result, they have fewer cues to make judgments about speaker personality. Particularly, when judging actors with vivid characteristics (i.e., with extremely high or low scores in certain personality traits), participants may be less confident in identifying these personality traits.

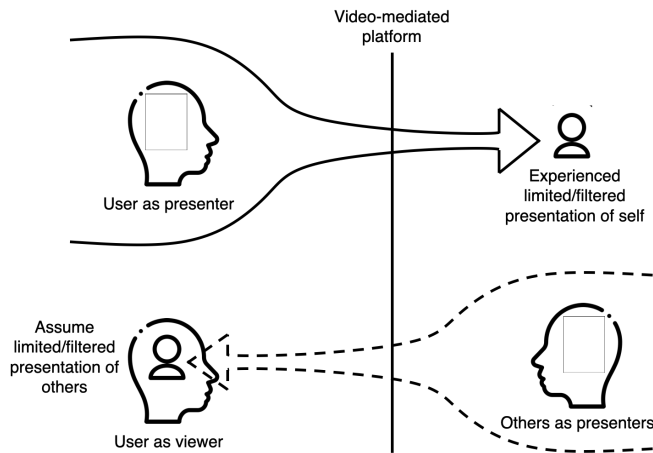


Fig. 13. Conceptual illustration of the operation of metaperspectives in video-mediated communication.

In addition to the effect of processing environmental cues, the concept of *metaperspectives* in CMC literature provides additional insight into the muting effect of virtual backgrounds [7, 15, 32, 52, 54]. Metaperspectives suggest that users' perceptions toward others are often affected by their own perceptions of a CMC platform. How metaperspectives operate and influence participants' experiences and perception toward others is illustrated in Figure 13. In the context of the present research, although users commonly make an effort to manage ideal impressions of themselves on mediated platforms, they may worry whether the medium can effectively convey their individual characteristics. In this research, we observed some of the motivations and considerations participants put into selecting appropriate virtual backgrounds in response to the conversational partners and the purpose of a conversation. However, participants may be uncertain whether the virtual backgrounds can effectively deliver their persona in video-mediated communication. In tandem, participants may suspect or even assume there is missing information about speakers' characteristics when virtual backgrounds are applied to their videos. In this regard, participants might also be less decisive in rating actors as having extreme personality traits, given their realization that they did not have full knowledge about the actors through these communication channels.



### 5.3 Limitations and future work

We acknowledge a number of limitations in our present research, which provide potential avenues for future research. Foremost would have to be that this study took place during unusual circumstances, in which many of our participants were forced into a WfH situation. Within that context, we will point out some aspects of our study that invite further investigation.

When participants were asked to select virtual backgrounds to demonstrate different personality types, we did not instruct them to envision a clear group of audience to whom they would self-present. By potentially overlooking the moderating effect of participants' relationships with their intended audience, this may have resulted in noise in the data of the backgrounds selected by participants obtained from the second task in Study 1.

Second, the video clips from the First Impressions dataset used in Study 2 had been trimmed to 15 seconds. Literature in social and clinical psychology has repeatedly supported the accuracy and appropriateness of "thin-slice judgments" (i.e., individuals can effectively and efficiently make accurate judgments of others' personal characteristics within a fairly short amount of time) [2]. However, whether these methodological practices are transferable to the context of online research remains arguable. Therefore, we would like to first clarify that findings of the present study can be best applied to explain the effect of virtual backgrounds on users' first impression toward other interactants in video-mediated communication, while it remains unknown how virtual backgrounds may impact user perception in the long run. Additionally, it is important to acknowledge that our participants, unlike clinical practitioners, were not professionally trained to identify traits of individual characteristics in a short interim (i.e., given "thin-sliced" information). At the same time, they were also losing a lot of temporal and subtle nonverbal cues when performing these tasks online. Therefore, a potential follow-up study can look into whether the muting effect persists if participants can view longer video clips. Furthermore, future laboratory studies can also conduct real-time video conferencing to further examine the muting effect of virtual backgrounds.

Thirdly, the fact that participants in Study 2 did not directly interact with actors in the stimulus videos as they would have in real interviews may prompt questions about the ecological validity of the experiment design. With this concern in mind, we did not directly ask questions that required participants to play the role of interviewers. Instead, participants were simply asked to rate the actors using Big Five Personality inventory. Given the universality of individuals' Big Five Personalities, it is commonly believed that these personality traits should be stable, and they can be revealed and perceived between individuals, regardless of their relationships and forms of interaction [14, 53]. In this regard, while our measures and study design are may still fall short of ecological validity, future research can also implement virtual background as a stimulus while conducting field experiments in video conferences.

Another concern for the experiment design is whether the evaluative task in Study 2 led to attentional biases [37]. Specifically, it is unclear whether the prompt asking participants to judge actors' personality would lead them to pay attention only to the actors while ignoring other cues in the videos. A feasible validity check is to add an attention or cognitive test after participants view the task videos (e.g., asking participants what they saw in the background or asking whether they noticed anything other than the actors per se). However, we do note that there did appear to be an effect of virtual vs real backgrounds, whether or not the participants reported consciously attending to them.

Last but not least, participants were asked to rate unknown actors in Study 2, while typically, users may more often engage in video calls with friends or acquaintances. As a result, further investigation is required to ensure the generalizability of our findings. In other words, it remains an open question whether the muting effect can mitigate our existing perception toward familiar

individuals, or rather, if it is uniquely effective on the formation of first impressions. Future work should investigate how impressions may change when participants are placed in a common, shared background, as in Microsoft Teams, or in other virtual worlds. This might remove the muting effect caused by the sense that people are hiding their backgrounds.

## 6 CONCLUSION

The COVID pandemic has led to a sudden and dramatic increase in the use of video conferencing applications. The Working from Home (WfH) transition has blurred the boundary between work and personal spaces and created challenges of managing self-presentation while preserving a comfortable degree of privacy in videoconferencing. Although applying virtual backgrounds could mitigate these issues, how the use of virtual backgrounds affects people's perception of the user in the video is a critical yet underexplored issue. In this paper, we conduct two user studies. We investigate how users choose virtual backgrounds in scenarios with different conversational partners and/or with the goals of increasing specific personal traits, and examine how virtual backgrounds impact the viewers' perceptions of the speakers in the videos. Our study results suggest that participants selected different virtual backgrounds with various motivations and considerations, depending on the perceived closeness with their conversational partners and their intent to self-presentation during video chats. But, we found that the selected virtual backgrounds did not change the personality trait ratings in the intended direction. Instead, virtual background use of any kind resulted in a consistent "muting effect" that mitigates very high or low ratings compared to the original background.

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