Don't Forget to Disinfect: Understanding Technology-Supported Hand Disinfection Stations

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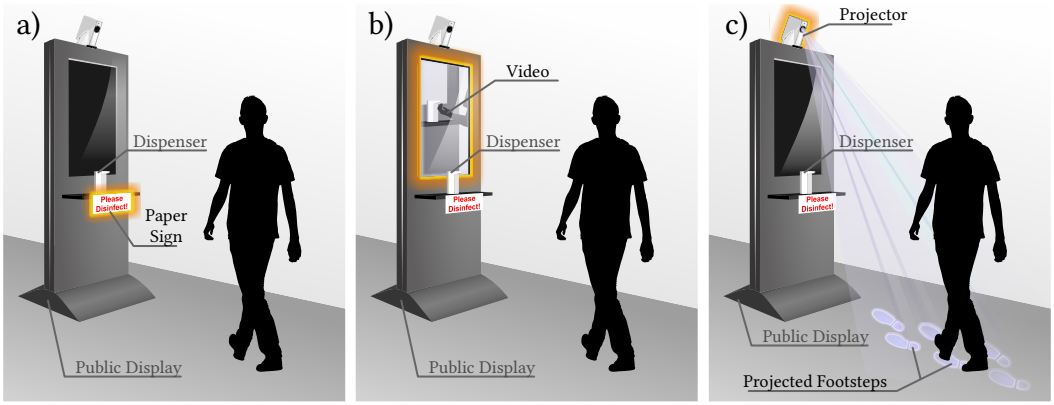

Fig. 1. We explored different public display designs to encourage hand disinfection in public spaces using visual cues. We conducted semi-structured interviews with passersby for our three conditions: (a) paper-based, only utilizing a paper sign, (b) adding screen-based cues, utilizing a repeating video clip, and (c) adding projection-based cues, utilizing a video projector and showing walking feet.

The global COVID-19 pandemic created a constant need for hand disinfection. While it is still essential, disinfection use is declining with the decrease in perceived personal risk (e.g., as a result of vaccination). Thus this work explores using different visual cues to act as reminders for hand disinfection. We investigated different public display designs using (1) paper-based only, adding (2) screen-based, or (3) projection-based visual cues. To gain insights into these designs, we conducted semi-structured interviews with passersby (N=30). Our results show that the screen- and projection-based conditions were perceived as more engaging. Furthermore, we conclude that the disinfection process consists of four steps that can be supported: drawing attention to the disinfection station, supporting the (subconscious) understanding of the interaction, motivating hand disinfection, and performing the action itself. We conclude with design implications for technology-supported disinfection.

CCS Concepts: • **Human-centered computing** → *Human computer interaction (HCI)*; *Displays and imagers.*

Additional Key Words and Phrases: disinfection; visual cues; public display; attention

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1 INTRODUCTION

In late 2019, the world witnessed the outbreak of SARS-CoV-2. In 2020, the World Health Organization (WHO) declared it a pandemic under the name Coronavirus Disease 2019, thereafter to be known as COVID-19[1]. Before COVID-19, humanity had overcome various other pandemic events throughout history, from the Plague of Athens, one of the oldest documented pandemics, to the Spanish Flu and Ebola, some more modern examples [19]. Besides the appearance of pandemics, we adapted to the existence of some viruses, such as the reoccurring seasonal flu. In the future, researchers expect new viruses to appear with increased frequency [37].

To protect people, research has discovered successful countermeasures, such as vaccines and disinfection. These countermeasures are important for containing the spread of diseases and reducing severe or fatal outcomes. Although this precaution was already widely considered in healthcare facilities, recommending it to the public became more common as a result of the spread of COVID-19. To endorse such precautions, people started to place disinfection dispensers and stations in shared areas. As a result of the stress of facing what was then a new and unknown virus, much of the public was keen to follow all recommended precautionary measures. Over time, the novelty of the pandemic wore off and, along with other factors (e.g., having vaccinations), governments started to lift various restrictions (e.g., wearing masks on only specific occasions), pushing life back to normal [11]. In contrast, health experts around the world started to propose measures to avoid new pandemics while still maintaining the use of disinfection and other preventive measures to limit virus spread [41].

However, even though hand disinfection is a quick and effortless way to protect oneself and others, the public started disinfecting their hands less and overlooking disinfection stations. Research has shown that forgetting is one of the main reasons for not disinfecting [40], yet the current situation requires more attention. In clinical setups, technology has been deployed for surveillance and to act as a reminder for hand disinfection[2]. In public, however, disinfection signs remain the most commonly used reminders.

Therefore, in this work, we explore the role of technology in encouraging hand disinfection in public spaces. Specifically, we conducted semi-structured interviews with passersby ($N = 30$) using paper-based, screen-based, and projection-based displays as public hand disinfection reminders to gain insights into how such a system should be designed. Our findings highlight that technology-based solutions are more engaging than paper-based ones. In addition to attracting attention, it is essential to motivate the users to disinfect their hands. For this, personalizing feedback and offering a reward are promising methods. Consequently, we provide implications that can guide the design and deployment of technology-enhanced hand disinfection stations in public spaces.

2 RELATED WORK

In the following, we first reflect upon the different solutions researchers have proposed to support hand disinfection with technology. After that, we look at public displays and discuss their potential for disinfection reminders.

[1] https://www.who.int/emergencies/diseases/novel-coronavirus-2019, last visited on 27/06/2023.
[2] https://www.vitalacy.com/dispenser-sensor, last visited on 27/06/2023.

2.1 Technology-Supported Hand Disinfection

Given the lasting importance of disinfection, researchers have investigated various technology-based solutions that aim to support their users in that regard. They have explored automatic disinfection stations for footwear [25] and improved the appearance of disinfectant dispensers to encourage children to disinfect [44]. Nevertheless, most solutions focus on hand hygiene, for example, by providing insights into the cleansing quality by tracking the hand washing behavior or with ultraviolet rays [32]. In previous years, researchers proposed different approaches to track handwashing behavior, including motion tracking [14] and wearable pattern recognition [26]. But not only tracking hand washing behavior is relevant, also analyzing the behavior itself can help to inform the design of supportive technology. Therefore, Asai et al. have studied the behavior before someone washes their hands [4], resulting in an "AIDA" model that differentiates four phases: attention (A), interest (I), desire (D), and action (A). As attention is a prerequisite for using a disinfectant dispenser, researchers have focused on this phase. For example, they examined visual signs but found that the use of sanitizers decreased over time [47]. Hence, researchers proposed reminder systems and investigated different user actions as triggers for disinfection reminders [10]. They tested their system with nurses in intensive care units and found that hygiene events increased by 24%. In most cases, these reminder systems are evaluated in a clinical setting [3, 10, 12, 47]. As a consequence, other contexts are neglected, and it is unclear to which extent the findings generalize. In particular, as some aspects are not feasible in a public context (e.g., video surveillance [3]).

A survey by Pearson et al. relating to behavior change since the beginning of the COVID-19 pandemic revealed that 73% of the respondents stated to wash or sanitize their hands before or after interacting with devices operated by touchscreens or physical buttons [35]. Further, people use several avoidance strategies, such as using knuckles, elbows, or tools, which Pearson et al. also observed in a pedestrian crossing user adaption study. To maintain the usage instead of users avoiding the technology or taking it out of service, the authors identified three areas: While "Retrofitting" aims to modify buttons to be touchless, "Adapting" intends to give COVID-19-specific infrastructure an additional purpose. Lastly, "Replacing" changes the interaction modality from touch to other types, such as facial expressions or speech. For the goal of supporting hand disinfection using technology, the adaptive strategy is well-suited. Pearson et al. implemented a voting system consisting of two disinfectant dispensers. A handwritten sign displaying a question asks the passersby to vote for one of two options by using the corresponding dispenser. But this approach assumes that the users' attention was already directed to this sign and that they perceive and understand the situation. To reach this condition in the first place, our work focuses on comparing paper-based only cues with adding screen-based or projection-based visual cues.

While mobile disinfection solutions exist, for example, wearable hand disinfection [22], robots with disinfectant dispensers that move along [23, 48], or drones that focus on surface disinfection [24], these solutions can be impractical. A solution can be stationary disinfection stations. The WHO suggests for public events the frequent use of these disinfection stations [34]. Moreover, they recommend visual cues as reminders. Previous work has demonstrated that combining public displays with disinfectant dispensers can be a beneficial approach to motivate hand disinfection [12].

2.2 Public Displays as Disinfection Stations

Public display research explored the interaction behavior of passersby with public displays, aiming to identify the major aspects that influence such interactions [27]. While some researchers took into account the spatial relation between display and user while designing the display [38, 45], others focused on exploring the passersby behavior while interacting with public displays [18]. For example, Mueller et al. showed the honeypot effect in a real-life setting in shop windows [29]. They further segmented the public into interacting people, people who want to interact, and passing-by

individuals [29]. Reporting similar results, Brignull and Rogers observed the interaction behavior of groups of people with a public display at parties focusing on their activities with respect to the display [7]. They also grouped the public into peripheral awareness activities (i.e., display in the periphery), focal awareness activities (i.e., giving the display attention), and direction interaction. On the one hand, researchers explored various approaches and technologies for designing public displays. One approach integrated multiple projections to create a subtle display [28]. For instance, Bird et al. proposed an interactive floor display allowing full body interaction [5]. Other work proposed using laser projection as an interactive floor display [9]. On the other hand, public displays face two main challenges. The first challenge is display blindness, where the users overlook the display (e.g., Hardy et al. [16]). The second challenge is interaction blindness, where the passersby who notice the display fail to recognize the interactivity behind it (e.g., Ojala et al. [33]). Previous work has therefore divided the interaction with public displays into three main phases, namely attention-getting, motivating interaction, and eliciting interaction [27].

Investigating how to attract users' attention to public displays has thus been the focus of research. For example, researchers explored the design of visual presentations like static/animation, text/icons, as well as color/grayscale, and found that animated, colored, and text displays are the most efficient to attract attention [20]. Further, another study showed that animation attracted passersby's attention more than text and still images [18]. Researchers also compared the different attributes of displayed shapes (e.g., color, contrast, and deformation), where they showed that manipulating the presented cues, pixelation, and brightness were perceived best by participants [1]. Similarly, other researchers displayed approaching users' skeletons, silhouettes, fireworks displays, and following eye animation to create a more personalized experience resulting in increased attention [13, 39]. Given the current situation with the pandemic, the main idea of our work is to shift the users' attention toward the disinfection station. We base our ideas on the assumption that users, once their attention is shifted to the disinfection station, would use it because we assume that the public interest for hand disinfection would be sufficient, given the current pandemic situation and formed habits in the last years.

3 COMPARING PUBLIC DISPLAY DESIGNS FOR DISINFECTION REMINDERS

In this paper, we investigate different technology-supported visual cues to draw the attention of passersby to a disinfection station and remind them to disinfect their hands. Our work is motivated by the still-ongoing COVID-19 pandemic and the continuous need for hand disinfection beyond this pandemic. Besides simple paper signage, we identified two additional types of visual cues that could be promising for disinfection reminders: screen-based cues and projection-based cues. Here, we selected paper-based instructions as the baseline, given their frequent usage in this context. The overall setup of our disinfection station consists of a sensor-based disinfectant dispenser attached to a public display at the height of 100 cm, as shown in Figure 1. This electronic dispenser enables contactless interaction, allowing users to obtain disinfectant by holding out their hands. Considering wheelchair users, Vatavu et al. [43] found that the main challenge is to reach the content as 72.7% of their participants reported this issue. Since the public display will only be used for visual cues and no interaction with the screen is necessary in our study, it is unlikely that the results of our work would change for wheelchair users. Furthermore, the disinfectant dispenser is reachable at the height of 100 cm with an accessible pathway in front of it and with sufficient room for a wheelchair in front of the dispenser. Furthermore, we used screen-based and projection-based cues together with the paper-based instructions to investigate the potential of technology-based reminders. After implementing these different visual cues , we performed a study in the hallway of our office building, where we set up the disinfection station. In the following, we describe our three conditions for visual cues representing the variant display types.

3.1 Visual Cues for Guiding Attention

Previous work divided the interaction with public displays into three main phases: attention-getting, motivating interaction, and eliciting interaction [27]. In our work, we deem the first point as the most relevant as we make the assumption that, given the current pandemic crisis, the public has enough motivation to disinfect their hands once their attention is redirected to disinfection stations. Therefore, we implemented three conditions, each a different kind of display visualizing instructions to catch passersby's attention to disinfect their hands. Figure 1 depicts these three conditions: (a) Paper-based Instructions, (b) Screen-based Instructions, and (c) Projection-based Instructions. Below, we explain each condition in detail.

Paper-Based Instructions. In the first condition, we attached a 30 x 11.5 cm white paper sign to the disinfection station that said "Please Disinfect!" in red letters. Since the public display was turned off in this condition, the instructions were presented on a purely analog signage. As this condition was our baseline condition, the paper sign was also present in the two other conditions where we added digital displays to our setup.

Screen-Based Instructions. For the screen-based instructions, we utilized the 56-inch upright public display in addition to the baseline paper sign to show a video of a person disinfecting their hands at our disinfection station. The video consists of three short scenes separated by two cuts. The first scene shows a person on the real floor walking towards and recognizing the public display and is approximately 2 seconds long. The second scene is a close-up of them using the disinfection device and rubbing the liquid on their hands for four seconds. The last scene contains the actor walking away for two more seconds. Hence, the video has a total length of 8 seconds matching the duration of the projection in the following condition. The video was displayed on the screen in a repeated loop without a pause. Thus, it replicated the exact situation of a passerby walking toward the disinfection station.

Projection-Based Instructions. For the third condition, we added a digital display to our baseline paper sign in the form of a trapezoidal projection of 260 cm height and 170 cm width at the wider, 105 cm width at the thinner side on the floor 50 cm in front of the disinfection station (cf. Figure 2). We turned the corresponding projector by 90 degrees to project an upright image in order to cover as much floor as possible. Furthermore, we mounted it on the station at a height of 260 cm with a laser-cut case, which enabled us to adjust the projection angle on the floor. We implemented the projection-based instructions through a looping animation of footprints that start far away from the dispenser and lead through the hallway directly to the disinfection station at a common walking speed. Because we projected obliquely onto the ground, we received a trapezoidal projection causing footprints that were closer to the disinfection station to be initially displayed as smaller than footprints that were farther away. Thus, we adapted the size of the footprints regarding their positions on the floor to eliminate distortion. The duration of the animation was the same as that of the video from the screen-based instructions.

4 EVALUATION

To evaluate our three designs using different kinds of displays and visual cues, we conducted semi-structured interviews with 30 participants. We derive subjective measures from the semi-structured interviews, including responses to individual Likert items. Further, we deduce themes and categories from our qualitative analysis of the interviews regarding our technology-enhanced disinfection station.

4.1 Study Design

The independent variables of our study were the three types of displays giving visual cues to disinfect hands (cf. Subsection 3.1). We used a between-subjects study design [8] because individuals who saw the disinfection station in one condition would likely be influenced by the previous condition and would no longer need to be cued to the dispenser location. We had the setup running in our institute's corridor for three weeks, overall (one week per condition, Monday to Friday from 9 am to 5 pm). In the interviews, we assured that none of our participants (students and other visitors, coming to the institute e.g., as participants for other studies, seminars, oral exams, or externals coming to the university for meetings) took part twice. For the subjective measures, our dependent variables were the answers to our semi-structured interview (cf., Appendix A). Our research questions and hypotheses are as follows:

RQ: Can technology-based visual cues positively influence passersby's disinfection behavior compared to paper-based instructions? How can we remind passersby in public places to disinfect their hands in an enjoyable way?

H_1 The attention of passersby for technology-supported visual cues is higher compared to an analog paper sign.

H_2 The intrusiveness of technology-supported visual cues for passersby is higher compared to paper signs.

H_3 The motivation of passersby to use the disinfectant dispenser is higher for technology-supported conditions compared to an analog paper sign.

4.2 Apparatus

We placed our setup, which consists of an automated disinfectant dispenser, a paper sign, a public display, and a projector (see Figure 1), on the corridor in our HCI Lab. It was positioned at the corner so that the projection space covers the tube-shaped hallway and the public display is facing towards the entrance. This way, passersby will likely be coming from the entrance, walk through the projection space facing the paper sign and public display on the way towards our offices or the room we use for seminars and other studies (see Figure 2). Further, the disinfection station partially reaches into the corridor without blocking the way.

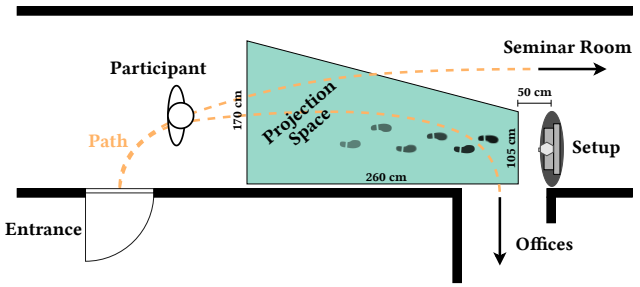

Fig. 2. Floor plan of the corridor where the disinfection station was deployed during the study. Participants coming from the entrance will likely walk through the projection space facing the paper sign and public display while moving to the offices or seminar room.

4.3 Procedure and Asked Questions

Our aim was to identify, through a semi-structured interview, how apparent our setup was, what the participants' motivation was to (not) use the dispenser, and what could be improved in the future. Therefore, the authors observed the situation from the offices and after a person was passing by and possibly interacting with the system or not, one of the authors asked the person if they wanted to participate in a semi-structured interview for about 10 to 15 minutes. In case of seminars,

meetings, or oral exams, they were asked after they finished if they had time for the interview. We conducted all interviews in physical meetings in the offices next to where the setup was located and excluded other team members and affiliated students, who knew about the system already. We welcomed the interviewee and inquired if they had observed anything in the hallway. Then we informed them about the study, handed them the consent form, and obtained written informed consent to record the interview audio. The interview protocol explored three main aspects, namely; attention, intrusiveness, and motivation. For each aspect, we had a question reflecting on the current setup, future improvements as well as a Likert item (cf., Appendix A). Furthermore, we asked the participants about their concern about the ongoing COVID-19 pandemic because our hypothesis is that it could influence their perception. Additionally, we collected demographic data (age, gender, profession, and area of study, if applicable).

4.4 Participants

For each week, we interviewed 10 passersby who had time for a semi-structured interview, leading to $N = 30$ interviews across the three weeks. The durations of the interviews were between 6:53 and 18:55 minutes ($mean = 13{:}12$, $SD = 2{:}40$). The interview participants were of age between 21 and 55 ($mean = 28.9$, $SD = 7.15$). Furthermore, 6 participants identified as female, 24 participants as male. As the setup was placed in the office space at our university, we mainly interviewed students with a background in computer science. We stated an individual 7-point Likert item regarding the concern of the COVID-19 pandemic as "I am currently highly worried because of the pandemic". The participant's responses are shown in Figure 3.

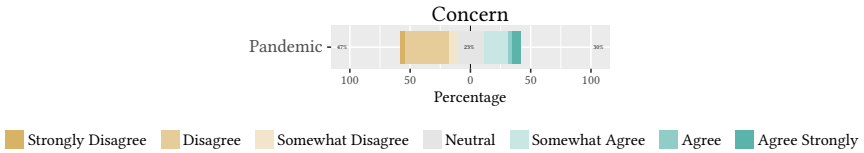

Fig. 3. Stacked bar charts of the responses of the 7-point Likert item regarding concern because of the COVID-19 pandemic accumulated across all participants. Participants on the left ("Strongly Disagree", "Disagree", and "Somewhat Disagree") answered to be currently less worried because of the pandemic, while participants in the middle ("Neutral") were neither concerned nor unconcerned, and participants on the right ("Somewhat Agree", "Agree", and "Strongly Agree") answered to be currently more worried.

4.5 Ethics

For conducting the experiment, we followed the ethical guidelines of our institution. To all participants, who participated in the interviews, we first explained the procedure and then obtained written and informed consent from them. All questions that were asked concerning the procedure were answered thoroughly before the beginning of the interview. All recorded audio data were manually transcribed, pseudonymized, and deleted after the end of the project.

4.6 Results

In the following, we present the results of our semi-structured interviews. We evaluate the subjective ratings of our individual Likert items regarding attention, intrusiveness, and motivation . Further, we evaluate the answers to the semi-structured interviews using qualitative analysis.

4.6.1 Subjective Measures. In the semi-structured interviews, we asked participants to rate individual 7-point Likert items regarding their attention for the disinfection station, the systems intrusiveness, and their motivation to use the disinfectant dispenser. The results are shown in Figure 4.

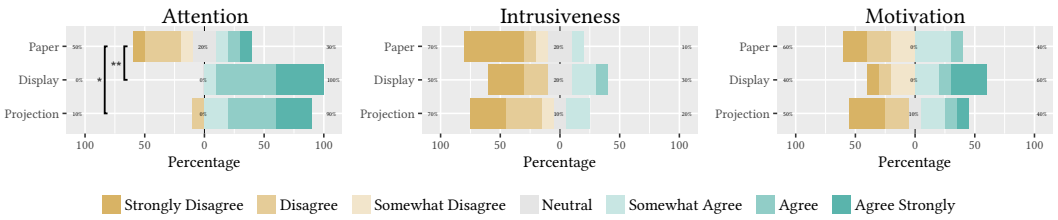

Fig. 4. Stacked bar charts of the responses of the 7-point Likert items regarding Attention, Intrusiveness, and Motivation using the three conditions: paper, screen, and projection. First, we asked the participants how much they agree that the system caught their attention (left). Second, we wanted to know if they think that the system is intrusive (middle). Last, we asked if the system motivated them to disinfect their hands (right). Significant differences are marked with * for $0.01 < p \leq 0.05$ and ** for $0.001 < p \leq 0.01$.

A Kruskal Wallis test revealed a significant effect of the condition on attention ($\chi^2(2) = 10.1394$, $p = 0.006 < 0.01$). A post-hoc test using Mann-Whitney U rank sum tests with Holm-Bonferroni correction showed the significant differences between the Groups paper and screen as well as between the Groups paper and projection. Regarding the comparison between paper and screen, the medians of Group paper and Group screen were 3.5 (IQR: 2.75) and 6.0 (IQR: 1.0), respectively. A Mann-Whitney U rank sum test shows that there is a significant effect ($U = 12.0$, $Z = -2.9408$, $p = 0.007 < 0.01$, $r = 0.537$). Regarding the comparison between paper and projection, the medians of Group paper and Group projection were 3.5 (IQR: 2.75) and 6.0 (IQR: 1.5), respectively. A Mann-Whitney U rank sum test shows that there is a significant effect ($U = 20.0$, $Z = -2.3072$, $p = 0.044 < 0.05$, $r = 0.421$). The comparison between screen and projection does not yield significance. The effect sizes can, therefore, be classified as large ($r = 0.54$) and medium to large ($r = 0.42$). A Kruskal Wallis test did not reveal a significant effect of the condition on intrusiveness ($\chi^2(2) = 1.1630$, $p = 0.559$) and motivation ($\chi^2(2) = 2.4450$, $p = 0.295$).

4.6.2 Qualitative Analysis of the Open Questions. The first, second, and third authors analyzed the interview transcripts following thematic analysis as after Braun and Clarke [6], an approach that allows inductive theme generation. We needed the flexibility of thematic analysis to reveal the possible reasons behind the interaction patterns observed in our field study. After a phase of familiarization, the initial codes were extracted, then iteratively discussed and refined by three authors. We started out with code clusters (candidate themes) that were then developed further, revisiting the original interview recordings whenever necessary. Along this process, code categories were contextualized and contrasted with the questions asked in the questionnaire, leading to overarching themes. In the process, we created an online affinity diagram for the open codes [15]. In total, we generated four themes out of the initial open codes that highlight the main aspects influencing the design of a motivating disinfectant dispenser.

Theme 1: Setup. The first theme we derived from our analysis is the participants' perception of the general setup, including the disinfectant dispenser, the public display, and the projector. Regarding the setup's size, thirteen participants perceived the disinfection station as big, which drew the participant's attention to the station. For instance, P6 said: *"[It caught my attention] because it is a very large cabinet and quite monumental."* However, five participants commented on the intrusiveness of the size or suggested making the setup smaller. In this context, P2 mentioned: *"This tower with the projector at the top is not exactly discreet. If it were smaller, it would be less intimidating."*

Another aspect of our general setup discussed by our participants was the position. On the one hand, ten participants stated that the setup's positioning promotes attracting attention. For

example, P18 said: *"[It caught my attention] because it's basically in the way. You can't miss it. It occupies almost half of the hallway."* On the other hand, eight people disliked the position in terms of inconspicuousness or its intrusiveness. Therefore, P7 stated: *"Another position would be less intrusive. This way, it did not blatantly block the way, but it was slightly in the way."*

Regarding the general appearance, 10 participants commented on noticing the disinfectant dispenser when entering the hallway. Seven of them were part of the screen-based condition. For example, P21 said: *"I think there was a disinfectant dispenser."* However, five participants stated that they overlooked the dispenser. For instance, P8 mentioned: *"My mind was somewhere else. I didn't notice that at all."* Furthermore, 11 participants noticed the technological components of our setup. Thus, P30 said: *"There was a monitor with a projector hanging above it."*

Overall, Theme 1 includes the general appearance, size, and position of the setup, drawing attention and influencing the intrusiveness.

Theme 2: Display Design. Another theme that emerged from the analysis is the display design regarding how the participants perceived the different displays from each condition and what they suggested for future displays. Among the participants that were part of the paper-based condition, six stated that they did not notice the paper sign. For instance, P3 said: *"I noticed no signs and no explicit request to disinfect my hands."* Moreover, five participants think that the paper sign is not intrusive. Therefore, P5 stated: *"It's not intrusive because it doesn't prompt me to disinfect my hands."*

All participants in the screen-based condition noticed the video when entering the hallway. Three of them described the movements in the video as eye-catching. For example, P23 said: *"I noticed the video on the display [...] something was moving in my field of view."* Furthermore, seven participants perceived the video as a motivation or a reminder to disinfect their hands or stated that they understood the connection between the video and the disinfection station. P28 mentioned: *"The video is motivational and is meant to get people to disinfect their hands."* In addition, four people within this condition think that the system is not intrusive. Thus, P26 said: *"I don't find the device or the video intrusive per se."*

For the projection-based condition, nine participants mentioned that they noticed the projection, but only two noticed the paper sign. For instance, P14 explained: *"I have seen footprints, without which I would have paid less attention to the disinfectant dispenser."* P16 added: *"Funnily enough, I only saw the footprints, but not the disinfection sign."* However, two participants did not understand the connection between the footprints and the disinfection station. Thus, P17 stated: *"I did not understand the connection between the footprints and the disinfection. I would simplify the design around the other distraction."* Regarding the intrusiveness of this condition, five participants perceived the design as not intrusive. For example, P11 said: *"It has tried to discreetly draw attention. There are much more intrusive things like the flashing of a red light."* Furthermore, P15 mentioned the risk of getting used to the system by expressing: *"I feel like if I got used to it now, it wouldn't be new anymore, and I wouldn't use it as much."*

For future recommendations of our display design, participants suggest another kind of feedback. Three participants within the paper-based condition suggested lightning could draw attention to the disinfection station. One participant with the screen-based condition recommended tracking the user and showing them within the video. Two participants within the projection-based condition suggested having better lighting conditions in the hallway so that the footprints can be seen more clearly, and two participants recommend to make the connection between the footprints and the disinfectant dispenser clearer. Overall, two participants had the idea to show updated information about the pandemic to make people aware of the disinfection. Two persons suggested changing the visualization occasionally to keep a novelty effect. Furthermore, five persons suggested using audio feedback like a voice reminding passersby to disinfect their hands. However, two participants

stated that this would increase intrusiveness. Therefore, P20 told: *"If sound were played in an endless loop, then I could imagine it being really intrusive."* Four participants expressed their awareness of the trade-off between attention and intrusiveness and accepted a certain degree of intrusiveness for increased attention to the system. In addition, three users stated that they were distracted by the turned-off public display as they thought they could interact with it for the paper-based and projection-based conditions. Moreover, three participants mentioned that it is important that disinfection does not become obligatory. For instance, P5 said: *"It should be voluntary. It should not be something that obliges you to disinfect your hands."*

Overall, Theme 2 covers the importance of a connection between the display and the dispenser and provides additional design ideas and modalities for technology-based cues for disinfection.

Theme 3: Motivation and Interest. Another theme we identified is motivation and interest, including all the factors that motivated or demotivated our participants to disinfect their hands. Eight participants stated that the system caught their interest because of their curiosity about our technical setup or because they were bored waiting in the hallway. For instance, P22 said: *"The system looked like interesting technology that caught my attention."* Two participants suggested adding gamification to our system to motivate people. Therefore, P7 stated: *"The system could need something compelling that people find cool, like gamification or something novel, so that users are motivated to use the device."* Three participants recommended rewarding the users after disinfecting their hands. P2 commented: *"If a chocolate fell out of it or some kind of reward system would motivate me."* Regarding the disinfection motivation, safety is also a factor discussed by several participants. Thirteen participants reported that preventing diseases like Corona or personal welfare were reasons to disinfect their hands, e.g., P18 said: *"In general, I want to appear as clean as possible and don't want to infect anyone."*

But there were also some negative factors our participants mentioned that prevented them from disinfecting their hands. Seven participants stated that they were stressed and thus overlooked the disinfection station. Therefore, P10 said: *"I was honestly nervous about the exam and didn't think about anything else or noticed anything else in my environment."* Furthermore, six people already disinfected their hands shortly beforehand, and two persons did not interact with the dispenser because of a hand injury. For each, one participant indicated that they do not disinfect their hands because of the disinfectant smells, is sticky, or due to the experience that public dispensers were often empty. Five participants expressed that disinfecting their hands had become unnecessary because they were immunized, for example. For instance, P11 commented: *"I didn't see the need that way. I'm also a bit tired in this context because these things are now standing around everywhere. Then I heard that the probability of getting infected with Corona through contact is very low. It is transmitted via aerosols."* Moreover, five participants expressed that social factors like peer pressure influence their interaction with disinfectant dispensers. For instance, P20 said: *"Especially if other people are standing in the hallway looking at you, I would feel prompted to disinfect my hands."*

Overall, Theme 3 collects factors motivating or demotivating the disinfection usage, including intrinsic motivation, gamification, rewards, prior experiences, and peer pressure.

Theme 4: Pandemic. The last theme we derived from the interviews is the pandemic, including participants' feelings and attitudes towards the corona pandemic. Seven persons expressed they were annoyed or tired of the situation. For instance, P8 said: *"There were a lot of problems with the laws because it was always going back and forth in the pandemic. At some point, you can't deal with that anymore."* Moreover, five participants expressed their anger about how few people still care about the pandemic and about opponents of vaccination. Thus, P12 commented: *"I find it appalling how indifferently our society seems to accept this misery."* Twelve participants stated that

they were concerned about the pandemic and underlined their fear of a severe course of the disease, possible upcoming mutations, and their worries about the future. For example, P2 said: *"I am afraid to get Corona myself, afraid of a severe course."* Thirteen participants stated that they are barely worried anymore because the pandemic has already been going on for two years, they are already immunized or have the impression that society has the pandemic under control. In this context, P27 noted: *"I believe that the pandemic is no longer so dangerous in the sense of severe courses due to the vaccination."*

Sixteen participants explained that the pandemic has led to incorporating certain habits into everyday life, like wearing masks, disinfecting hands, vaccinating, or testing oneself before meeting other people. For instance, P20 said: *"You do everything - wash your hands, hygienic measures, keep your distance – automatically."* However, the pandemic also seems to integrate some negative habits into people's daily life. Four participants indicated that they have become blind to disinfectant dispensers and tend to overlook them. Thus, P9 expressed: *"You see the signs [to disinfect your hands] every time, so you don't notice them anymore."*

Overall, Theme 4 aggregates feelings and attitudes towards the COVID-19 pandemic, which can amplify or weaken the attention regarding disinfectant dispensers.

4.6.3 Limitations. We acknowledge the following limitations to our work. First, our field study took place on a university campus, where the demographic distribution is limited to a certain user category. We primarily interviewed students with a background of computer science, resulting in a quite tech-savvy sample. Therefore, we cannot claim whether similar results would be obtained in every location. Then, while we tested different design conditions (i.e., paper-based, screen-based, and projection-based) based on previous literature, we did not opt for any variance within the same condition (e.g., animation vs. static). While the paper-based instructions are static and the screen-based, as well as projection-based instructions, are animated, we did not replace the paper sign but used it in all three conditions consistently. Therefore, the motion perception raises the participants' visual attention as expected, which is supported by our findings in the subjective measures regarding attention. Additionally, the footprints in the projection-based condition are not suitable for wheelchair users to identify themselves with, which is a limitation of this condition. Furthermore, we placed the display to be facing the direction of walking, however, placing it in different positions might result in different outcomes. At last, we did not explicitly measure participants' walking speeds as they moved next to the apparatus. We invited them to the interview independent of their walking speed. If they were hurrying to an appointment, we asked them to visit us afterward. It is likely that a higher walking speed indicates stress and, therefore, reduces the attention for the disinfection station.

5 IMPLICATIONS AND ITERATED DISINFECTION MODEL

Our results confirm that there are four main phases by which we can categorize the passersby approaching a disinfection station in a public space. We iterated the model proposed by Asai et al. and added reasons for passersby to drop out of the process and not disinfect their hands [4]. For the iteration of the model, we took inspiration from other prior models [38, 46] and combined it with our own findings. The "AUMA" model and its' phases are illustrated in Figure 5. Previous work targeted attention-getting as a main step towards interaction followed by motivation and the action itself [27]. However, this interaction modeling does not apply in our case as the main target for the passersby who want to interact is not the display itself but rather the disinfection station. Our model suggests a new phase between attention and motivation that we refer to as understanding. We found that providing the bridge between the visual cue and the motivation to use the disinfectant dispenser is essential – whether implicit (e.g., by a specific color or design

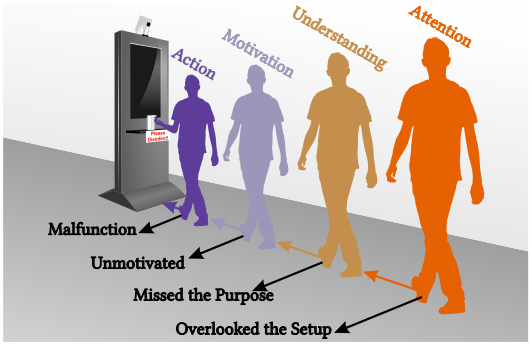

Fig. 5. "AUMA" model based on the results of our study that users go through to disinfect their hands in public places. The model iterates the "AIDA" Model proposed by Asai et al. [4]. Our model adds reasons for passersby not to disinfect their hands. In this process (right to left), users can possibly drop out at four key points: (1) Attention – users can overlook the setup, (2) Understanding – users might miss the purpose of the system, (3) Motivation – users can be not motivated to disinfect their hands, and (4) Action – the dispenser can malfunction or be empty. Only if they pass all four phases, the process will result in a disinfection event.

pattern that has been shown to unconsciously prompt people to use the dispenser) or explicit (e.g., a sign with clear instructions or a message encouraging the person to use the dispenser for hygiene purposes). While the interest and desire phase partly model the motivation phase, additional factors such as previous experiences are relevant at this point. In the following, we describe each step of our proposed "AUMA" model (Attention, Understanding, Motivation, Action) and explain the factors influencing users' decisions based on the results of our study.

5.1 Attention Phase

The first step of the hand disinfection process is getting aware of the disinfection dispenser. Through the semi-structured interviews, we identified potential reasons why people did not notice and overlooked the disinfection station. One main reason indicates that the mental state is influencing and guiding the passersby's attention as some of them said that they were *"stressed"*, *"distracted"*, or indicated thinking about something else (cf., T3: Motivation and Interest). This goes in line with the load theory stating that the efficiency of selective attention is set by the level of perceptual load (e.g., focusing on something) in a task [21, 31]. Therefore, passersby who are focused on something else tend to overlook such systems. Our results further show that passersby are prone to not noticing signs and disinfectant dispensers (cf., T4: Pandemic). While this could also result from the mental status, it has also been observed in similar setups with digital public displays [30]. Although in other studies, that was referred to as display blindness [16, 30], in our study, we refer to it as *"disinfection blindness"*. Such development may be caused by the ongoing pandemic as well as the integration of disinfection stations and dispensers in public places. Consequently, people got used to paper signs and dispensers and easily overlook them. In our work, we used animated visual cues in the technology-based conditions as suggested in prior work [20], where we obtained similar results. As indicated by our study results since participants' attention toward the disinfection station increased when adding animated visual cues for both technology-based conditions (cf., T2: Display Design and Figure 4).

On the positive side, we identified factors that directed people's attention toward the disinfectant dispenser. The first of these factors is the size – passersby's awareness of the disinfection station seems to be influenced by its size (cf., T1: Setup). A bigger setup is more eye-catching than a single dispenser. This is in line with previous attention research that suggests that size influences attention shifts [17]. However, it also somewhat contradicts prior work, explaining that the public

might be more engaged with small displays [18]. The second factor is the positioning of the disinfection station, as our participants tend to perceive the station's position in the hallway, where they must pass it to get to their destination, as attention-grabbing. A similar result was deduced from a field study, where the researchers observed only how the passersby interact with the displays [18]. The third factor is intrusiveness: while the subjective measures do not indicate any difference among the conditions, the qualitative data was more insightful. Interestingly among all the Likert scale questions, there was a pattern in the answers always ranking from lowest to highest the paper-based, then projection-based, and last the screen-based condition. According to the results, the condition that scored the highest attention-getting is also the one with the highest intrusiveness. This raises the question of what is the fine-lined trade-off between intrusiveness and attention. Remarkably in other fields like business, the relation between intrusiveness and attention is inversely proportional [2]. While our results do not show a conclusive explanation for the discrepancy in our results and the theory links attention and intrusiveness, one potential conclusion could be that it depends on the use case, the users' needs, and how it is viewed by the user. We, therefore, conclude that the **overall position and animation are two major factors for attention guidance toward interaction with technology-based disinfection stations.**

5.2 Understanding Phase

After becoming aware of the disinfection station and the corresponding display, the next step on the way to interacting with the disinfectant dispenser is understanding the connection between the visual cues and the disinfection station. This phase is deduced from our findings and differs from the interest phase described by Asai et al. [4]. The reason is, that throughout the analysis, the differences between our approach to investigating the role of technology in reminding people to disinfect their hands in public places became clearer. Our setup is not guiding an interaction with the public display. However, we aim to use the public display as a visual cue to interact with the disinfection dispenser. With this substantial difference in the finally targeted interaction, the importance of this phase is linked. For the projection-based condition, some participants tend to misunderstand the meaning of the projected footprints (cf., T2: Display Design). This may have been caused by the design of the footprints that do not directly prompt disinfection like the paper sign or visualize the disinfection process like the video. Yet, it guides the passersby towards the direction of the disinfection, where the paper instruction and dispenser are located. Another reason could be that the display is not integrated into the disinfection station but is projected on the floor 50 cm in front of it. Thus, people could miss that these two components belong together. Moreover, some of our participants within the paper-based and projection-based conditions were distracted by the turned-off public display since they thought the dispenser was only for disinfecting hands before interacting with the public display (cf., T2: Display Design).

Nevertheless, visual cues can also contribute to a better understanding as some other users, for example, seem to be guided by the footprints interpreting them as a request for disinfection or tend to imitate what they have seen in the video (cf., T2: Display Design). Previous work by Hardy et al., also reported that the users' expectations regarding the public display shaped their behavior [16]. As passersby tend to avoid interaction for not knowing that there is one or what their task would be. Although people's understanding of the disinfection station may be influenced by visual cues, we cannot conclude if a full understanding of the connection between visualization and disinfection is necessary. Thus, it could potentially be that users follow the guidance unconsciously and disinfect their hands without realizing the whole intention of the system. This finding, hence, raises the point of whether all the interactions need the same clarity of visual cues or if it is more the case that the visual cue design is action-driven. In all cases, we deduce that **a link, let it be direct or indirect, should be established between the display and the targeted interactive object (i.e., disinfection station).**

5.3 Motivation Phase

The third phase of the process addresses the users' motivation to disinfect their hands. From the semi-structured interviews, we deduced reasons that influence the users' motivation. On the one hand, we have identified reasons against using the disinfection dispenser (cf., T3: Motivation and Interest). Participants either deemed it unnecessary, were not interested in the system, or associated disinfection with negative feelings, such as experiencing empty public disinfection dispensers or unpleasant disinfectants. Others cited various reasons like having hand injuries, already having disinfected or washed their hands.

On the other hand, several participants motivated the dispenser usage (cf., T3: Motivation and Interest). Participants regarded it as a safety measure for themselves, their families, and society (cf., T4: Pandemic). They further highlighted its importance in sensitive environments (e.g., hospitals) and mentioned the value of sharing real-time pandemic updates (e.g., death count) as motivating aspect for the criticality of the situation (cf., T4: Pandemic). Our assumption was that the passersby have strong intrinsic motivation for hand disinfection due to their previous experience with the COVID-19 pandemic. Therefore, we assumed that the visual cues would trigger their motivation in different ways, yet, the Likert items showed no significant difference in motivation across the various conditions.

However, motivation has multiple facets and is difficult to be measured and fully comprehended. Therefore, we deduced that reminding the user of hand disinfection and relying solely on intrinsic motivation is not sufficient. Although some people whose level of intrinsic motivation is high enough (in this situation) will use the system, others need an additional source of motivation. Brignull and Rogers also highlight the necessity of encouraging people to overcome the threshold from awareness to participation [7]. Peters et al. further underlined this challenge and associated that with the difference between autonomous motivation, which is driven by the users themselves, and controlled motivation steered by external influences [36]. According to the authors, controlled motivation is highly influenced by pressure or obligation and external rewards or penalties. In comparison, the work of Pearson et al. used the possibility to participate in a voting by using one of two disinfectant dispensers as a motivating factor [35]. We also observed similar findings, as 25 of our 30 participants either related to a direct benefit for using the system or asked for incentives that varied between rewards or integrating fun elements for gamification and interaction (cf., T3: Motivation and Interest). While Müller et al. came to the same conclusion and suggested challenging people and raising their curiosity [27], Alt et al. suggested shape-changing cues as visual feedback for entertaining and engaging users [1]. Another approach is to lower the perceived dispenser using hurdle by indicating to passersby that they do not waste time by interacting and highlighting the returned value [42]. There are countless more approaches that should be tested to increase the motivation of passersby to interact with our dispenser station, but we conclude that **if intrinsic motivation is noticed too low, external motivating factors should be considered in the design.**

5.4 Action Phase

The fourth of our interaction model is the action phase. This phase is identical to the model from Asai et al. [4]. It is the last phase before the disinfection of the hands. Nevertheless, there are still reasons that could lead to a person not disinfecting their hands. Primarily the reason for dropout at this stage is the malfunction of the dispenser due to technical failure or lack of disinfectant. As these reasons are not connected to the user but rather the technical setup, we do not discuss them here in more detail.

6 CONCLUSION

Hand disinfection in public places is likely to stay important as a precautionary measure against the spread of various diseases and any potential future pandemics. Thus, most of the public spaces and facilities have been equipped with disinfection dispensers. With time and the excessive presence of disinfecting material, the public tends to overlook the possibility of hand disinfection. In this work, we investigate the potential of using technology to remind people of hand disinfection in public spaces. Through a three-week study with different display designs, we explored the passersby's interaction with a disinfection station while augmenting it with paper-based and technology-based visual cues. For this purpose, we conducted interviews with a random sample of the passersby ($N = 30$) to identify the potentials and challenges of each technology. While previous work highlighted the importance of getting the users' attention and motivating an interaction [27], our results indicate that for our scenario, the attention-getting cue should be linked to the aim of the display. In our scenario, this reflects the importance of creating an implicit or explicit bridge between the presented visual cue and the disinfection dispenser. It also indicates that designing such reminders should account for external motivating factors (e.g., rewards) in case of insufficient intrinsic motivation. Furthermore, our interview results provide reasons why users drop out of the process, which is included in our "AUMA" model. With our outcome, we are confident that we pave the way to improve the design of disinfection stations and, thus, increase the disinfection rate in public spaces. In the future, we plan to conduct studies in public places taking the various aspects linked to the user's motivation into consideration.

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A SCHEDULE OF THE SEMI-STRUCTURED INTERVIEWS

Interviewer: Excuse me, are you free for a quick interview of 10 to 15 minutes? [In case the participant agrees, they sit down together in one of the offices, and the interviewer welcomes the participant.]

A.1 Unbiased First Impression

Q1. Did you notice anything in the corridor?
Q2. What? / Why? / Why not?
Interviewer: I am sorry that I asked you these first two questions without explaining the context. This was, unfortunately, necessary to capture your unbiased first impression with respect to your attention. [Interviewer explains the setup of the disinfection station and the purpose of the interview. Further, the interviewer asks for consent to do audio recordings of the interview, which are transcribed later.]

A.2 Likert items Regarding Attention, Intrusiveness, and Motivation

Interviewer: On a scale from 1 to 7 with 1 meaning "strongly disagree", 2 meaning "disagree", 3 meaning "somewhat disagree", 4 meaning "neutral", 5 meaning "somewhat agree", 6 meaning "agree", and 7 meaning "strongly agree", how do you rate the following statements:
Q1. The system highly caught my attention.
Q2. The system was very intrusive.
Q3. The system strongly motivated me to disinfect my hands.

A.3 Reasoning for the Likert items

Q1. Why did it (not) catch your attention?
Q2. Why was it (not) intrusive? What annoyed you, if anything?
Q3. Why did it (not) motivate you to disinfect your hands?

A.4 Possible Future Changes and Improvements

Q1. What should be changed so that it catches your attention?
Q2. What should be changed for it to not be intrusive?
Q3. What should be changed so that it motivates you to disinfect your hands (more often)?

A.5 COVID-19 Pandemic

Interviewer: On a scale from 1 to 7 with 1 meaning "strongly disagree", 2 meaning "disagree", 3 meaning "somewhat disagree", 4 meaning "neutral", 5 meaning "somewhat agree", 6 meaning "agree", and 7 meaning "strongly agree", how do you rate the following statement:
Q1. I am currently highly worried because of the pandemic.
Q2. Why are you (not) worried? How do you feel about the pandemic? What emotions does it provoke in you?

A.6 Demographics

Q1. What is your age?
Q2. What gender do you identify as?
Q3. What is your profession? And if applicable, what is your area of study?
Interviewer: Do you have further comments or questions about the study? Thank you for your participation!

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