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MagicFace: Stepping into Character through an Augmented Reality Mirror

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ABSTRACT
Augmented Reality (AR) is coming of age and appearing in various smartphone apps. One emerging AR type uses the front-facing camera and overlays a user's face with digital features that transform the physical appearance, making the user look like someone else, such as a popstar or a historical character. However, little is known about how people react to such stepping into character and how convincing they perceive it to be. We developed an app with two Egyptian looks, MagicFace, which was situated both in an opera house and a museum. In the first setting, people were invited to use the app, while in the second setting they came across it on their own when visiting the exhibition. Our findings show marked differences in how people approach and experience the MagicFace in these different contexts. We discuss how realistic and compelling this kind of AR technology is, as well as its implications for educational and cultural settings.

Author Keywords
Augmented reality; Opera characters; Interface design; In-the-wild study.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION
Augmented Reality (AR) has much potential for overlaying a variety of digital content onto the real world. So far, it has been mainly used for educational, commercial and gaming applications, for example, providing location-based information about buildings and landmarks, and signage about places of interest. The recent craze, Pokémon Go, has demonstrated its popularity as a gaming platform, where players hunt virtual Pokémon creatures in real life. Most AR apps use the *back-facing* camera in smartphones/tablets to superimpose the digital content onto the real world, to make it appear as part of it. In contrast, our research is concerned with how the *front-facing* camera enables digital content to appear in real-time on one's own face – a popular app of this kind is SnapChat filters. Here, we are interested in how the technology can be used to create looks of historical characters. How do people react when virtually trying on a look of another person, and when given the opportunity to 'step into character'? *Does it make them feel like the character in question - by being able to imagine what it is like to be like them? If so, what does the experience engender, for example, further interest in the character?*

To step into character involves viewing and seeing oneself as a particular persona from real life, film or theatre. The virtual make-up can be designed to provide a certain look, for example, one of David Bowie's persona or that of an Egyptian Pharaoh. As well as exploring how people react when seeing themselves in this way for the first time, we were also interested in how the same AR technology can be used by those who step into character on a regular basis. For example, those who perform on stage for a living (e.g. singers, actors) or who make the performers appear in character (e.g. make-up artists). *Are they able to imagine the tool helping them in their work?*

The way the interface is designed and where the app is located is likely to have an impact on how people engage with a virtual try-on [11]. To investigate this further, we compared different interfaces when used in a private space versus a public setting. To understand the AR user experience we used a framework [11] that characterizes it in terms of: (i) how users approach the technology; (ii) the level of control provided; (iii) the perception of how convincing the technology is; (iv) how engaging it is and (v) the impact of its situatedness in a setting. To explore the different aspects of the user experience, we created an app, MagicFace, that provides four different kinds of interface, varying in level of control, type of entry point, available information and presence of additional atmosphere effects. For the app, we developed virtual make-up looks of the two main characters from Philip Glass's opera Akhnaten. To explore how it would be used in the different settings, the MagicFace was placed, first, in the private confines of a

dressing room of an opera house and, second, in the public space of a museum.

To make the different looks appear convincing, we collaborated with an AR company, Holition, and the English National Opera. The MagicFace was initially placed in the backstage dressing rooms of the Coliseum, where the opera was being performed. An in-the-wild study was carried out which explored how different users, when invited to look into the mirror, reacted and their subsequent interactions with the app. In the second study, MagicFace was placed in a museum that had an exhibition on about the same Egyptian Pharaoh, Akhnaten. Conducting the study in these two settings enabled us to compare people's responses between being invited to try it out versus discovering it by oneself and then trying it out. The findings from the two studies showed both similarities and differences between how users (performers, make-up artists, school children, museum visitors) were taken by surprise on seeing themselves in the AR app, followed by different forms of engagement and reactions. We discuss these in terms of their potential for creating different experiences and benefits when stepping into character for different purposes, be it for the audience, performers, visitors, or school children on their first trip to the opera.

BACKGROUND

The user experience of AR has been researched in a variety of contexts. We describe these below followed by an overview of how other technologies have been used to enable people to step into character.

Application of virtual try-ons

Virtual try-on mirrors have so far been deployed mainly in social media and commercial contexts. For example, SnapChat provides various AR filters that users can select from for augmenting their facial features, such as having a rainbow colored animated tongue. Another virtual accessory was Michael Kors sunglasses that reflect the sky and palm trees and appear on the user's face as if for real [8]. More recently, other kinds of 'lenses' have been introduced, to enable users to resemble film characters, for example, X-Men [18].

Virtual try-on AR works by analyzing the user's face using the front-facing camera of a smartphone/tablet. Motion capture techniques build up an internal 2D model of a person's facial features in real time that then forms the basis of the virtual try-ons. This capability has attracted companies to investigate its potential in the context of shopping, both online and in retail [11]. Several AR mirrors can now be accessed online (for example RayBan Virtual Mirror) or downloaded as apps on smart devices (for example Rimmel Get The Look). The objects currently available for try-ons are predominantly make-up looks, jewelry and sunglasses, as their realistic simulation can be achieved with 2D modeling. The AR mirrors allow users to try on different products and see them appearing on their faces, offering a convenient tool for narrowing down a set of preferred choices that is easier compared with trying on the physical items. In comparison with online deployment, there have been fewer attempts to situate try-on mirrors in public contexts. A recent study showed how important it is to consider the physical context in a store where the mirror is to be located [11]. If it feels suitably embedded, users are more likely to approach and use it.

Within a research setting, AR has been found to improve learning, by situating augmented knowledge in the context that is being learned about [4,5,24]. The technology has been found to provide accessible and intriguing visualizations for conveying concepts, such as the various structural models used in chemistry, biology and electronics [3,7]. Furthermore, Jung et al. [12] demonstrated that AR can evoke social presence, i.e. the sense of "being there", in a museum context. This kind of social presence has also been found to enhance learning by provoking increased curiosity about a visited site, as evidenced by visitors' intention to revisit the museum.

This research suggests AR has much potential for creating a memorable experiential impact [2,12,16]. By this is meant both utilitarian and hedonic aspects - in the sense that the AR experience is perceived to be useful while also fun and entertaining [20,23]. Shankar et al. [21] predict that future AR could further capitalize on such experiential aspects by delivering new ways of presenting virtual content.

One of the limitations of current AR technology, however, is that sometimes the modeling can be slightly off, so that the overlaying of the digital information appears in the wrong place or is out of sync with what is being overlaid. This may not be critical when the overlay is text or related visual content. However, when Di Serio et al. [6] tested the effectiveness of an AR application for a visual arts course that used handheld mobile devices to overlay images on to buildings, they found that sometimes the images did not fit well with the physical building's features, or the image disappeared unexpectedly. The effect of these technological limitations can effectively break the magic. Furthermore, accuracy is likely to be even more critical when the AR visualization needs to be aligned with the object in order to be convincing, such as virtual try-ons. Hence, how well the AR technologies align with the features of a physical object (e.g. building, face) is often critical as to how convincing the augmented experience is.

Stepping into character

Interactive technologies have been widely deployed in theatres and museums, to create artistic value and foster audience engagement when integrated as part of a performance [1,13] or exhibition [22]. By evoking imagery and focusing an actor's or audience's attention, various kinds of digital screens have been found to draw people into the narrative or characters of a play [1]. Sensing technologies and audio-visual techniques have also been used to distort time, space and people's images in compelling and creative ways for a variety of playful

interactive installations [19,22]. Likewise, avatars have been developed in virtual reality to immerse users into virtual role-playing. In so doing, it can create a psychological link between the user and the virtual avatar that impacts the person's sense of self [17]. The downside of VR, however, is that it requires donning a head-mounted display that cuts the user off from the rest of the real world.

In contrast, AR differs from VR in that it immerses the user in both the real and the virtual – so people can interact with both. However, little is known how it can draw users into a state of immersion. Does the digital augmentation enable people to step into different characters and, if so, how does it change how people feel?

RESEARCH AIMS

The aim of our research is to investigate the extent to which an AR mirror is capable of creating the illusion of becoming another person, in this case a historical character. Our study was conducted in the context of how AR can enhance the visitor and the performer experience in arts and cultural settings. We were also interested in how different interface designs affect the approachability and usage of the AR mirror; in particular, comparing a look that suddenly appears in front of someone versus one that users select themselves. Does one draw the user in more and, if so, lead to a more engaging experience?

MAGICFACE APP AND INSTALLATION

An AR app was developed using virtual try-on technology for two characters from Ancient Egypt: the pharaoh Akhnaten and his wife Nefertiti. Akhnaten is the Pharaoh who had a vision to abandon the worship of many gods for just one. The two characters were selected as they were the lead roles in the Opera Akhnaten that the English National Opera (ENO) were staging. During the 6 months leading up to the production, we worked alongside members of the company to ensure the MagicFace looks were to a professional standard. A high level of quality was required by both the ENO and Holition – as it was important for their reputation. Much thought was also given to where and how to situate the MagicFace in the ENO's Opera House (the Coliseum) to make the experience convincing. After exploring various possibilities, it was decided that the best location was in one of the dressing rooms - a private space where the singers prepare for their performance. The MagicFace was placed on the wall to appear like one of the mirrors already there. To create the impression of a dressing room mirror, a large tablet (iPad Pro) was placed in a white frame that was studded with light bulbs (Figure 3). The construction hid the edges of the tablet leaving only the screen visible.

At the same time, an exhibition about the history of Akhnaten was being curated for the Petrie Museum of Egyptian Archaeology in collaboration with the ENO. After much consultation with the museum directors, the same MagicFace app that was used for the Opera setting, was embedded in a picture frame that could be hung on a wall in the museum so that visitors would come across it while looking at the exhibit. The idea was that visitors who were looking at the displayed material for the exhibition on Akhnaten would happen upon it by their own volition. In this stand-alone setting, we were interested in seeing whether the automated version was more effective at drawing people in compared with the versions requiring the user to initiate interaction with the app.

The MagicFace interfaces

To explore how having differing degrees of control over the AR experience, versus it just appearing, affected user's experiences, four different types of interface were designed for the MagicFace (Figure 1). They differed in the way the virtual try-on was applied and controlled, with each having a different landing page. We were interested in how each one attracted users; how they drew them in to explore an interface and how they kept them engaged.

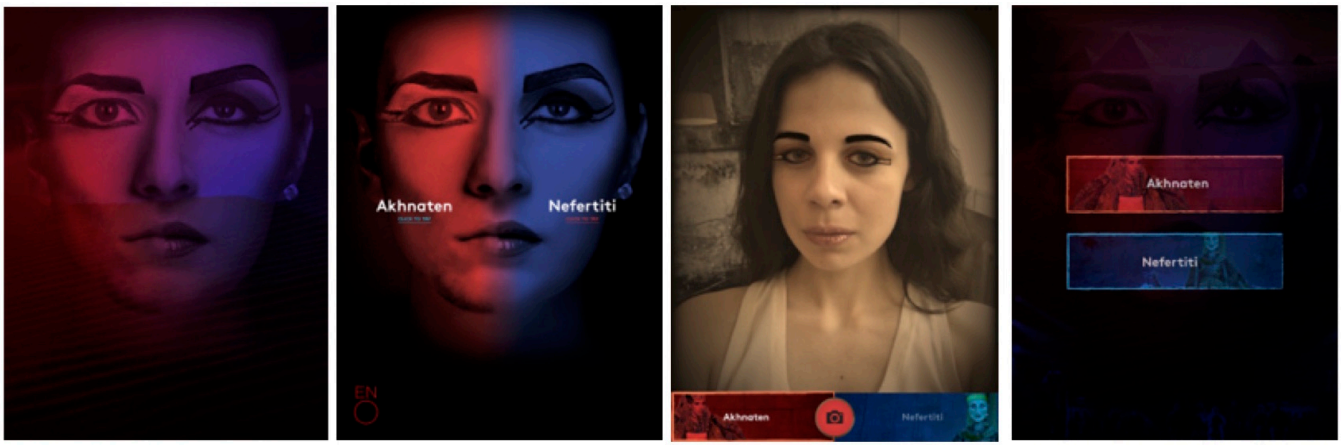

Figure 1. Four landing pages: (i) screen saver that is automatically replaced with virtual make-up once a user appears in front of the camera (first from the left); (ii) screen saver with buttons that a user clicks on to see the virtual make-up (second from the left); (iii) screen saver is automatically replaced with the virtual mirror with the buttons for switching between the two looks (third from the left); (iv) screen saver with the choice of two names that the user taps on to see the virtual looks (fourth from the left)

Version	Mode of applying make-up	Additional features
1	Automatic make-up applying and automatic look-switching	None
2	Controlled make-up applying and controlled look-switching	Background music
3	Automatic make-up applying and controlled look-switching	Photo-taking option
4	Controlled make-up applying and controlled look-switching	Background music, Photo-taking option, Info page

Table 1: Differences between the four interface versions

Table 1 outlines the differences between the four designs. Version 1 was designed to place the two looks automatically on the user when they sat or stood in front of the mirror, switching between them every 5 seconds.

Figure 2: Info page that dropped down if an info button in the upper right corner of the virtual mirror was tapped

The rationale for including an automatically changing interface was to create a realistic impression of a mirror that the user does not interact with in any other way, besides looking into it – in the way mirrors normally work. In contrast, version 2 was designed to virtually overlay a look on someone's face when initiated by tapping on a button on the screen. Music from the opera was also provided to create the atmosphere of the performance. Version 3 was designed as a hybrid: it was automated to begin with but then allowed a user to take over control and make their own choices of what to explore. A photo taking option was also available. Version 4 allowed the users to change between the two looks themselves. It also provided other interactive features, including a drop-down menu with more information about make-up in Ancient Egypt (Figure 2).

STUDY 1: THE OPERA SETTING

Method

An observational study was conducted in the dressing room of the Opera House throughout the two-weeks when Akhnaten was on show. The researcher and the ENO education director were present, inviting people to see it in the context of an authentic dressing room.

Figure 3: Framed AR mirror in the Opera dressing room

Participants

A number of different user groups were invited by the Opera House to take part in the study as part of the learning and accessibility programme. It was planned for about 40 school children to take part (10 for each interface type). However, owing to logistics and timing that were out of our control, only half the number of groups showed up during the two weeks' period available for the study. We also invited 4 older college students to participate. In the end, 16 school children, accompanied by 4 teachers took part, coming into the dressing room in groups of 3-4. None of the children had been to the Opera before. The groups and the respective interface version they used are shown in Table 2.

12 opera singers (coded as S1 – S12) and 5 make-up artists (coded as M1-M5) were also invited to try the MagicFace and discuss about its potential use for helping them step into the characters, especially when developing the

characters for the theatrical performance. These two groups were encouraged to experiment with all four versions in order to provide as much feedback as possible on the different interfaces and their impact on the artistic process.

Version	Student groups	Code
1	8 young teenagers; Group 1 (1 M, 3 F) Group 2 (1 M, 3 F)	P1 - P8
2	4 young teenagers; Group 3: (4 F)	P9 - P12
3	4 mid-teens; Group 4 (1 M, 1 F) Group 5 (2 M)	P13 - P16
4	4 college students; Group 6 (1 M, 3 F)	P17 – P20

Table 2: Versions used by the students (M=male, F=female)

We first observed the various participants using the app and then interviewed them. We asked all of them how they felt when they saw themselves with the virtual make-up, what they thought of the app and if they were interested in using it again. The pupils and students were also asked about their interest in the opera and if the mirror made them relate to it. The questions to the artists on the other hand focused on the possibilities of the MagicFace being integrated in the artistic process, such as at which points (if at any) of the character-building they could imagine the app being used, what was the role of appearance in preparing for the role and what features they found helpful.

The interactions, the comments and the interviews in the dressing room were all recorded with cameras that were placed in two corners of the room. Next, we provide an overview of the qualitative findings followed by detailed analyses of the user experience in relation to the five core aspects of the conceptual framework: (i) how users approached MagicFace; (ii) the impact of the app automatically switching between looks versus providing user control and the length of engagement with the different interfaces; (iii) the perception of how convincing the looks were; (iv) how and whether it helped them step into character and what this led to, and (v) the impact of the situatedness in the dressing room setting. In addition, a codebook was developed to categorize the content of the interviews, based on the following topics: the app and its features; AR technology; opera; make-up; and current and future app uses. Two coders conducted the analysis.

Findings

Overall, the AR experience evoked much intrigue and user engagement. The students used the mirror between 1-5 minutes; the make-up artists between 1-4 minutes and the singers the longest - between 1.5-9 minutes. Most of the participants could imagine themselves in the two characters of the opera. The professionals, in particular, spoke at length about their perception and ideas for how they might use such a tool - having the benefit of knowing much more about the background of the different looks and the artistic context due to their expertise. It enabled them to consider other possibilities of how they might use it when practicing and experimenting with designing other theatrical appearances. The students, in contrast, spoke to a lesser extent, and reflected more about how it made them think about what happens behind the scenes at an opera.

(i) Approaching behavior

When first trying out the different looks, all participants were struck by the way it transformed them into the main opera characters. Over half of the participants laughed out loud when seeing themselves for the first time with the virtual try-on. Nearly all appeared to be taken by surprise, as evidenced by them gasping when seeing themselves and making exclamations, such as "*Wow!*", "*This is amazing*", "*That's so cool*" and "*I haven't experienced something like this before*.". Observed surprise was stronger for version 1 and version 3, where the sudden appearance of themselves as an Egyptian character took them unawares.

Following their initial surprise, many proceeded to experiment with the mirrored look to see how the make-up followed them, by moving their eyebrows, opening their mouth, and moving their head from side to side. There was a difference between age groups as to how much they

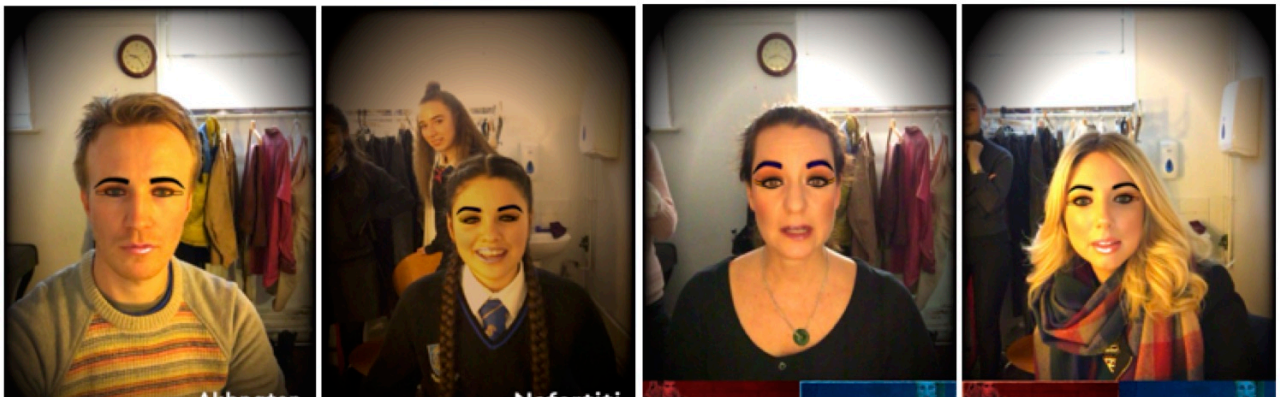

Figure 3. Different groups of visitors trying on virtual make-up in the opera dressing room: opera singer (first from the left); pupil (second from the left); make-up artist (third from the left), opera singer (fourth from the left).

experimented. The two groups of mid-teen students seemed more self-conscious when using the MagicFace in front of their peers, preferring to remain aloof, possibly for fear of being mocked by them. In one mid-teen group (gender-mixed) the initial discomfort disappeared as the students began taking numerous photos while continuously switching between the two looks. The students in the other mid-teen group (male-only) remained uncomfortable throughout. The young teen groups also displayed initial embarrassment with their transformed image in the mirror, commenting: "*That's so weird*." (P7). But once they overcame their initial surprise, they reflected more on the role of such a mirror in the dressing room and for the opera production. Girls in the young teenage groups appeared more intrigued about the make-up looks than the boys, who thought make-up is not for them: "*I wouldn't use it because I'm a boy and I don't like make-up, but I think for girls this app can show if they look nice."* (P1). In contrast, the older students did not display any embarrassment and after the initial surprise started commenting on the accuracy of the virtual try-on and explored the app and its features.

The singers and make-up artists also displayed a high level of fascination and interest when starting to interact with the apps: "*I love the way it follows you*" (M1), "*That's mad, isn't it*" (S12), "*Wow, that's beautiful! That's some of the nicest make-up I've ever seen*" (S10), "*Wow, I'm Egyptian!*" (S8), "*Oh, it's found my eyes already!*" (S7) and "*I love the fact that it can move with my eyes*" (S5). They did not appear embarrassed at all, possibly because they are used to spending time in front of the mirror, observing or creating the transformed artistic image. One singer emphasized: "*You're constantly getting in the zone by looking in the mirror and focusing on what you've got to do. That's why we come early to get our make-up done*" (S2).

(ii) Automatic switching between looks and user control

For versions 1 and 3, which automatically placed the different opera character's looks on the face, all the participants appeared perplexed at the beginning about how to use it. They did not know what to expect or what to do next. They also found it unsettling when the mirror suddenly changed the look for them. In contrast, the participants felt comfortable being in control and switching between the two looks repeatedly by pressing the buttons when using the other versions.

On average, participants looked at themselves in the characters of Akhnaten and Nefertiti only once in version 1; twice per each look in version 2, two to three times in version 3 and three to five times for version 4. This indicates that participants spent more times exploring and contrasting themselves in the two characters when they were able to switch between the two compared with when passively watching themselves change. Furthermore, in version 1, they did not know when a look would change or why. For example, P6 asked: "*Is it changing? Can you do a different look?*" Another student (P8) who wanted to come back and use it again, asked: "*So how do I make it appear on the screen?*" As expected, participants spent more time exploring the versions that had the photo-taking option and the info page available. Three asked if there were other make-up designs that they could try, suggesting they wanted to explore even more looks. As the looks were designed to be gender-different for Akhnaten and Nefertiti, the controlled switching between them enabled the participants to compare the male and female looks more because they were able to immediately compare the differences once they had switched. Automatic switching on the other hand did not result in participants exploring the differences between the looks. It seems that providing users with a greater sense of control enables them to know where to look and prevents the confusion of not knowing which look would appear next on their face, as well as enticing them to compare the two looks more.

The subtle differences in the colors and eye extensions used in the make-up for Nefertiti and Akhnaten led some of the participants to switch between the two looks to see what the differences were. They were also interested in exploring why the characters had certain features.

The opera professionals preferred the versions providing more control over the displayed content. The nature of their work involves exploring different looks, so the option of being able to change looks was often mentioned as a plus: "*If you could interact and then change things, like colors, that would be really useful (…). When you're rehearsing it would be such a quick way into that imaginary world that you could physically see. If you could then interact and practice, (...) it would be really special to do so when you're practicing your arias because then you can quickly do that switch,*" (S4) and "*We tried so many different things with my make-up artist, that if you were able to manipulate different things and try them here that would be a much quicker way to achieve different looks*" (S6).

(iii) Perception of how convincing the looks were

Most of the participants' comments mentioned how realistic the looks were. For example, *"Amazing…even if I am moving it doesn't go away… You are freaking out in the beginning because you don't realize it's you, it's somebody else that's moving like you but it looks exactly like you"* (P20) and "*It felt very realistic, because the tracking allowed the make-up to move with you*" (P17), "*It does feel real*" (S4) and "*It's fantastic how it moves and contours with the face. And even though it's bright here, there's all the contouring that they did of the make-up and the lipstick, which moves really realistically with the face*" (S6).

A make-up artist emphasized the convincing way of how the looks adapted to specific facial features: "*It's very nice, because every person has a different type of face, so to match the specific make-up with a specific style of face, with the shape, is really clever*." (M5)

However, some also noted how it sometimes distorted how they looked, for example, saying, *"It makes my teeth a little*

yellow" (P5), *"It breaks down a bit"* (P7), *"The lips are too big*" (P13) and "*At some points it kind of disappeared, but it was still realistic*" (P17). If the tracking broke, participants then tried changing their pose or position in order to get the make-up to appear correctly again on their faces.

S3 commented on how the MagicFace could extend their existing set of props they use to step into the character: *"Make-up is a prop, it's part of the show so anything extra that can help that process is good…anything that can add the thoughts of the designer or director onto us"*(S3). Moreover, singers expressed how other add-ons would enhance the effect of such a make-over: "*For me it would be really useful if you could add more elements to it. If I could see myself with the wig and everything then that would be amazing*" (S4). The artists thought that especially when the appearance of the performer is drastically modified, such as with roles of a different gender, age or similar: "*If its particularly crazy, or if there are prosthetics being used, or if you're suddenly having to be ninety that is going to really change your creation of your character in that early stage*" (S9) or "*When you are looking at yourself as a female and you are practicing, it would be very different to then see yourself as a male when you're practicing*" (S2).

(iv) User engagement with the characters

The participants all found it easy and often immediate when looking into the MagicFace to feel like one of the characters. For example, S3 commented: "*When I sat down, it certainly focuses my thoughts on who I'm about to be."* P7 also mentioned how quickly the transformation happens: "*It makes you feel different, you feel like you are a different person, it changes so quickly*." One of the opera singers (S2) stated how, "*As soon as your make-up is on you feel like a totally different person. It's a huge part, because you're no longer you. You see yourself everyday in the mirror as you, then suddenly that transformation into character where you put your face on and it's that next dimension of role-play*." However, there were times when it made some participants feel distinctively uncomfortable. In particular, 8 out of the 12 young teenagers displayed moderate to strong embarrassment, by choosing to stop using it or looking away. In contrast, all the other groups (mid-teens, young adults, singers and make-up artists) did not show any visible embarrassment.

The additional features provided in versions 2, 3 and 4 led participants to further engagement. The photo-taking option appeared very popular, as all the participants using versions 3 and 4 took a photo of themselves and more than half of them took more than one. The accompanying music in versions 2 and 4 appeared to help the participants in this condition step into character: "*The music makes even more sense of the make-up*."(P18) and "*I did really like the music. I think that really brought the whole atmosphere together*."(P17). For the opera singers, the music had a higher significance because of their familiarity with opera, for example, S3 noted, "*Hearing the music, and I know the music, it immediately focuses into a character, which I hadn't anticipated*." All the participants pressed the 'more information' button in version 4, and spent time reading the displayed information, often for several minutes. They showed interest in the additional content and commented on it, asking more about the process and pointing at some of the depictions: "*Wow, is this what they use*?" (P18). The additional information allowed them to acquire further appreciation and context about the process of building a character. They then returned to the virtual try-on mode and started off experimenting with the looks again.

Thus, the singers and make-up artists saw much potential of using MagicFace as an addition to their existing repertoire of methods for helping them design and finalise their characters and looks. For example, S8 commented, *"It's helpful if you wanted to see as a character what facial expressions could be particularly expressive. It's useful to be able to experiment with the make-up because you can come up with a whole repertoire of gestures that you might want to make. If you're doing a role and you haven't got long to prepare, this would really help you understand the visual concept, if you haven't done that long build-up"*

It became evident that the technology made a strong impression on the users. However, it was also crucial to understand to which extent that was due to the setting and how the groups responded to the specific environment.

(v) Situatedness of the MagicFace

The dressing room in the Opera provided an authentic place to situate the MagicFace app as it embodied the physical context of the artistic process. Some of the young teens and older college students found it easier to relate to the process of preparing for the role. For example, P2 said: "*If you have a dressing room like this, it gives you more private time to look at your mirror, to practice and see how you can improve it*," while one of the older students (P17) commented: "*The clothes behind in the room really brought the whole atmosphere together*."

This led them to reflect on what they had read about and what they had experienced using the app. One student (P6) commented: "*I thought opera singers didn't have a lot of make-up, they just learn the song and go and sing it*." Another student, P22, also remarked, "*You would think singers don't use much make-up. I thought they just came on stage and sang*." This suggests that the MagicFace provided them with an opportunity to think about what was involved in the profession. They posed questions such as "*Does the make-up have to be a lot stronger in theatre than in real life?"*(P8), *"How many people would do one's make-up?"* (P3), and *"Why does the pharaoh have on lipstick?"*(P21). The make-up artists and singers also seemed at ease when first trying out the MagicFace in in the familiar setting of the dressing room, as it made it easier to relate to the application as a tool they could potentially use in the creative process: "*I do think it would be useful in*

terms of thinking of different options and trying to imagine what they look like." (S6) or "*For revivals, that's a really cool idea, because then it's all just there for whoever is having to step in*." (S1).

The setting created a specific ambiance and clearly focused the attention of the different groups on the activities that take place in the Opera, as a part of the performers' preparations for a role. The reflection about this process might have been very different had the MagicFace been placed in a more public setting, for example, the foyer of the Opera House, where they could have happened upon it. However, we were unable to try this out due to the high profile of the Opera House (in order to avoid any potential negative media coverage). Instead, we were able to place the MagicFace in a quite different public setting – an exhibition on Akhnatan being displayed at a museum.

STUDY 2: THE MUSEUM SETTING

Method

Following the Opera House study, the MagicFace, in a new picture frame, was placed in the museum for 3 months for the duration of the exhibition. As the MagicFace was situated as a stand-alone installation, neither staff nor the researcher assisted the interaction or invited the visitors to use it. During this period, the tracking technology in the app took photos of the users each time it detected a face. This allowed us to observe: number of people who used the app, their gender, approximate age (senior, middle-aged, young or child), social interactions (if the visitors used the app alone or together with others) and facial reactions (laughing or smiling and pouting/making grimaces in front of the mirror). The photos were all deleted after the analysis. The museum staff was in charge of the app (e.g., charging the tablet). It was also them who alternated between the interfaces on a daily basis according to their decision. In addition to the analysis of the photos, we also conducted an observational study to further examine how the four versions were used over four different days for the following: (i) the number of people that used the app and their approach behavior, (ii) the length of time spent with the MagicFace, (iii) the visitors' comments and (iv) the social interactions. We also interviewed some of the museum staff, asking them about whether they thought the MagicFace had an impact on how visitors engaged with the exhibition, their reactions to it and any comments they had after their visit.

Findings

Similar to the Opera House study, people reacted and interacted with the MagicFace in a variety of ways. Our observations showed that the visitors used the mirror on average between 30 seconds and 2 minutes. However, the length varied depending on the version displayed and also whether it was a single person or group of two or more in front of it - the latter often spending longer talking about it to each other when trying it out. Below we look in more detail at the visitors' various behaviors.

(i) Approaching behavior

During the 4-day period of our in-situ observations, 79 people visited the Akhnaten exhibition. This may seem a small number but the museum is a specialist one as part of a university's collection and such daily numbers are typical. Table 3 shows the number of visitors walking past or using it and time spent. Of the visitors, 25 walked straight past the mirror and did not pay attention to it, while 54 stopped in front of it (3 visitors stayed at the mirror for less than 5 seconds and then moved on, so we did not count them as interacting visitors).

Version	Visitors using MagicFace	Average interaction time	Visitors walking past
1	10	23 sec	6
2	7	1.7 min	4
3	23	42 sec	9
4	14	45 sec	6

Table 3: Overview of the engagement with 4 versions as recorded during 4-days observation study

Version 1 had to the shortest interaction times compared to the other ones. No one used version 1 for more than a minute. 5 visitors used version 2 for more than a minute (3 of which were in a group), 5 visitors spent more than a minute at version 3 while 4 visitors did so with version 4.

The photo analysis showed 845 people interacted with the MagicFace for the study period of 3 months, of which 493 were female. In terms of age range, 258 appeared young, 144 middle-aged and 91 seniors. This shows that large numbers of young people were drawn to the MagicFace, which is encouraging – as they are typically the age group who might find such an exhibition boring. While we counted twice as many females compared to males who used the MagicFace, surprisingly, the number of males trying it out was high.

(ii) Automatic switching between looks and user control

Similar to the Opera study, the findings showed that the automatic version appeared the least successful in drawing people to interact with it, while versions 3 and 4 had the most successful rate of enticing people. Considerable time was spent in front of version 1 talking about and looking at how to switch between the looks as noted by visitors asking their companions: "*How can you change it?*", "*How does it change between the two?*", "*Does the style only change when the name changes?*" or "*How does the app change the make-up?*". In contrast, for the other versions, more time was spent switching between the looks, photo-taking and talking with fellow visitors.

(iii) Perception of how convincing the looks were

Similar to the Opera study, the initial reactions to the mirror were surprise at first, often accompanied by laughing and similar exclamations such as: "*Oh my gosh!*", "*Wow!*", "*How cool is that!*", "*It's quite good.*" and "*That's great!*". Moreover, the photos analysis showed nearly 50% (353 of 845) of visitors smiling or laughing when looking at

themselves using the MagicFace. We also saw much initial astonishment when the children saw themselves made up as the Pharoah or his wife. This was indicated by the photos showing high levels of surprise and joy on their faces.

(iv) User engagement with the characters

The visitors were seen to often change their expressions and poses (e.g. see Figure 5), turning their heads in different directions and pouting to watch themselves with the virtual looks from various angles. There were also a large number of photos (n=196) showing visitors interacting with the mirror in pairs or groups. Some even tried to switch the look between each other by moving their faces or arms as if to 'pass on' a look.

The groups often separated while in the museum to look separately at the various exhibits. When one of them came across the MagicFace by themselves, they would call out to their companion/s for them to also try using the mirror. Others would call back to their friends to return if they has not tried both looks, for example: "*Come back, you haven't tried the other look, you haven't tried the Nefertiti*." There were no signs of social embarrassment when the visitors were using the MagicFace when visiting with others. Instead, there was much evidence of enjoyment, as they commented on each other's looks, chatted while using the mirror and discussed how the technology worked.

Figure 5: A museum visitor doing an Egyptian walk while interacting with the MagicFace

(v) Situatedness of the MagicFace

As the mirror was situated as a part of the exhibition, the visitors automatically came across it when looking at the displayed artifacts. In that sense, the museum offered a context for visitors to be primed to the displayed items, which led to them noticing the MagicFace. The museum curators also noted that many visitors had enjoyed the experience of using the MagicFace when happening upon it when walking around. In the interviews, the curators reported that 10% of the visitors came to talk to them about the MagicFace afterwards, expressing their interest in it and asking questions about it. They also described the visitors' reactions as being very positive, saying that many were excited about the MagicFace being part of the exhibition. In the curators' opinion, it delivered a more tactile experience for the visitors compared with the other Egyptian artifacts (that were not allowed to be touched as they were too valuable and were protected in glass boxes) – bringing the exhibition alive more.

DISCUSSION

The findings from the two studies demonstrate how a novel augmented reality installation using the forward facing camera in a tablet was able to draw a diversity of users to explore the looks of two historical characters: an Egyptian Pharaoh and his wife. While many people were initially startled or surprised when first seeing their faces transformed through the virtual Egyptian make-up, most then subsequently enjoyed exploring its effects on them – by posing, pouting, and talking to others about it. Only a few male teenage participants appeared embarrassed to carry on using the MagicFace app when in the Opera House dressing room. However, this reluctance may have been because of the presence of the researcher, the teacher and fellow students – making them feel too self-conscious. In contrast, such self-consciousness did not appear to affect the visitors in the museum setting, where teenagers, who came across it, often called out to the others they were visiting the exhibition with, to take a look. Who is present in the vicinity, when trying on a virtual look in front of an AR mirror, clearly plays a role in how comfortable someone feels before deciding to explore the app any further. Next, we discuss 5 core dilemmas, arising from our study, to consider when designing AR technology in cultural settings to enable visitors/audience to engage with the experience by stepping into character: physical versus virtual, technological fidelity, the surprise factor, aiding versus hindering performance and the gimmick factor.

(i) Physical versus digital

The most common way people step into character is by dressing up – for example, putting on clothes, wigs, real make-up and so on. Children spend much time playing in this manner and it can be an effective way of enabling them to get into the shoes and minds of different characters. This raises the question of what is the added value of doing the same using digital AR? One benefit is that AR can transform a user's face into a *specific* character, which is quite magical and can be difficult to achieve when putting on physical clothes. In our case, we were able to make people to look just like the faces of two historical characters, Akhnaten and Nefertiti. AR mirrors thus provide the scope to draw attention to particular facial features – such as the way the eyes looked in Egyptian times - rather than, more generally, dressing up in a role, such as a doctor or a fantasy character (cf. video game avatars). This can engender quite a different felt experience.

(ii) Technology fidelity

One of the difficulties of developing technologies for stand-alone use in public places is ensuring they are robust and are convincing. When the feedback is slightly out of sync or the calibration not quite right, it can make it difficult for users to enjoy or feel comfortable interacting with it. For example, other research has shown how visitors will

quickly stop using a novel application running on a tabletop – when placed in a museum, tourist center, store or other location – if their finger movements on the digital surface don't cause an immediate effect or trigger an unexpected one [14]. In our project, we saw how occasionally the tracking did not follow the way a person moved and the make-up look disappeared for a couple of seconds. But rather than being a limitation that stopped people using it, this misalignment did the opposite, enabling them to momentarily see themselves 'unmade' again. Then, when the camera picked up their face again, it immediately switched their face back into the virtual make-up. Instead of disrupting the experience, therefore, it provided them with a way of stepping out of and then back into the character - potentially offering them an opportunity for reflection and to think about the character they were being made up as.

(iii) Surprise factor

The findings revealed how the manner in which the virtual make-up is applied on a face can affect the quality of a person's experience using the AR app. As mentioned above, when virtual make-up suddenly appears on someone's face it can take them literally by surprise. Having that look then suddenly change into another one, without any user input, can also be disconcerting. The study showed how having control over a look was important for engaging users more with the app but that there is also value for directly placing a virtual look on someone's face as they walk pass an AR installation. Hence, if the AR mirror is to be placed in a public setting, like a shop window, cafe or the entrance to a museum, then it can be beneficial to spring a virtual look on their face - drawing their attention to it. Once inside the space, other AR mirrors could be provided that offer user-controlled interactivity.

(iv) Aiding versus hindering performance

An unexpected finding from our first study was how much the opera singers and make-up artists talked at length about how they could see this kind of AR being a valuable tool for designing and experimenting with looks or when preparing for a role, especially when the character is a difficult one to envision for different settings. For example, the make-up artists thought that such a tool could help them imitate the change of the make-up color tones under different theatre lights - which is currently difficult for them to visualize. They often come up with a make-up design only for it to appear quite different under varying lighting conditions – which they are not privy to at the time of their design work. It can also offer them a communication tool with which to engage with the actors when they discuss and finalize their looks for the particular production. Furthermore, this way of using AR technology during rehearsals for a production contrasts with previous research that has shown how technology, such as mixed media, can obstruct, because of the way it interferes with the close relationship between the director and the actors [1].

AR technology, therefore, has much potential for being designed as a stand-alone tablet-based toolkit, providing a palette of colors, templates and special effects, that is easy for make-up artists, educators and actors to learn and readily use. There is scope for commercial development - in contrast with other kinds of more heavyweight technology, such as VR or mixed media that usually need to be set up, and maintained by technicians at hand. Our current software was designed to appear on a person's face all at once. In future applications, it would be desirable to develop the software to make it appear on someone's face in the way in which make-up artists currently design and create looks. This kind of layering, with the option of undoing colors etc., would enable more experimentation and, in turn, insights into the combinations for a given look.

(v) Overcoming the gimmick factor

For SnapChat users, AR in its current form offers a wealth of filters that can overlay their image with often hilarious or silly looks, that they can then send to their friends. While harmless fun in this context, there is the danger that such front-facing AR becomes trivialized – and viewed more as a gimmick. Indeed, this was an issue we were very sensitive to throughout the project. We thought that if the make-up was seen simply as a bit of fun it would make the goal of using it to enable people to 'step into character' much more difficult to achieve. An important concern therefore is how to create AR apps, especially for educational purposes that can focus users' attention on the character it is trying to convey rather than being simply fun. That is not to say, that playfulness should be avoided in the design, but that the features that are accentuated and the overlaying detail can engender a professional look.

CONCLUSIONS

Front-facing AR offers people a way of imagining in first person what it is like to be a character they are seeing on stage or learning about during a visit to an exhibition. This is especially beneficial for audiences who are put off going to a museum or the opera if they perceive it as being too boring. It can bring alive a static exhibition or performance resulting in reflection and discussion about what is behind the scenes. It also offers potential for developing a new kind of design toolkit for professional make-up artists and singers working in the arts, opening up new possibilities for them when designing new looks and rehearsing. Far from being a gimmick, AR technology can provide a hook into culture, especially for younger generations who have previously experienced AR technology only as a fun social media app on their smartphones.

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