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The realness of fakes: Primary evidence of the effect of deepfake personas on user perceptions in a design task

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ABSTRACT

Deepfakes, realistic portrayals of people that do not exist, have garnered interest in research and industry. Yet, the contributions of deepfake technology to human-computer interaction remain unclear. One possible value of deepfake technology is to create more immersive user personas. To test this premise, we use a commercial-grade service to generate three deepfake personas (DFs). We also create counterparts of the same persona in two traditional modalities: classic and narrative personas. We then investigate how persona modality affects the perceptions and task performance of the persona user. Our findings show that the DFs were perceived as less empathetic, credible, complete, clear, and immersive than other modalities. Participants also indicated less willingness to use the DFs and less sense of control, but there were no differences in task performance. We also found a strong correlation between the uncanny valley effect and other user perceptions, implying that the tested deepfake technology might lack maturity for personas, negatively affecting user experience. Designers might also be accustomed to using traditional persona profiles. Further research is needed to investigate the potential and downsides of DFs.

1. Introduction

Personas are fictitious people that represent real end-user groups (Anvari and Richards, 2018, 2016; Anvari and Tran, 2013; Clarke, 2015; Goodman-Deane et al., 2018, 2021; Grudin, 2006; Grudin and Pruitt, 2002; Korsgaard et al., 2020; Nielsen, 2019; Nielsen and Storgaard Hansen, 2014; Spiliotopoulos et al., 2020). Personas are used in design tasks, software development, and marketing as surrogates for real designers to bring the end-user mentally closer to the people using personas. As a term, the *persona* has two meanings presented in this research. *Persona* can refer to a user persona, a representation of a user group, to be used in, for example, design tasks, thus benefiting the persona user. As such, the persona's goal is to carry the properties held by a group of people and grow empathy in the user, such as a designer. Secondly, a *persona* can also refer to a self-image, a concept originating from the works of Carl Jung in analytical psychology (Jung et al., 1953). *Avatar* also refers to the self-expressive use of personas, such as a picture used to portray oneself on the internet or to the persona image in a

profile. Personas help decision-makers form mental models (Bødker et al., 2012; Seidelin et al., 2014) that communicate the goals, needs, and wants of focal end-user groups and thus help guide micro-level decision-making about product features, usability options, service offerings, and other interfaces and systems (Cooper, 1999). As such, the persona approach is a user-centered design method based on creating fictional users aimed at helping designers understand the needs and expectations of actual or target users of a product (Bonnardel et al., 2016).

Personas are typically portrayed as persona profiles, also called templates or layouts (Long, 2009; Nielsen et al., 2015; Salminen et al., 2020b). These profiles tend to be static and are often circulated as PowerPoint presentations, PDF slides, or printed posters on office walls (Jansen et al., 2020; Nieters et al., 2007). This static format of representing users has raised criticism from persona researchers, calling for more dynamic and immersive forms of presenting personas as design artifacts (Jansen et al., 2020; Long, 2009; Nieters et al., 2007). However, aside from attempts at creating web-based interactive persona systems
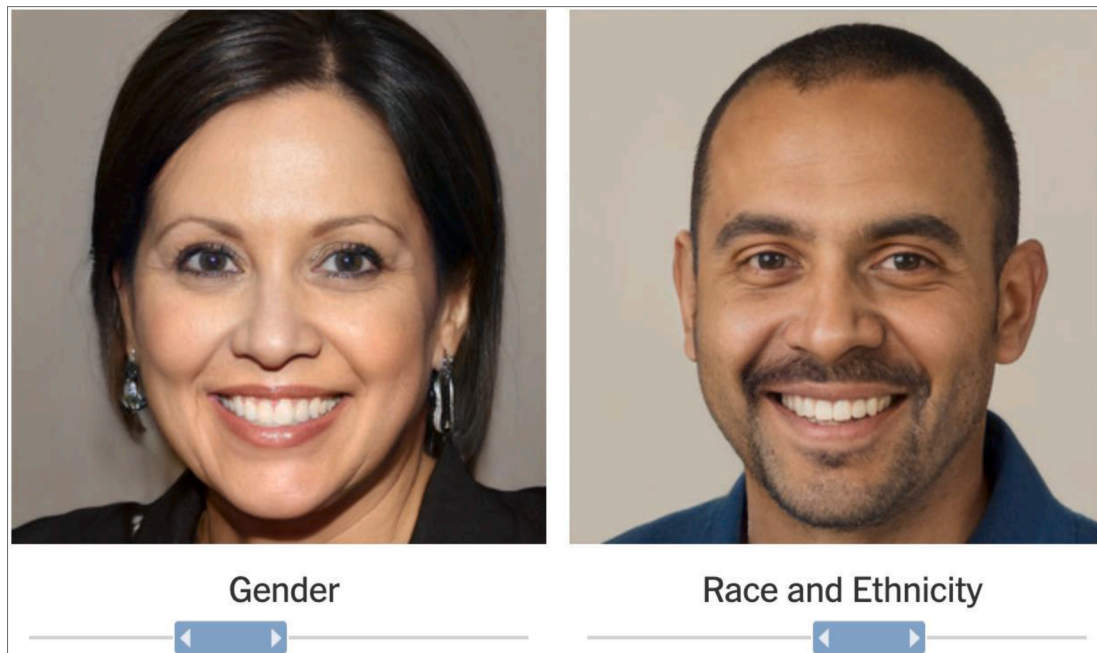
Fig. 1. Two deepfakes created by artificial intelligence (AI). With the slide bar, one can alter the gender and ethnicity of the personas (Hill and White, 2020).

(Jung et al., 2018; Jung et al., 2018; Salminen et al., 2022b), multimedia (including voice and video) has yet to be made available in for example, all 47 of the persona templates reviewed by Nielsen et al. (2015) were based on a static persona template, which we refer to as 'classic persona profile' in this study. Similar findings were made by Salminen et al. (2020b), who investigated 31 templates for data-driven persona profiles.

While the tradition of presenting personas to their users (e.g., designers, software developers, marketers, and others working in user-centered decision-making – henceforth, we refer to these stakeholders as 'designers') has been based on this static notion of personas, there is no hard constraint for alternative designs that would make use of multimedia in communicating information about users to designers. Making use of different information modalities might bring about benefits in how designers perceive and use personas, for example, by making them take personas more seriously (personas *not* being taken seriously by stakeholders has been observed as a challenge in prior work (Matthews et al., 2012; Rönkkö, 2005; Rönkkö et al., 2004) and diving into the potential of different persona modalities is one new aspect of persona research presented in this study.

As put by Weisman and Peña (2021): "Deepfakes can potentially be used to enhance the naturalness of artificial agents and improve their ability to build simulated empathy and emotional connection." In other words, deepfake videos can potentially carry messages and influence people more efficiently (van Esch and Stewart Black, 2021). Consequently, this potential could also be utilized in the field of deepfake personas for purposes that support designers in their work. Examples of deepfakes are presented in Fig. 1.

This study defines deepfakes as photo- or hyper-realistic characters that mimic real people, usually in the form of videos. This is consistent with other definitions. For example, Gamage et al. (2022) define deepfakes as follows (p. 1): "Deepfakes are synthetic content generated using advanced deep learning and AI technologies". Thus far, deepfakes have not been broadly applied to user-centered design, and precisely herein lies the opportunity this research delves into. In particular, deepfake technology could help increase the level of immersion in personas. Deepfakes promise to create more lively, immersive, and realistic end-user representations (e.g., personas) that designers and other stakeholders can interact with to understand better users' needs, goals, wants, and life circumstances. Therefore, deepfake personas could result

in more realistic and empathetic representations of groups of users, thus bringing personas more to life and closer to people utilizing deepfake personas, while conveying information about users more effectively to the designer (van Esch and Stewart Black, 2021; Whittaker et al., 2021). Therefore, deploying the deepfake technology for personas could increase the consideration of the end-user needs that the personas communicate, thus improving the level of user-centricity in an organization's offerings (Cooper, 1999). Based on this logic, the matter of selecting persona modality is an essential design choice for personas, and here might lie the potential of rapidly generated deepfake personas.

This being said, there is also a possibility that deepfake technology is not yet mature enough for personas. Defects in deepfakes, such as uncanniness (Mori, 1970), may exist, affecting the user experience and perceptions of the personas in particular. A special consideration here is that if the deepfake personas might be 'too close' to being realistic (i.e., emanating realism without still being completely realistic), they may trigger adverse effects on user perceptions, akin to the well-known uncanny valley effect identified by Mori (1970), that predicts that an entity appearing as almost human will risk eliciting cold or eerie feelings in viewers. Although there is some indicative evidence of this effect in deepfakes (Cleveland, 2022), thus far, no one has tested it for personas making the testing of the uncanny valley effect in deepfake personas a major contribution to the current study.

Thus, to empirically investigate this tension of whether deepfake technology provides value for personas or not towards better-representing users, we propose a motivational question, *To what degree do deepfakes improve or worsen designer perceptions and design task performance?* Based on this motivational question, we focus on three specific research questions (RQs):

- RQ1: How does persona modality affect designers' perceptions of the persona?
- RQ2: How does persona modality affect design task performance?
- RQ3: Is there an uncanny valley effect associated with deepfake personas?

By *persona modality*, we refer to the persona's medium of presentation. We experiment with three modalities: (a) narrative persona (i.e., a text account from a first-person perspective that describes who the

persona is); (b) classic persona profile (i.e., a static picture that contains a name, picture, bullet points, and quotes); and (c) deepfake persona (i. e., an AI-generated video of the persona explaining their behaviors and needs). In this study, deepfakes are created to resemble real people (i.e., actual actors).

As video is, at the moment, the most common media format for deepfakes (Li and Lyu, 2018), it is natural that video is also the format of choice for testing deepfake personas. Narrative and classic personas have been applied in previous research (Kunur et al., 2016; Nielsen, 2004), whereas deepfake personas are currently a novelty. Overall, choosing the personas' modality plays an important role in the design of personas. This has not only theoretical importance but practical importance as well. From a practical point of view, the topic in this study can be understood in terms of the question: *How should personas be designed so that end-user needs are effectively communicated to stakeholders?* This is a vital question not only for personas but also for HCI more broadly because user understanding that is both accurate and immersive is generally seen as a requirement for a high degree of user-centricity (Johanssen, 2018), the premise being that systematic user understanding requires delving into the users' details. This process of delving into the users' details is facilitated by immersion, as designers that immerse in the users' details are more likely to obtain and recall key information about the users (Johanssen, 2018; Ragan, 2010; Rieuf et al., 2017; Spaulding and Faste, 2013). One could even say that a high degree of user-centricity is one of the core tenets of the HCI discipline. In turn, high user-centricity implies better products, i.e., those that effectively serve end-user needs and solve real issues in the surrounding world. Therefore, if deepfake personas (or any other modality for personas, for that matter) "get the job done" well in terms of resonating with the persona users (e.g., designers, managers, and other decision-makers), then a potential shift towards that modality warrants the HCI community's interest.

2. Literature review

2.1. Richness of persona designs

Personas can be portrayed in different ways; in this section, we focus on literature that either reviews different persona designs or guidelines for creating effective personas.

First, Nielsen et al. (2015) analyzed 47 persona descriptions from 13 Danish companies and found that the information from persona descriptions can be grouped into five categories: background information, business and marketing, design, graphics, and others. The researchers also discovered that personas are designed based on practical hearsay and heuristics instead of theory-driven conventions, thus highlighting the need for a more robust theoretical basis for why a particular persona design is preferable over another.

Second, Salminen et al. (2020b) analyzed data-driven persona layouts, finding a dramatic variation in their information richness, which they divided into three categories: simple, moderate, and high. Simple persona layouts contain limited information and are not identified with characteristics that make them human, while moderate persona layouts are richer in information and thus more human-like. Furthermore, highly informative persona layouts include quotes, visuals, and demographic and psychographic details and are highly identifiable with human characteristics.

Third, Visser and Stappers (2007) suggest that creating a detailed and realistic representation is preferable. Therein, the persona representation should include enough information, photos should be combined with a name and background information, and it is recommended to use a set of photos rather than one image, as this can stimulate empathy and a richer view of users' needs. Furthermore, it is advisable to use photos of real people rather than stock photos to avoid distrust and confusion among designers (Salminen et al., 2019b). Also, if using sketches, it is advisable to combine them with real photos. A realistic persona closely mimics reality, and it is presumed this requires using real photographs (Salminen et al., 2021, 2018). However, researchers have not examined the vividness of *video* as a media format for personas.

Fourth, Hill et al. (2017) found that understanding people's persona perceptions is not as straightforward as it would seem. First, using a gendered persona picture seemed to have little effect on the designers' perception of the persona's gender. Second, using solo or multiple images of the persona had little effect on the designers' perceptions of the persona.

Fifth, the effectiveness of personas was further investigated by Long (2009), who found that using personas in product design significantly affected the usability characteristics of the outcoming products. The researcher also found that the effectiveness of persona pictures was more significant than persona illustrations in terms of the design outcomes being more user-friendly. Long (2009) found that using illustrations instead of persona images reduced the level of empathy felt by designers towards the persona, which is also in line with the findings on the effect of persona image style on realism and empathy (Salminen et al., 2021). Similarly, it has been found that presenting more contextual persona images (i.e., pictures of the same person in the persona profile in different contexts) helps channel information to the persona user (Salminen et al., 2018).

2.2. Should personas be dynamic?

The important question is, to what extent should personas be static (i. e., not moving or changing) versus dynamic (i.e., moving and changing)? One way to fathom the idea of dynamism within personas is to associate the persona with a given context. For example, Nielsen (2003) asserts that "static" personas are rendered "dynamic" when inserted into a scenario – in other words, "scenarios bring personas to life by giving them a context" (p. 72). Ferreira et al. (2016) claim that persona designs tend to leverage too much information, and a textual persona description (which we refer to as 'narrative persona' in this study) provides limited guidance and direction for designers to identify functionalities and features that would serve end-user needs. This is a dire concern, as it has led some designers to question the usefulness of personas, which hinders the adoption and acceptance of personas in the real world (Rönkkö et al., 2004). Nevertheless, Ferreira et al. (2016) still suggest that alternative designs that designers perceive as useful and easy to use are needed.

Investigating the differences between the static and dynamic persona, Bonnardel et al. (2016) argue that the static persona elicits less empathy than a dynamic persona. The authors conducted an experiment where they analyzed the impact of the static and dynamic persona on levels of creative performance, empathy, and quality of collaboration. Their results confirmed that the interaction with the static persona produced fewer ideas (both in number and quality) and that the quality of collaboration was also lower compared to the dynamic persona. Blythe and Wright (2006) argue that the careless design of personas can lead to "unconvincing, static personas," while Cutting and Hedenborg (2019) note that personas rarely change, are biopolitical (meaning that they focus on making real people fit the personas), and frame experiences into a somewhat narrow perspective.

The literature also suggests that static personas cannot grow and develop as they lack depth, personality, history, and cultural context (Leong et al., 2021). Unlike dynamic personas, a 2D poster cannot elicit multiple experiences. Leong et al. (2021) performed an experiment where the designer had to interact with an *Experiential persona* represented by a carefully staged collection of everyday objects and artifacts, as well as an audio monolog. An *Experiential persona* is an alternative persona open to interpretation, as the designer must investigate and interpret objects and artifacts (Leong et al., 2021). Using real objects and artifacts increases the desire to interact with this persona, leading to a more curious and engaging interaction. Unlike the static persona, the *Experiential persona* can be seen as real and "alive," which makes it

particularly effective. In addition, such personas support multiple interpretations of their stories, which allows people to be genuinely interested in learning about them and in forming meanings about their life experiences. Therefore, dynamism can be seen as beneficial for persona design, logically supporting the idea of deepfake personas that move and speak.

2.3. Deepfakes in HCI

The first steps of deepfake were taken in 1997 when Bregler et al. (1997) released their paper *Video Rewrite: driving visual speech with audio* in which the researchers presented their innovation of using existing footage of people speaking words not present in the original footage. In recent years, deepfake technologies have become increasingly common for crafting realistic human portrayals in both images (Karras et al., 2019; Salminen et al., 2020c) and video (Tahir et al., 2021), with video being the more dominant media format. For personas, deepfakes are an attractive modality option since they could make the user representation livelier and more appealing (André et al., 1998). Also, deepfake personas could open a pathway for user-centric design to emulate real conversations between stakeholders and personas that represent users' needs.

However, thus far, the application of deepfakes in personas (and in HCI more broadly, for that matter) has been limited. Of the few existing examples of applying or investigating deepfakes for HCI, Tahir et al. (2021) examine the risks of deepfakes for abuse, associating them with deception, disinformation, and propaganda. This perspective of seeing deepfakes as risky and more of a threat than an opportunity is commonplace in the literature.

Another reoccurring theme is the focus on deepfake detection. For example, Wöhler et al. (2021) conducted an eye-tracking study to investigate how people perceive authentic and face-swapped videos. Their findings indicate that physiological measures can be helpful for the automatic detection of deepfakes. Researchers have also tested how contextualized training can improve deepfake detection and help raise awareness about them (Tahir et al., 2021). Towards the latter purpose, Safinah Ali et al. (2021) focused on the ethical implications of generative AI technologies, including deepfakes. The researchers organized four student workshops, finding that educational material about generative adversarial networks (GANs) helped the students understand how GAN models work and their positive and negative sides. Educating people about deepfakes is important because of the risks associated with deepfake technologies and the ability of deepfakes to fool people. For example, Shahid et al. (2022) conducted qualitative research among thirty-six social media participants in India, finding that most people lack the necessary skills to distinguish deepfake videos from real ones.

Overall, HCI research has thus far been concerned mainly with the *risks* of deepfakes, rather than their productive use for elevating HCI experiences. For example, Wöhler et al. (2021) speak of "potential manipulations" and "unethical forgeries" (p. 1). In a similar vein, Gamage et al. (2022) center their implications on "mitigating the harm created from deepfakes" (p. 1). Often, the focus is on either algorithmic detection of deepfakes or user education. However, deepfakes also offer opportunities for HCI, such as increasing designers' immersive experience of user needs, as we mentioned in the introduction. Among the rare studies that aim to leverage deepfake technologies towards positive ends, Kolb and Kranzlmüller (2021) used deepfake technology to create records to preserve the experiences of Holocaust survivors digitally. They found that the deepfakes yielded emotional and immersive experiences that correlated with the participants' learning about the Holocaust. Furthermore, the study by Gamage et al. (2022) that analyzed more than 6000 posts and 86,000 comments on Reddit about deepfakes, showed evidence of pro-deepfake attitudes among the users, supporting the creation and sharing of deepfake content (especially for entertainment purposes) and developing a marketplace for deepfakes. Therefore, we can also envision *benefits* and *value* from deepfakes, a topic we

undertake in this work.

2.4. The role of the uncanny valley effect in deepfakes

One of the earliest studies in human-robot interaction was performed by Mori (1970), whose major finding concerned human-likeness versus affinity towards a robotic figure. Mori found an uncanny valley of affinity near the most human-like robotic figures. These 'close-to-realistic' human-like robots were considered abnormal, whereas the realistic human-like robots had a higher affinity. A similar effect has been found for personas (Salminen et al., 2021), but it has not been investigated in relation to deepfake personas.

The uncanny valley effect put forth by Mori (1970) has been taken along in studies researching deepfakes and personas. Broad et al. (2020) found in their study on AI-based deepfake creation that turning the system-based optimization of deepfake images from a state where the system is optimized to create as realistic looking images from its perspective to an inverted process where the system produces images based on images that it has priorly interpreted as fake. This process alteration amplifies the uncanniness of the deepfakes (Broad et al., 2020). In turn, Welker et al. (2020) tested a form of deepfakes (face swap and partial face swap), where only a real person's face or part of it is changed to a deepfake in the study. Their war documentary research concluded that a partial face swap (where only the eyes of the participating Chechnya war torture victims were changed to a deepfake face) was more unsettling to the viewers than a total face swap. They also found that the full face swap was seen as less uncanny than the real faces of the documentary performers (Welker et al., 2020). Partial face swaps were seen to feature at the deep end of Mori's uncanny valley.

Research on viewers' reactions when seeing their faces on an AI-generated doppelganger, a double figure, or a talking head significantly increases the viewer's uncanny valley perception. Weisman and Peña (2021) found that when a study participant is exposed to a doppelganger of themselves, it had an increasing uncanny valley effect compared to presenting the doppelganger with a face of a stranger. Similarly, using one's face in a virtual reality (VR) doppelganger scene immerses the participant in false memories, i.e., where they believe that they participated in the action portrayed in the VR video (Segovia and Bailenson, 2009; Weisman and Peña, 2021). It has also been found that the stronger uncanny valley effect results in a lower affect-based trust created by the doppelganger (Weisman and Peña, 2021). Philosopher Don Fallis has also described this lowering in trust or the path resulting from it as the epistemic threat of deepfakes (Fallis, 2021). Fallis describes epistemic threats based on the power of visual media to disperse information. Notably, videos have a high capacity to carry information, encouraging individuals to believe what they see in videos. Consequently, information spread via videos is often seen as "the standard of truth" (Fallis, 2021).

Finally, while images of real people have traditionally been used in persona profiles, Salminen et al. (2021) tested six different image styles for personas. They found that perceptions of completeness, empathy, clarity, consistency, and credibility for a persona increase with picture realism. However, the uncanny valley effect was found when participants were exposed to realistic cartoon personas, resulting in decreased user perception measures. This lends credence to the idea that deepfake personas, if not at an adequate level of quality, may deteriorate the user experience of designers.

3. Research gap and hypotheses

3.1. Overall reasoning

Investigating how persona modalities affect persona perceptions matters for multiple reasons. First, there are grounds to presume that the deepfake-evoked realism of the persona affects other user perceptions. Second, stakeholders' perceptions of personas drive the actual use of

Table 1

Study hypotheses. Measurement items are reported in Section 4.4.

RQ	H		Measure
RQ1: How does persona modality affect designers' perceptions of the persona?	H1	Deepfake personas result in a lower degree of empathy than (a) classic persona profiles and (b) narrative personas.	Empathy
	H2	Deepfake personas result in a lower degree of credibility than (a) classic persona profiles and (b) narrative personas.	Credibility
	H3	Deepfake personas result in a higher degree of completeness than (a) classic persona profiles and (b) narrative personas.	Completeness
	H4	Deepfake personas result in a lower degree of clarity than (a) classic persona profiles and (b) narrative personas.	Clarity
	H5	Deepfake personas result in a higher degree of willingness to use than (a) classic persona profiles and (b) narrative personas.	Willingness to use
	H6	Deepfake personas result in a higher degree of immersiveness than (a) classic persona profiles and (b) narrative personas.	Immersion
RQ2: How does persona modality affect design task performance?	H7	Deepfake personas result in a lower degree of control than (a) classic persona profiles and (b) narrative personas.	Sense of control
	H8	Deepfake personas result in lower time spent with the persona than (a) classic persona profiles and (b) narrative personas.	Dwell time
	H9	Deepfake personas result in lower time spent with the task than (a) classic persona profiles and (b) narrative personas.	Dwell time
RQ3: Is there an uncanny valley effect associated with deepfake personas?	H10	Deepfake personas result in a higher sense of abnormality than (a) classic persona profiles and (b) narrative personas.	Uncanny valley

personas, affecting decisions about users and thus driving the user experience (UX) of products. For example, Miaskiewicz et al. (2009) found that designers tend to produce more effective designs if they empathize with a persona. For these reasons, it is important to investigate persona perceptions in empirical work. We do so through multiple hypotheses (see Table 1).

Regarding the hypothesis formulation, though deepfakes might be of value for personas, it must be considered that deepfake technology, although been in use for years now (Bregler et al., 1997), may not be mature enough to be used in the context of personas, especially in professional settings where people are highly focused on the persona information. We have formulated our hypotheses to be aligned with the idea that deepfake personas suffer from the uncanny valley effect to a noticeable extent. This is merely a choice of framing the problem: an alternative hypothesis – that deepfake personas offer a *better* user experience – to which we alluded in the introduction and literature review is equally reasonable. The empirical results will show us the direction of the evidence.

3.2. Empathy

Unlike a static persona represented with a photo, a dynamic persona employs multimedia content (Bonnardel et al., 2016) to encourage designers to understand the design problem more deeply and consider the limitations. Therefore, Bonnardel et al. (2016) argue that interaction with a dynamic persona enhances the designer's ability to generate new ideas and improves empathy. However, the uncanny valley effect can interfere with this perception, as "if an entity is sufficiently non-humanlike, then the humanlike characteristics will tend to stand out and be noticed easily" (Nieters et al., 2007) (p. 1820). In contrast, Nieters et al. (2007) continue, "if the entity is 'almost human', then the non-human characteristics will be the ones that stand out, leading to a feeling of 'strangeness' in the human viewer." (Nieters et al., 2007) (p. 1820). This prompts the expectation of *decreased* empathy when dealing with deepfake personas (see H1 in Table 1).

3.3. Credibility

Credibility is seen as a key measure when using persona in decision-making processes (Vincent and Blandford, 2014), and more realistic persona presentations could be envisioned as more credible. The effect of persona modality on the persona's credibility is contingent upon its ability to convey realism. On the other hand, the psychological foundations for personas drawn from Grudin (2006) advocate the principle of a realistic appearance because, in cognitive terms, it feels more natural to identify with real people. Deepfakes emanate realism, and this applies to personas as well. On the other hand, it remains to be answered as to whether deepfakes are perceived as realistic. In our case, adopting the paradigm of the uncanny valley, we hypothesize they are *not more* credible than other persona modalities (see H2 in Table 1).

3.4. Completeness

Completeness means the persona has all the necessary information for productive use. Determining this information is essential in creating personas (Pruitt and Adlin, 2010). Bødker et al. (2012) wrote that incomplete personas might seem unactionable to the designers, which could subsequently result in an unwillingness to adopt personas into use. Deepfake technology adds missing components of audiovisuality and dynamism to the persona presentation compared to classic and narrative personas, making it more complete (see H3 in Table 1).

3.5. Clarity

Persona studies have addressed *clarity* from two different directions. Firstly, a persona profile's clarity (such as pictures and text) may influence the perceptions of the end-user (Salminen et al., 2020e). Secondly, the information in the persona profile can sometimes be unclear, which confuses the end user (Salminen et al., 2019a). Madsen et al. (2014) have noted that without clarity, it is impossible to communicate the needs and goals of the persona/user and also meet these needs. Because deepfakes use non-verbal communication of user information to stakeholders (Hamilton, 2009), this puts extra pressure on clarity, and any mistakes in the deepfake presentations are likely to reduce clarity (see H4 in Table 1).

3.6. Willingness to use

Willingness to use (WTU) is crucial in adapting personas among organizations and individual designers (Friess, 2012; Matthews et al., 2012; Rönkkö, 2005). Rönkkö et al. (2004) described a case where a laborious persona creation process ended up at a point where the personas created were never implemented in a real-world use case. Personas also risk not being used in design activities in practice and are rarely mentioned in decision-making processes by designers (Friess,
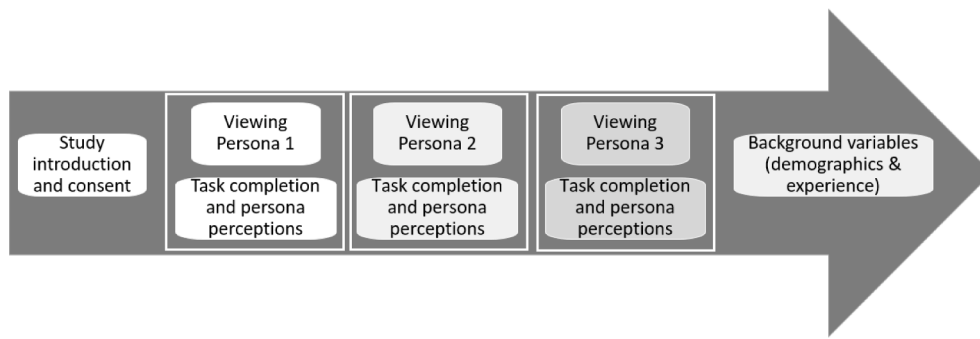
Fig. 2. Study procedure beginning with the introduction, viewing of the personas, and ending with background data collection.

Table 2
Experiment flows (D = Deepfake, C = Classic, N = Narrative. j = James, s = Susan, f = Fiona).

Dj Cs Nf	Ds Cf Nj	Df Cj Ns
Cj Ds Nf	Cs Df Nj	Cf Dj Ns
Nj Cs Df	Ns Cf Dj	Nf Cj Ds
Cj Ns Df	Cs Nf Dj	Cf Nj Ds
Dj Ns Cf	Ds Nf Cj	Df Nj Cs
Nj Ds Cf	Ns Df Cj	Nf Dj Cs

2012; Matthews et al., 2012). If the persona is not properly implemented in the design process, it may result in distrust towards the persona (Long, 2009). Thus, we hypothesize that designers are more willing to use deepfake personas because the deepfake personas' video format engages the designers better than the other media formats (see H5 in Table 1).

3.7. Immersion

Immersion is a deep mental involvement in an activity and is important for UX (Jennett et al., 2008). Immersion refers to a state of deep involvement with software and involves five dimensions: temporal dissociation, heightened enjoyment, control, attention focus, and curiosity (Jennett et al., 2008). Persona advocates postulate that personas may increase immersion in design contexts, compared to designing for a nameless/faceless target group is perceived as more elusive (Salminen et al., 2020d). Because deepfakes are a multimedia-based modality that contains audio, video, and non-behavioral cues, we hypothesize that they are more immersive than other persona modalities (see H6 in Table 1).

3.8. Sense of control

Sense of control is an essential aspect of UX, and for designers to enjoy a system or process, they ought to feel in control of the process (Limerick et al., 2014). As stated by Limerick et al. (2014), "HCI has long recognized the feeling of control as a key factor in how people experience interactions with technology" (p.1). In our case, deepfake personas are presented in a linear form (a video that proceeds linearly), while classic and narrative personas can be browsed more freely, jumping easily from one source of information to another. We surmise that this non-linear form makes it easier for stakeholders to jump back and forth between persona information elements while lowering the sense of control in the deepfake persona (see H7 in Table 1).

3.9. Dwell time

Logically following on from the idea that deepfake personas result in a higher degree of immersion, we also expect that stakeholders spend more time engaging with them (see H8 in Table 1) and that they spend more time carrying out the design task for deepfake personas (see H9 in Table 1).

3.10. Uncanny valley

From an HCI perspective, the persona's human-likeness is worth pursuing for preferable persona perceptions (Salminen et al., 2021), but 'too much realism' can also have unintended side effects. In his classic article about human-like robots, Mori (1970) concluded that a robot being nearly but not quite human-like has a notable effect on the perceived abnormality of the robot. This is called the *uncanny valley* effect. For personas, there is evidence that the uncanny valley effect is real in the persona picture context. Some designers might find realistic persona pictures too informative (Salminen et al., 2021). Furthermore, in her thesis, Cleveland (2022) found indications of the uncanny valley effect in deepfakes (an example quote from her study participants viewed that: "It can emulate human movement, but it can't imitate the person's unique movements, so it looks like a person I know and love being poorly operated by an alien. Not nostalgic. Just creepy."), but the effect was not tested against any other visual modality. Therefore, we hypothesize that deepfake personas might be 'too close' to realism, and their minor defects may cause an uneasy feeling among the participants (see H10 in Table 1).

4. Methodology
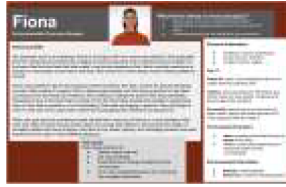
4.1. Experiment design

4.1.1. Study procedure

We adopted a within-subjects experiment (also called repeated measures) design, which is a study that involves observing the same variable among the same participants under varying conditions. In our case, persona modality was the within-subject factor, i.e., all participants were exposed to all persona modalities. Following the within-subject research design, we designed three different persona modalities with three distinct personas (see Section 4.2 for details). Thus, each participant saw each persona with a different modality.

Fig. 2 describes the participation process from a participant's point of view. After viewing the first persona and completing the task and survey, the participants were presented with another persona in their assigned flow. Finally, after completing all three personas and the background questionnaire, the participants were automatically redirected to the data collection platform (see Section 4.3 for details).

The personas that the participants saw were randomly chosen so that each participant saw one persona from each modality (classic, narrative, and deepfake). The order of the modalities was randomized by building experiment flows in Qualtrics and using the randomization function to randomly (but evenly) allocate participants into each flow, thereby mitigating order and learning effects (i.e., all modalities had an approximately even probability of being shown all personas). Each participant only participated in one flow (see Table 2). Each flow

Table 3

The created personas in different modalities. Full versions are provided in the supplementary material (https://bit.ly/3AzqIqp), and the full-sized versions are also available in Appendix 1.

Modality	James	Susan	Fiona
Classic personas			
Narrative personas			
Deepfake personas			

included all personas and all modalities (D = Deepfake, C = Classic, N = Narrative. j = James, s = Susan, f = Fiona). For example, [Dj Cs Nf] is a flow that contains "Deepfake James", "Classic Persona Susan", and "Narrative Persona Fiona".

The order of the survey items was also randomized to prevent any order effects. Furthermore, the survey included an attention check for controlling data quality.

4.1.2. Briefing the participants

Participants were informed that the study investigated people's perceptions of personas. They were told the definition of a persona, a fictitious representation of a group of people, and that personas help designers understand end-user needs. Participants were instructed that they would be shown three different personas, and they would need to design three mobile apps or games, one for each persona. They were assured that the data would be used anonymously and that they could contact the researchers when needed and stop their study participation at any time.

The introduction defined the persona concept ("A persona is a fictitious person that describes a certain type of user or customer. It is not a real person but a representation of a group. Personas help designers *understand end-user needs*.") to ensure that each participant had a foundational understanding of personas. The work task scenario (WTS) asked the participant to design an app or game to support the persona's environmentally friendly shopping. After viewing each persona, the participants were asked to perform the WTS and answer a questionnaire containing the user perception variables (see Section 4.4).

4.2. Persona creation

4.2.1. Overview

As the basis for the personas, we selected three personas from those created by Carey et al. (2019). These personas were selected because they describe people's sustainability attitudes and behaviors, i.e., they match our study context. The classic and narrative persona modalities are common in the field, and we wanted to compare these modalities to the deepfake modality. We also evaluated several alternative persona sets within the sustainability context (those mentioned in the literature review section). However, we deemed the personas created by Carey et al. (2019) as the most actionable for a user experiment. From the

selected personas (James, Susan, and Fiona), we created variations along three modalities (see Table 3), described in the following sections.

The sustainability personas by Carey et al. (2019) consist of the following design elements: (a) a photo, (b) a quote from each persona along with a summary, (c) a personal profile (the main text field of the persona, narrative persona content in classical persona form), (d) personal information (i.e., profession, annual income, location, age, home life, hobbies, personality, purchasing information including likes and dislikes), (e) user goals, and (f) design objectives of the focal organization for the target group corresponding to the persona. We used all these elements in our personas except design objectives which we incorporated into the work task scenario (WTS) presented to the participants. The following section explains the persona creation procedure.

4.2.2. Creating the persona modalities

First, the classic personas (CPs) were recreated versions of the personas created by Carey et al. (2019). We created the CPs in PowerPoint, and the only significant alteration to the original designs was replacing the persona pictures with facial pictures of the deepfake avatars, which was done to ensure the consistency of persona imagery. The CP profiles are shown in Table 3, and full-sized versions are provided in the supplementary material.[1]

Second, the narrative personas (NPs) are textual presentations with the same content that the CPs had, written from a third-person viewpoint (e.g., "James is…"). Therefore, their content corresponds to the CPs but without visual form and facial images. Accordingly, the NPs are purely textual descriptions of the persona and correspond with Nielsen's notion of narratives in persona application (Nielsen, 2004). The NPs were created based on each CP profile in Word (see Table 3). Text files containing the NPs are provided in the supplementary material.[2]

Third, the deepfake personas (DFs) were created using a commercial deep-learning service called Synthesia (https://www.synthesia.io/) in video format. Synthesia was chosen for the DF creation because it uses state-of-the-art technology for creating realistic digital avatars (Lyu, 2020). We (a) created an account in Synthesia, (b) selected avatars among those available in Synthesia that corresponded with the

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[1] https://bit.ly/3AzqIqp
[2] Ibid.

Table 4

User perception variables. PPS = Persona Perception Scale (Salminen et al., 2020e). IEQ = Immersive Experience Questionnaire (Jennett et al., 2008).

Item	Construct	Source
I felt like I understood this persona as a human being.	Empathy	PPS
I felt an emotional connection with this persona.	Empathy	PPS
The persona seemed like a real person.	Credibility	PPS
The persona looked authentic.	Credibility	PPS
The persona seemed complete.	Completeness	PPS
The persona provided enough information to understand the people it describes.	Completeness	PPS
The information about the persona was well communicated.	Clarity	PPS
The information provided by the persona was easy to understand.	Clarity	PPS
I would use this persona again for my task.	Willingness to use	PPS
I feel that the persona improved my ability to complete the task.	Willingness to use	PPS
I lost track of time when learning about the persona.	Immersion (Temporal dissociation)	IEQ
I became less aware of my surroundings when learning about the persona.	Immersion (Spatial dissociation)	IEQ
I became less self-aware when learning about the persona.	Immersion (Perspective taking)	IEQ
At the time the persona was my only concern.	Immersion (Real world dissociation)	IEQ
Learning about the persona felt effortless.	Immersion (Cognitive involvement)	IEQ
I felt focused on the persona.	Immersion (Cognitive involvement)	IEQ
I enjoyed learning about the persona.	Immersion (Heightened enjoyment)	IEQ
The persona was creepy.	Uncanny valley	Mori (1970)
The persona felt unnatural.	Uncanny valley	
Something was not right about the persona.	Uncanny valley	
I felt in control of learning about the persona.	Sense of control	Limerick et al. (2014)
I was able to learn about the persona at my own pace.	Sense of control	

Table 5

Normality assessment for each variable, per persona type.

	Deepfake		Narrative		Classic	
	Sk	Ku	Sk	Ku	Sk	Ku
Persona Dwell Time	4.095	21.851	2.471	10.202	5.037	28.891
Task Dwell Time	3.227	15.339	1.817	4.287	1.914	4.946
Empathy	0.045	−0.881	0.112	−0.012	−0.012	−0.539
Credibility	0.26	−1.163	−0.633	0.528	−1.552	3.243
Completeness	−0.508	0.189	−0.46	−0.219	−0.334	−0.503
Clarity	−0.691	−0.236	−1.088	1.178	−0.954	0.454
Willingness to Use	−0.175	−0.962	−0.578	0.884	−0.368	−0.459
Immersion	−0.199	0.386	0.262	−0.187	0.047	0.214
Uncanny valley	−0.63	−0.743	1.328	2.728	1.042	0.659
Sense of control	0.047	−1.067	−0.948	1.611	−0.709	0.862

demographics of the identified personas, and for each DF, (c) provided a text narrative in the first-person that the persona then articulates for designers (i.e., telling their name, background, and sustainability information). Among the deepfake avatars available in Synthesia, we chose avatars that matched each persona's demographic attributes. As Synthesia enables the selection of the avatar's vocal accent, considering

that our personas were all Irish, we chose Irish accents. The created DFs were exported as video files (.mp4) to be used in the experiment. The DF videos are available in the supplementary material.[3] The use of other methods for creating DFs is left for inclusion in future research.

4.3. Participants

The participants were recruited using Prolific (https://www.prolific.co/), an online research platform (Palan and Schitter, 2018). Prolific has been used in several social science and HCI studies, including persona user studies (Peer et al., 2017; Salminen et al., 2021). The screening criteria for the participants included the country (English-speaking countries: UK, US, Ireland, Canada, Australia) and the industry they worked in (Software, Video games). Based on the participants' reported professions, 77 participants (85.6%) have or could have some prior designing experience. Out of 1149 eligible participants, 100 were recruited for the study. Around one-third of the participants were female (33.7%, $n = 30$).[4] One participant did not indicate their gender. Their average age was 33.1 years old (SD = 8.9). The participants were compensated for their time with a reward corresponding to a £9 hourly wage (recommended as a standard option by the platform). We tested the average duration with ten pilot respondents with a 20-minute duration and set the compensation for the post-pilot group based on the obtained median duration, which was approximately 25 min.

4.4. Variables

The perception measurements adopted in this study and their sources are shown in Table 4. User perception values were measured with a seven-point Likert scale (1–7).

Perceptual measures can be problematic since they are based on participants' subjective opinions (Slater, 1999). Therefore, it is important to measure actual behavior in addition to user perceptions. This actual behavior can refer to real-world task performance, design outputs (e.g., quality), or strictly objective behavioral metrics such as the number of gaze fixations or time spent with a persona design. Similar to earlier persona user studies (Salminen et al., 2022a, 2018), we measured dwell time (i.e., the amount of time a participant spent with the persona profile before moving on to the task) to address H10.

4.5. Analytical approach

After 100 participants had completed the study, the data was exported from Qualtrics and cleaned in Excel, removing unreliable or suspicious submissions. First, nine participants failed the attention check ("It is important that you pay attention to this study. Please choose 'slightly agree' to this question."). Second, we checked that the participants worked in a field we originally wanted (software or related). Of these 91 participants, 14 worked in fields other than software or related. However, we nonetheless kept the participants because the apps or games they designed demonstrated a good understanding of the task upon manual review. One participant was excluded due to superficial task completion, which indicated a poor understanding of the task (the participant did not know what he/she was doing). All task completions were manually reviewed by two researchers jointly, one by one, in a discursive manner. After the data cleaning, 90 participants were retained for analysis, amounting to a 10% ($n = 10$) data loss. This amount generally falls in line with the reported quality of the Prolific participant pool (Peer et al., 2017; Salminen et al., 2021).

Because each participant was exposed to each persona modality, a repeated measures analysis of variance (ANOVA) was chosen as the

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[3] Ibid.

[4] This number is based on the cleaned sample of N = 90 participants; see Section 4.5.1 for data cleaning.
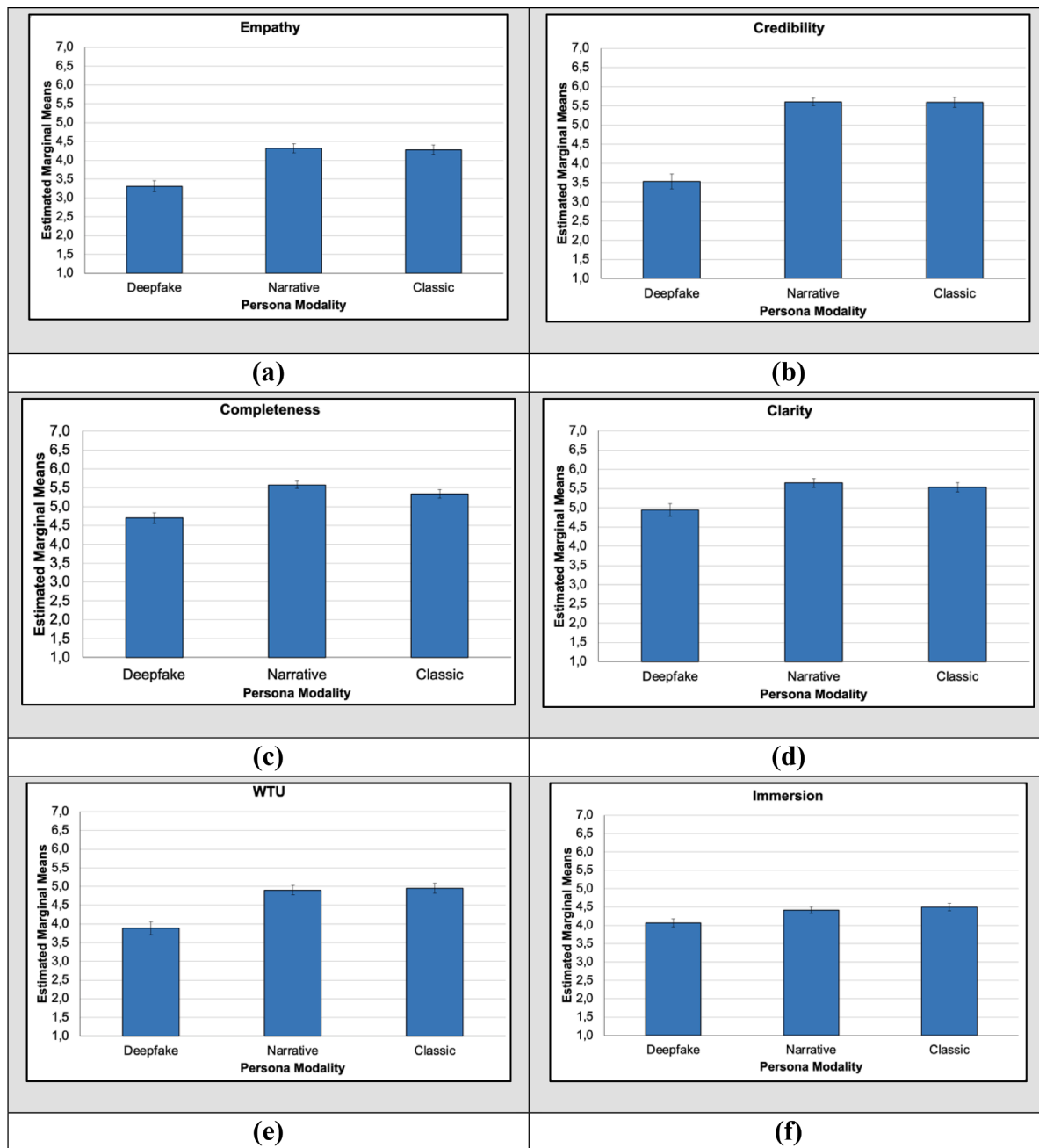
Fig. 3. Study results. Y-axis indicates estimated marginal means (Likert scale in a-g and j, seconds in h-i). Error bars indicate standard error.

statistical approach. The repeated measures ANOVA (also known as within-subjects ANOVA) compares the means of one or more variables based on multiple observations. In our case, the tests reveal if there is a statistically significant difference between the means of the independent variables by persona modality, given that the same participants contributed to the scores of each modality. The analysis was run on SPSS. Conditions for the application of the ANOVA were checked before running the analysis. Specifically, normality was assessed through the skewness and kurtosis of each variable for each type of persona, using Kline's (2016) criteria – that is, an absolute value of under 2 for skewness and under 7 for kurtosis indicates that the distribution is sufficiently normal for purposes of statistical assumptions. Based on these criteria, it was determined that nearly all variables exhibited a quite normal distribution, except for the dwell time variables. Table 5 shows the skewness and kurtosis values for each variable. Because of this, the

comparisons for both dwell time variables were instead conducted with Friedman's test, the non-parametric alternative to the repeated measures ANOVA. Finally, post-hoc comparisons for significant variables were carried out using Tukey's test. A full report on the post-hoc tests is available in Appendix 2.

5. Results

RQ1: How Does Persona Modality Affect Persona Designers' Perceptions of the Persona?

There was a significant effect of persona modality on empathy between at least two groups [$F(1, 89) = 24.42$, $p < .001$]. More detailed examination shows that DFs garnered less empathy ($M = 3.11$, SD = 1.38) than NPs ($M = 4.27$, SD = 1.22) and CPs ($M = 4.31$, SD = 1.19; $p < $
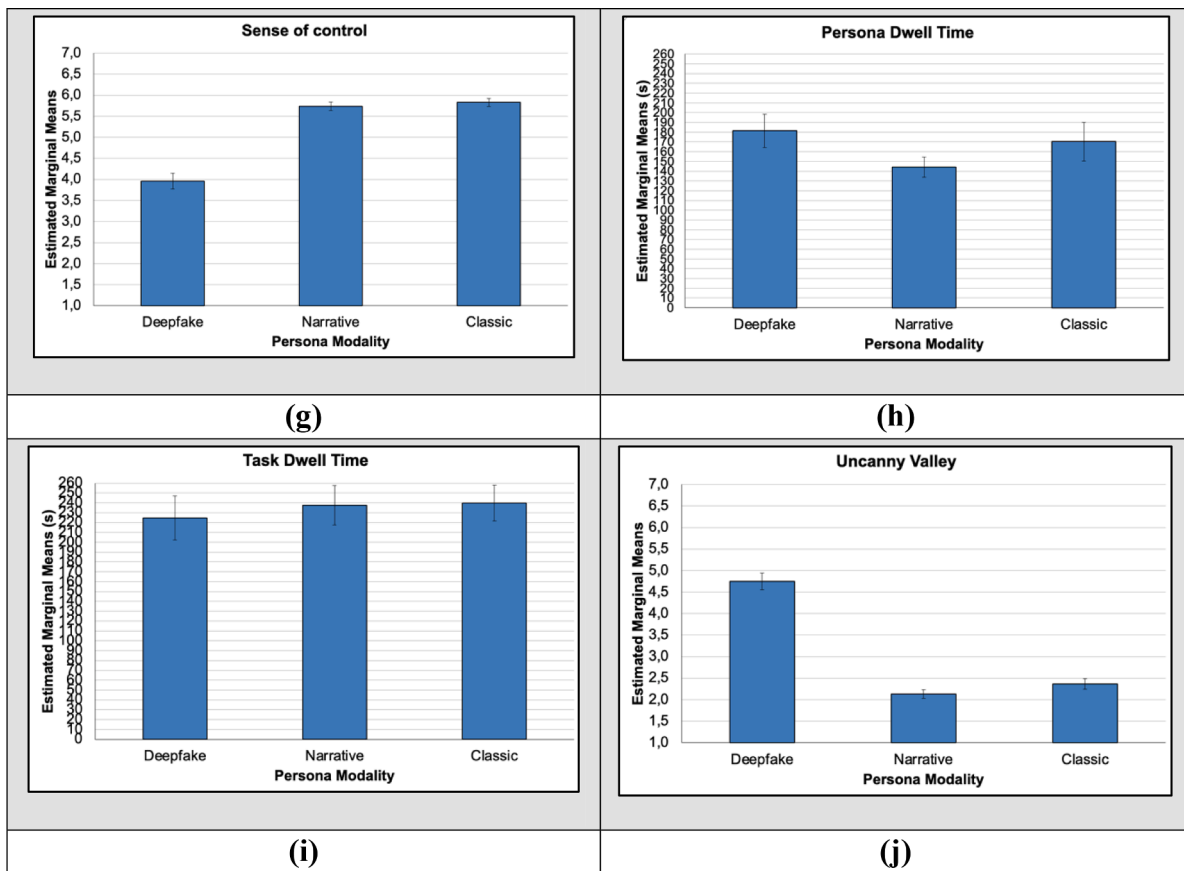
Fig. 3. (*continued*).

.001), while the latter do not exhibit significant differences (*p* = .969) (see Fig. 3a) (see Fig. 3a). Therefore, H1 is fully supported: *Deepfake personas result in a lower degree of empathy than (a) classic persona profiles and (b) narrative personas.*

Testing H2, a repeated measures ANOVA was performed to compare the effect of persona modality on credibility. There was a significant effect of persona modality on credibility between at least two groups [F (1, 89) = 76.05, *p* < .001]. More detailed examination shows that DFs garnered less credibility (*M* = 3.53, SD = 1.86) than NPs (*M* = 5.59, SD = 1.21) and CPs (*M* = 5.60, SD = 0.93; *p* < .001) (see Fig. 3b and Table 5); NPs and CPs do not exhibit significant differences (*p* = 1.000). Therefore, H2 is fully supported: *Deepfake personas result in a lower degree of credibility than (a) classic persona profiles and (b) narrative personas.*

Testing H3, a repeated measures ANOVA was performed to compare the effect of persona modality on completeness. There was a significant effect of persona modality on completeness between at least two groups [F(1, 89) = 19.73, *p* < .001]. More detailed examination shows that DFs garnered less completeness (*M* = 4.69, SD = 1.31) than NPs (*M* = 5.33, SD = 1.06) and CPs (*M* = 5.57, SD = 0.92; *p* < .001), while the latter do not exhibit significant differences (*p* = .214) (see Fig. 3c and Table 5). Therefore, H3 is *not* supported: *Contrary to what was expected, deepfake personas result in a lower degree of completeness than (a) classic persona profiles and (b) narrative personas.*

Testing H4, a repeated measures ANOVA was performed to compare the effect of persona modality on clarity. There was a significant effect of persona modality on clarity between at least two groups [F(1, 89) = 9.81, *p* < .001]. More detailed examination shows that DFs garnered less clarity (*M* = 4.94, SD = 1.57) than NPs (*M* = 5.53, SD = 1.13) and CPs (*M* = 5.65, SD = 1.09; *p* < .001), while NPs and CPs do not exhibit differences (*p* = 793) (see Fig. 3d and Table 6). Therefore, H4 is fully supported: *Deepfake personas result in a lower degree of clarity than (a)*

classic persona profiles and (b) narrative personas.

Testing H5, a repeated measures ANOVA was performed to compare the effect of persona modality on WTU. There was a significant effect of persona modality on WTU between at least two groups [F(1, 89) = 20,14, *p* < .001]. More detailed examination shows that DFs garnered less WTU (*M* = 3.88, SD = 1.66) than NPs (*M* = 4.95, SD = 1.27) and CPs (*M* = 4.90, SD = 1.16; *p* < .001), while the latter do not exhibit differences (*p* = .963) (see Fig. 3e). Therefore, H5 is *not* supported: *Contrary to expectations, deepfake personas result in a lower degree of WTU than (a) classic persona profiles and (b) narrative personas.*

Testing H6, a repeated measures ANOVA was performed to compare the effect of persona modality on immersion. There was a significant effect of persona modality on immersion between at least two groups [F (1, 89) = 9.47, *p* < .001]. More detailed examination shows that DFs garnered less immersion (*M* = 4.06, SD = 1.03) than NPs (*M* = 4.49, SD = 0.92) and CPs (*M* = 4.41, SD = 0.85; *p* < .01), while these last two do not exhibit differences (*p* = .696) (see Fig. 3f). Therefore, H6 is *not* supported: *Contrary to expectations, deepfake personas result in a lower degree of immersion than (a) classic persona profiles and (b) narrative personas.*

RQ2: How does persona modality affect design task performance?

Testing H7, a repeated measures ANOVA was performed to compare the effect of persona modality on sense of control. There was a significant effect of persona modality on the sense of control between at least two groups [F(1, 89) = 72.80, *p* < .001]. More detailed examination shows that DFs garnered less sense of control (*M* = 3.96, SD = 1.72) than NPs (*M* = 5.82, SD = 0.90) and CPs (*M* = 5.73, SD = 0.97; *p* < .001), while NPs and CPs do not exhibit significant differences (*p* = .851) (see Fig. 3g). Therefore, H7 is fully supported: *Deepfake personas result in a*

Table 6

Example task outputs from participants for James in different persona modalities. Each task output is written by a different participant.

Narrative James	Classic James	Deepfake James
James isn't environmentally conscious. I would design an app that finds deals on music equipment, including DJ gear. I would make sure the app holds detailed information and keeps track of price trends from different sites.	The app is called Bargain Hunter. It is an app that promotes products that are great deals and provides a scoring system for the deals. It allows shoppers to easily see what the best deals are and makes it easy to understand with the scoring system. This app fits well with the persona because he likes to get a good bargain while maintaining quality, something that the app is built for. He also hates bad online descriptions, something that the app tries to improve upon.	The app would help shoppers find things in certain categories that are important to them and are bargains and priced much cheaper than they normally would be. It would provide alerts to help the user keep on top of things so they don't have to constantly be watching it in their free time. This would help the user feel in control and feel like they are being smart with their money. It would provide free shipping options and easy returns and would sell things in all kinds of different packaging since the user doesn't really care about the environment.
This persona does not care about the Environment at all, or at least he is not concerned and his age suggests he is fully onto his "own things". I believe in this case an app or game should lead him towards a sustainable way of living-shopping by giving him rewards, substantial discounts, or being interconnected and integrated into his own hobbies. this should be done by connecting the rewards-tasks in the App with the achievements and unlockable contents in the gaming platform that he uses the most and the same applies to the online shopping place he uses the most	A game that involves music and encourages the user to focus on quality and longer-lasting items. The game should discourage the user from buying cheap and disposable items. The game could reward the user with points which can be used to purchase environmentally friendly items. The points are gained by showing the correct attitudes in the game.	This person isn't Irish, is a dick, and is a lost cause. I also couldn't pay attention to what he was saying because of the weird uncanny valley way his ears and face moved. I have no idea about how to make him shop in an environmentally friendly manner. A cliched response would be since he plays Xbox a console game that has a strong crafting element which encourages the reuse and recycling of components to make new equipment and gear. Instill in him an inbuilt urge to reuse and look after his things to reduce his shopping volume. It could be a 3d open world crafting and survival game (because that is definitely an undertapped genre). Maybe set in an urban post-apocalyptic area due to his urban, though not urbane, interests and DJing. The only way I can see this person shopping in an environmentally friendly way is simply by making him shop less.

lower degree of control than (a) classic persona profiles and (b) narrative personas.

Testing H8, Friedman's test was performed to compare the effect of persona modality on persona dwell time. There was no significant effect of persona modality on the persona dwell time between the groups [$\chi 2$ (2) = 2.067, p = .356]. More detailed examination shows that DFs did not garner less time spent (M = 181.33, SD = 162.40) on the persona than NPs (M = 144.15, SD = 98.81; p = .215) and CPs (M = 170.21, SD = 187.15; p = .870) (see Fig. 3h). Therefore, H8 is *not* supported:

Deepfake personas did not result in significantly different dwell times with the persona than (a) classic persona profiles and (b) narrative personas.

Testing H9, Friedman's test was performed to compare the effect of persona modality on task dwell time. There was no significant effect of persona modality on the task dwell time between the groups [$\chi 2(2)$ = 0.867, p = .648]. More detailed examination shows that DFs did not garner less time spent on the task (M = 224.73, SD = 162.40) than NPs (M = 237.43, SD = 191.45; p = 0.835) and CPs (M = 239.80, SD = 173.26; p = .775) (see Fig. 3i). Therefore, H9 is *not* supported: *Deepfake personas did not result in significantly different task dwell times than (a) classic persona profiles and (b) narrative personas.*

RQ3: Is there an uncanny valley effect associated with deepfake personas?

Testing H10, a repeated measures ANOVA was performed to compare the effect of persona modality on uncanny valley. There was a significant effect of persona modality on the uncanny valley between at least two groups [$F(1, 89)$ = 127.29, p < .001]. More detailed examination shows that DFs exhibit a higher uncanny valley effect (M = 4.74, SD = 1.82) than NPs (M = 2.36, SD = 1.15) and CPs (M = 2.13, SD = 0.96; p < .001), while NPs and CPs do not exhibit significant differences (p = .851) (see Fig. 3j). Therefore, H10 is fully supported: *Deepfake personas result in a higher sense of abnormality than (a) classic persona profiles and (b) narrative personas.*

The effect of the uncanny valley becomes even more striking when correlating it with other perceptions. As can be seen from Table 7, the correlation (using Pearson's correlation) is highly noticeable, with all the other perceptions negatively correlated to the uncanny valley measure. This implies that the uncanny valley effect is a notable antecedent in forming stakeholders' perceptions of personas. Table 8 shows the correlation measure by persona type.

6. Discussion

6.1. Discussion of findings

Overall, the study resulted in both expected and surprising findings. As expected, there was a stark contrast between the persona modalities for almost all measures. The results indicate that the deepfakes were perceived as startling and sufficiently bizarre. However, the strength of the uncanny valley effect and its interaction with other variables were surprising findings. The lack of support for WTU and immersion of DFs was also surprising. The staggering differences concerning the uncanny valley effect lead us to believe that with the current technology, DFs still have defects. Barari et al. (2021) refer to these as "uncanny deepfake artifacts that [...] do not perfectly replicate their intended facial features" (p. 4). Based on our findings, these defects in the DFs have worsened persona UX, which is generally compatible with the notion of 'uncanny valley syndrome'. Observations in Table 9 illustrate that (a) Fiona had unreal-looking hair and ears; (b) Susan had unrealistic hair and was blinking unnaturally rarely and sometimes twice in a row; (c) Susan's neck was twitching unnaturally while talking at places where a real human would not twitch their neck, her mouth movement was also unnatural while talking, giving an unnatural look; (d) James' hair looked unnatural, his neck and ears were twitching while he was talking, and his mouth movement was also at times unnatural when talking.

In her article about online avatars, Hamilton (2009) suggests that a rupture from authentic imagery may reduce the level of identification with artificial characters. She refers to the psychoanalytic notion that the ego develops a fabricated identity and a character that is already performative rather than realistic (see Table 10). Therefore, a digital avatar used as persona imagery can become a part of mental role-play, not separate from realism but expanding its expression. This idea is central to the use of DFs in personas as well, as DF personas use avatar imagery, in that DFs level of quality needs to fit within the imaginary

Table 7
Correlations between the perception measures.

	Empathy	Credibility	Completeness	Clarity	Willingness to use	Immersion	Uncanny valley	Sense of control
Empathy	1	0.675***	0.610***	0.537***	0.685***	0.595***	−0.640***	0.560***
Credibility		1	0.704***	0.589***	0.683***	0.523***	−0.838***	0.705***
Completeness			1	0.650***	0.704***	0.518***	−0.645***	0.673***
Clarity				1	0.677***	0.600***	−0.552***	0.648***
Willingness to use					1	0.674***	−0.656***	0.642***
Immersion						1	−0.398***	0.513***
Uncanny valley							1	−0.690***
Sense of control								1

Notes: *** $p < .001$; ** $p < .01$; * $p < .05$.

Table 8
Correlation between the uncanny valley and other perceptions by persona type.

	Classic	Deepfake	Narrative
Empathy	−0.393***	−0.673***	−0.627***
Credibility	−0.501***	−0.809***	−0.763***
Completeness	−0.459***	−0.685***	−0.613***
Clarity	−0.530***	−0.554***	−0.543***
Willingness to Use	−0.427***	−0.724***	−0.547***
Immersion	−0.217**	−0.464***	−0.352***
Sense of Control	−0.479***	−0.552***	−0.451***

Notes: *** $p < .001$; ** $p < .01$; * $p < .05$.

Table 9
Uncanny deepfake artifacts in personas. Note that these artifacts were observed by some of the research team members, while others did not pay attention to them. These differences in deepfake user perception warrant future work.
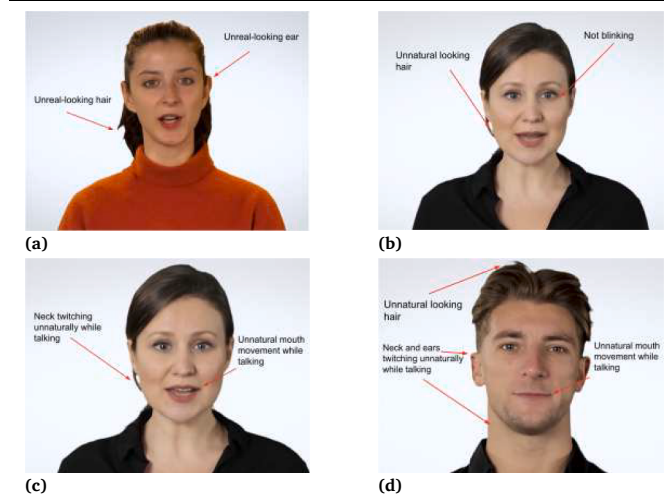
Table 10
Division of two types of personas and their benefits, namely (a) user persona benefits and (b) avatar persona benefits.

User persona benefits	Avatar persona benefits
Represents ethnographically a group of people	Represents the face of the persona
Helps designers understand end-user goals, needs, and wants	Helps one express themselves, for example, on the internet, gaming, etc.
Builds empathy in designers	Make personas more believable, identifiable, and immersive by being realistic representations of people (Hamilton, 2009)
Conveys information about a user group to the designers	Is the performative representation of the ego, such as in an online environment or video gaming
Helps designers form mental models of the users	Helps expand the expressiveness of user personas

power of designers. As indicated by our results, a disruption in this quality will likely decrease designers' immersive experience of personas.

Interestingly, previous research has seen DFs as a threat due to their high level of credibility. For example, Barari et al. (2021) report that "fabricated videos of public officials synthesized by deep learning […] are credible to a large portion of the American public – up to 50% of a representative sample of 5750 subjects" (p. 1). Our results show a lack of credibility toward DFs. While in politics and information dissemination, the realism of fakeness can indeed be a severe threat to society, in HCI, the realism of personas can, in fact, be an asset for eliciting heightened designer empathy and understanding. Thus, it is interesting that DFs do not yet seem mature enough for HCI. The conflicting findings might also stem from the higher degree of attention paid by our participants, which specifically focused on perusing the persona in detail rather than, for example, viewing it in passing on social media.

Another potential explanation stems from the customs and traditions of personas. In their reviews of persona templates, Nielsen et al. (2015) and Salminen et al. (2020b) observed that personas are most commonly presented as static profiles and not as live "creatures." Nielsen et al. (2015) found that the conventional persona template includes one portrait picture with various "boxes" of information, which stakeholders seem to prefer. As such, stakeholders are still not used to seeing personas talk, given that the standard format for personas is either static paper or PDF (Jansen et al., 2020). In other HCI studies, researchers have also observed that the default options of a system have an overwhelming influence and effect on user behavior and attitudes (Schneider et al., 2020); therein, what is standard and convention is usually accepted, while what deviates from the standard is frowned upon. Therefore, we surmise two effects that might be at play as to why DFs at the present stage do not outperform CPs or NPs: (a) the uncanny valley effect, and (b) the effect of convention.

6.2. Design implications

6.2.1. Theory

While there are no absolute answers to these questions, the empirical evidence does seem to favor a realistic user portrayal of personas (Salminen et al., 2021), mainly because of the level of professionalism and seriousness that realism involves, which is especially important for avoiding the perception of personas as being 'fun and games' rather than a serious decision-making instrument (Matthews et al., 2012; Rönkkö, 2005; Rönkkö et al., 2004). In other words, the 'visual norms' of personas might differ from use cases like entertainment and gaming, where less realistic depictions of people are commonplace. However, it is also important to acknowledge the other side of the argument, which is that abstract features might, in some cases, increase the degree of identification with the user representation, as was the case in the study of Nowak and Biocca that tested virtual human avatars (Nowak and Biocca, 2003). Conflicting findings regarding the level of detail and anthropomorphism in human-like characters thus underline the complexity of designing effective user representation in any given style.

6.2.2. Method

At the time of this study, DFs offer a not-yet-fully mature alternative to CPs or NPs. CPs and NPs appear to be far more versatile than DFs for conveying end-user information to stakeholders. The difficulty is not so much that DFs would not be used but rather that using them is less preferable to alternative modalities. In the words of André et al. (1998), "Despite the raging debate on the sociological effects that lifelike characters may have, yet cannot have and perhaps never will have, it is safe to say that they enrich the repertoire of available options which can be used effectively to communicate information to the user." (p. 25). Our present ability to create DFs is lacking in the greater scheme of things. As the offline and online worlds continue to merge, it will be interesting to see whether this changes in the future. Nevertheless, as DFs aim to preserve the appearance of real people, the goal of generating realistic personas aligns with the generic goal of deepfake technology.

6.2.3. Design practice

Currently, DFs seem to impose design tradeoffs. While an interesting technology, DFs are not mature enough to replace more traditional persona templates, such as NPs and CPs. However, designers should not completely overlook DFs as trivial. A particular segment of participants ($n = 16$, 17.8%) provided consistently higher persona perception scores for DFs than for other persona modalities (i.e., the mean for all combined deepfake scores was higher than the mean of all scores for both narrative and classic personas). This implies that a fringe user segment prefers DFs, and future research should investigate what drives their inclination to DFs. The deepfake technology has been under development since 1997 (Bregler et al., 1997), and recent research show that the use of DFs is increasing as well as DF quality is getting more believable to the human eye (Danry et al., 2022; Fallis, 2021).

Based on our study, the perceived uncanniness of the DF personas has a significant positive correlation with the credibility of the DF personas (Table 7). Low credibility of DF personas deserves attention also in future research if DF technology is to be used in fields such as movies, games, and education to name a few. It has been found in recent studies that adapting DF imagery in such fields as education, privacy, and therapy can leverage the attention and motivation of people participating in applications in those fields (Danry et al., 2022). However, our study findings imply that the uncanny valley effect represents a challenge in the implementation of DFs' credibility and usability at least in design tasks.

6.3. Limitations and future work

The limitations of this research offer a basis for future research ideas, which we discuss in this section.

First, our findings imply that the uncanny valley effect represents a challenge for the wider use of DFs in design tasks. In addition, opposite expectations, DF personas had lower immersion than narrative and classic personas. Combined with immersion, the task dwell time has little difference between all persona modalities. A similar notion can also be made on persona dwell time between all three persona modalities. Concerning the persona dwell time, it must be noted that the lengths of the DF persona videos were 144, 179, and 156 s (James, Susan, and Fiona, respectively) which impacts the DF persona dwell time. While the participants had to watch the whole video to get all the information from a DF persona, there are differences between people's ability to read and absorb information from visual representations (Becker, 2011) and text (Chung et al., 2004), i.e., there are slow and fast readers. Some might be, for example, dyslexic. These conditions were not considered when using the dwell time as a study variable. Second, people from different cultural and demographic backgrounds may perceive deepfakes differently. For example, Haring et al. (2014) found that the perception of robots differs between the Japanese and Australians. In a similar study, Herring et al. (2022) found that also gender and culture affect DF perception. Thus, cultural background and gender

should be studied more thoroughly concerning the use of DF personas in design tasks.

Third, it is possible that some other existing deepfake technology or service could outperform our personas. In this study, we used Synthesia, on the one hand, due to its flexibility and convenience in rapidly rendering DFs and, on the other hand, due to its good performance in terms of providing vivid deepfakes in our pilot testing of different commercial services. While we are aware of other services, systematically comparing these services is beyond the scope of this work. In our initial viewing, the personas created with Synthesia appeared to be of high quality, and we maintain they are high quality (as the reader can observe by accessing the video files in the supplementary material of this article). We compared other systems, finding Synthesia services to be state-of-the-art. However, the DFs were not perfect, and the relatively small DF artifacts seem to have a disproportionately high adverse effect on designers' perceptions. Due to fast development, studies like this one should be replicated frequently so that the findings remain aligned with state-of-the-art deepfake technologies.

Fourth, the study could also be performed by comparing DF videos with videos of real people. Similarly, the classic personas used in this study had DF persona images. There could also be persona images of real people. While we only used DF videos, classic personas, and narrative personas, future work could include a variety of real/fake video and image personas. In other words, the DF videos could be accompanied by personas videos with real people, and the classic personas could be formed with DF and real persona images to form a more comprehensive comparison.

Fifth, we know little about the interaction between designers and deepfake personas. For example, it is unclear what aspects of the DFs people generally pay attention to. Previous eye-tracking studies in the persona context have tested information elements such as the number of pictures and the picture types looked at (Hill et al., 2017; Salminen et al., 2018). However, there is a lack of testing of radically different persona designs, including DFs, using eye-tracking. Similarly, given the conceptual division between (a) interactive DFs, and (b) non-interactive DFs, future work could investigate the former. This endeavor could take the form of talking (voice interaction) or typing (textual interaction) to the persona.

Sixth, we focused on the sustainability context. Future work could vary the context for which the personas are deployed. To this end, a study with professional designers on how they work with personas would give a more in-depth view of the importance and meaning of DF personas and other persona modalities. This approach could involve using qualitative methods to analyze the importance and meaning of DF personas and other persona modalities. Inviting professional designers to evaluate the design concepts on the survey could also help evaluate the importance and meaning of DF personas and other persona modalities in design task completion in more depth.

Finally, while our study focused on the *promise* of deepfake technologies for HCI, there is also potential for abuse, bias, and stereotyping in DFs, as indicated by tangential work (Kirkpatrick, 2016; Turner and Turner, 2011). To counter this, deepfake services like Synthesia imposes a vetting procedure on the deepfake scripts before accepting them, making it more challenging to generate harmful deepfakes. Nevertheless, DFs might pose hidden dangers for HCI. Thus, a future examination in this field should consider ethical and moral standards for deepfake personas, similar to those research has proposed for data-driven personas (Salminen et al., 2020a).

7. Conclusion

The results of our study indicate that persona modality matters. Using DF personas in design tasks may not be the best persona modality to be used in design tasks, but the potential of DFs is most likely to grow in the future. Designers react differently when using a different modality to present the same facts about users. While the impact of persona design

on user perceptions and behavior is generally known, our study is the first to compare deepfake personas against narrative and classic personas, with findings indicating that user perceptions are less favorable for deepfake personas than for the other modalities. The sense of control also decreases with DF personas, but stakeholders spend roughly the same time with deepfake personas than with other persona modalities. Consequently, future work is required to understand stakeholders' interactions with deepfakes more deeply to improve the quality of deepfake technology and to further our understanding of optimal persona designs.

The empirical findings on the potential use of DF personas in design tasks show that the potential of deepfakes is not yet realized. Deepfake technology persona technology may become mainstream in the future years. Now, the power of AI technology used in creating DFs has flaws that do not suggest deepfake technology to be applied in design tasks. In this regard, the problems present in DFs are likely to be solved in the future. Deepfake technology has been developing only since 1997, and during the past less than 30 years, there have been leaps in the DF creation process and technology. DF personas may have lower degrees of empathy, credibility, completeness, clarity, willingness to use, immersion, and sense of control compared to narrative and classic personas. However, the call for more dynamic and immersive formats of presenting personas as design artifacts remains a focal topic. DFs have the latent potential to be the multimedia persona format as they mimic real people. The steppingstone for more usable DFs for design tasks requires tackling the uncanniness of DFs. The results presented in this study suggest DFs still require further evolution to offer a wholesome, immersive medium for user personas.

CRediT authorship contribution statement

Ilkka Kaate: Conceptualization, Methodology, Writing – original draft, Investigation, Data curation, Formal analysis, Validation, Writing – review & editing, Visualization. **Joni Salminen:** Conceptualization, Methodology, Writing – original draft, Investigation, Data curation, Validation, Writing – review & editing, Visualization. **Joao Santos:** Data curation, Formal analysis, Validation, Visualization. **Soon-Gyo Jung:** Software. **Rami Olkkonen:** Validation, Writing – original draft, Writing – review & editing. **Bernard Jansen:** Writing – original draft, Investigation, Writing – review & editing, Visualization.

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:
Ilkka Kaate reports financial support was provided by Foundation for Economic Education.

Data availability

Data will be made available on request.

APPENDIX 1: Full-sized versions of Table 3 pictures

Fig. A1. Classic persona James.

Fig. A2. Classic persona Susan.

Fig. A3. Classic persona Fiona.

James, Environmentally unconscious shopper

James is a twenty-year-old working as a barman and living in Sligo town, Ireland. He earns about twenty thousand euros annually. James lives at home with his parents, his older sister and younger brother. They have a dog, Rex. In his spare time, James DJ's a lot and watches TV, plays XBox and Playstation. He's very determined and focused, but sometimes he has a bit of a short fuse. Usually he's a mellow guy. He's loyal to his family and friends. As a shopper, James likes a good bargain and having nice DJ equipment. He doesn't like to spend money on expensive equipment; he also dislikes bad online descriptions, and shipping costs. His attitude towards the environment is negative and he does not pay attention to the environment when buying things.

James' younger brother Dave sometimes gets on his nerves. Dave is 14 years old and looks up to him. Dave likes to hang out with him, try out his DJ equipment, play XBox, and be generally tiresome. Just a while ago Dave broke a set of headphones to which James had saved money for weeks. This is annoying to James because he tries to keep good care of his own stuff and he expects this from others too. He's waiting to get enough money to move on his own.

James is working as a barman in the center of Sligo town at a place called Glasshouse which is a quite new place, a modern hotel and is expecting its staff to act according to its 4-star reputation. James says he doesn't like to be dressed as formally but he's secretly enjoying his working outfit. He likes to have his Saturday nights off since they are important to him and that is why he's working 3 days and 3 nights a week. James buddies as a DJ at the local dive bar every chance he gets. He likes the feeling a lot that he can create in the crowd and a lot of his friends come to hear him play.

James doesn't really care about the environment. He thinks that the environment is not a concern at the moment and he has little to do for the environment. His mother makes him recycle at home but that is all he's willing to do. He believes that somebody will come up with a solution for environmental problems and that will sort all things out.

James says that sometimes quality is worth paying for, but only sometimes.

James' goals as a product buyer are:
- help him be better at things he loves
- satisfy needs he has
- make him feel better
- feel he's smarter when he gets a bargain.

Fig. A4. Narrative persona James.

Susan, Socially conscious shopper

Susan is a thirty-year-old solicitor living in Dublin City, Ireland. She earns around fifty five thousand euros annually. She lives by herself in an apartment in Dublin City. Her parents live quite near her in Dún Laoghaire. In her free time, Susan goes to the gym twice a week. She's also a part of a knitting group. She also has a blog she likes to write sometimes during the weekends. Susan has a feeling that she can be a dominant person. A characteristic which she tries to correct whenever she meets new people. She's willing to try almost anything once.

As a buyer, Susan likes to spend money on things she feels she deserves and that she has earned. Susan likes things in her life. She doesn't like bad bargains, pushy sales personnel or items of poor quality. Susan is not really concerned about the environment, but she does pay some attention to the environment when buying things.

Susan has recently moved to a Dublin City apartment. This enables her a shorter commute to work and also makes it possible to move without car, bus, or taxi in the vicinity of her apartment. Susan takes her job seriously and she's very precise on the time she goes to work. She doesn't want to be late. She's aware that being a young woman in her profession makes her a hard worker. She wants to ensure she's at the top of the game in her profession.

Susan has a background from an environmentally conscious family. She still carries environmentally good habits she learnt in her childhood. She dislikes excessive packaging and uses recycled paper whenever possible. Susan tries to buy ecologically friendly cleaning products but she thinks they are a bit too expensive for daily use. Susan doesn't think too much about the environment but she just makes environmentally good decisions as a habit. She realises this and thinks she makes more eco-friendly decisions than she really means to.

Susan tries to buy necessary things she needs in her life. She thinks books are necessary for her because she needs them in her work. She has bought a majority of her books online but rarely does she buy shoes or clothes online since she likes to try them out first. Susan thinks she's buying only the necessities but that is not true. She often buys clothes and shoes for work. She wants to look smart and she believes that buying the right clothes will help her. During the weekends she meets with her craft group to enjoy some change of pace and culture. She thinks that that is a moment of fresh air in her week.

Susan says that she doesn't worry about the price but about the value.

Susan's goals as a buyer are:
- meet her needs
- help her out in her life
- fit within the habits and traditions of her childhood family life
- do not harm the environment nor her wallet.

Fig. A5. Narrative persona Susan.

Fiona, Environmentally conscious shopper

Fiona is a twenty-six-year-old teacher living in Navan, Ireland. She earns thirty thousand euros annually. She lives in a 2-bed apartment with her boyfriend John. In her free time, Fiona likes to spend time with her friends and family and go out for walks with her dog. She likes listening to live music and socialising on different occasions. She likes things to be tidy and neat and she dislikes clutter. She thinks she's more organised than she really is.

Fiona is keen on online purchasing. She likes to browse through online shops but prefers buying from a physical store. She doesn't like pushy sales personnel and stores that make her feel uncomfortable. She has a positive attitude towards the environment and she also minds the environment when buying things.

Fiona's boyfriend John is an electrician but he is not happy with his current work situation. Fiona graduated from the University of Limerick with a degree in science teaching. She is willing to pursue a master's degree in the same field but she feels that she needs to get some experience first. Fiona is currently working as a teacher in a secondary school which she likes. She's also fond of the steady income made possible by her job.

Fiona is responsible for day-to-day shopping of the household. She has a routine for grocery shopping and she hates waiting in line. She's a planning personality and she buys groceries for the week according to her pre-made list. However, she is willing to change her plans if she sees something interesting to buy in the store that is not in her list. She hates buying food packed in polystyrene trays or food with heavy packaging. She hates packaging in general. She just bought a new TV with John and it came with a whole lot of packaging that needed to be disposed of.

When Fiona gets her salary, she sometimes treats herself with a new pair of shoes or a new handbag. After work, she often browses through online stores but usually she prefers to see and feel the quality of something before she buys anything. She likes to buy shoes, jewelry, and handbags because she feels that they can be used in many different situations.

Fiona usually thinks about why there is so much packaging.

Fiona's goals as a buyer are:
- satisfy needs she has
- get a good feeling
- know that she is doing something for the environment
- be a more sustainable person by not always buying the cheapest alternative.

Fig. A6. Narrative persona Fiona.

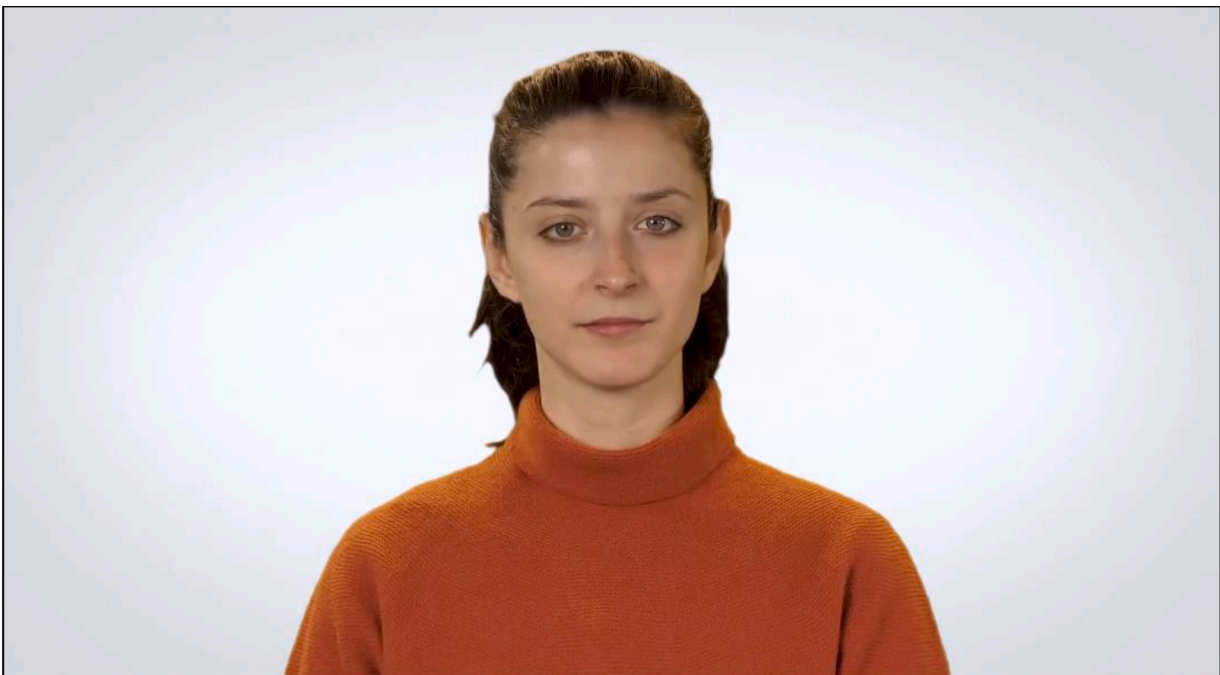**Fig. A7.** Deepfake persona James.

Fig. A8. Deepfake persona Susan.

Fig. A9. Deepfake persona Fiona.

APPENDIX 2: POST-HOC tests

Dependent Variable	(I) type	(J) type	p-value
Persona Dwell Time	Classic	Deepfake	0.870
		Narrative	0.468
	Deepfake	Classic	0.870
		Narrative	0.215
	Narrative	Classic	0.468
		Deepfake	0.215
Task Dwell Time	Classic	Deepfake	0.775
		Narrative	0.994
	Deepfake	Classic	0.775
		Narrative	0.835
	Narrative	Classic	0.994
		Deepfake	0.835
Empathy	Classic	Deepfake	0.000
		Narrative	0.969
	Deepfake	Classic	0.000
		Narrative	0.000
	Narrative	Classic	0.969
		Deepfake	0.000
Credibility	Classic	Deepfake	0.000
		Narrative	1.000
	Deepfake	Classic	0.000
		Narrative	0.000
	Narrative	Classic	1.000
		Deepfake	0.000
Completeness	Classic	Deepfake	0.000
		Narrative	0.214
	Deepfake	Classic	0.000
		Narrative	0.000
	Narrative	Classic	0.214
		Deepfake	0.000
Clarity	Classic	Deepfake	0.000
		Narrative	0.793
	Deepfake	Classic	0.000
		Narrative	0.002
	Narrative	Classic	0.793
		Deepfake	0.002
Willingness to use	Classic	Deepfake	0.000
		Narrative	0.963
	Deepfake	Classic	0.000
		Narrative	0.000
	Narrative	Classic	0.963
		Deepfake	0.000
Immersion	Classic	Deepfake	0.003
		Narrative	0.696
	Deepfake	Classic	0.003
		Narrative	0.000
	Narrative	Classic	0.696
		Deepfake	0.000
Uncanny valley	Classic	Deepfake	0.000
		Narrative	0.406
	Deepfake	Classic	0.000
		Narrative	0.000
	Narrative	Classic	0.406
		Deepfake	0.000
Sense of control	Classic	Deepfake	0.000
		Narrative	0.851
	Deepfake	Classic	0.000
		Narrative	0.000
	Narrative	Classic	0.851
		Deepfake	0.000

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