Digital Humans in Fashion: Will Consumers Interact?

Abstract

The ongoing COVID-19 pandemic is disrupting the fashion industry and forcing fashion businesses to accelerate their digital transformation. The increased need for more sustainable fashion business operations when coupled with the prospect that business might never be as usual again, calls for innovative e-commerce led practices. Recently, stakeholders have been experimenting with the idea of introducing digital humans for a more active role in fashion through the developments in artificial intelligence, virtual, augmented and mixed reality. As there is a lack of all-important empirical evidence on the consumer's propensity to interact with digital humans, we aim to quantitatively analyse consumer attitudes towards the propensity to interact with digital humans to uncover insights to help fashion businesses seeking to diversify their operations. The results reveal interesting, and statistically significant insights which can be useful for fashion business stakeholders for designing, developing, testing, and marketing digital human-based solutions. Besides, our findings contribute current insights to the existing literature on how consumers interact with digital humans, where research tends to be scarce.

Keywords: Digital humans; interaction; consumer behaviour; fashion business; e-commerce; innovative technologies.

1. Introduction

Changes in the global economic and political landscape, when coupled with the ongoing COVID-19 pandemic, have further instilled the need for rapid digital innovation in fashion (BoF McKinsey & Company, 2020; McMaster et al., 2020). Fashion businesses must be open to the prospect that lockdowns could have a long-lasting effect on consumer behaviour and that they may no longer wish to shop in-store (Kantar, 2020; Ward, 2020; Sheth, 2020). Going digital is not an entirely new phenomenon for fashion business, and there is evidence which shows how digital transformation can lead to a more sustainable and truly customer-driven business (Bertola and Teunissen, 2018; Perry et al., 2019). However, today, there is an urgent

need to develop new routes to the consumer as businesses prepare for increased competition for market share post-COVID-19. To this end, a more introductory form of digital humans is already being used in the world of fashion as influencers and fashion models (Marr, 2020). However, people crave for the human-touch (Ward, 2020). Accordingly, exploiting the evolution of augmented reality (AR) and mixed reality (MR), and investing in developing more intelligent digital humans (that could be brought to life) for inclusion in fashion business could be the solution for a more inclusive, sustainable and convenient shopping experience.

A digital human can be defined as a life-like being, powered by artificial intelligence (AI), with the capability of conversing, communicating and creating an emotional connection, like any other human being. Consumers would use a portal (e.g., phone screens, or AR glasses) to interact with digital humans, and Terry (2018) asserts they are tipped to be the future of influence. For Collier et al. (2019), a digital human resembles a human in form, features and expression, and enables connection and individualisation through sensing of a user's body language to respond appropriately. Digital humans are also distinguished from animated characters by one key characteristic, i.e., 'the illusion that they are "just living life" like the rest of us' (Terry, 2018).

The adoption of digital humans by fashion business can bring about several advantages. AI-based digital humans can know your taste better and can make clothing exactly to your measurements (McDowell, 2020a). This is likely to result in fewer returns and thus help create a more sustainable future. Furthermore, it would add to making the shopping experience more productive and efficient for the consumer. Digital humans can also be a sound solution to enable those with accessibility issues to have a seamless shopping experience, and Kantar (2020) believes consumers will associate more with brands that are focused on corporate social responsibility and wellbeing. However, there are also concerns that such advances in technology can lead to setting unrealistic body image expectations (Marr, 2019) and mass unemployment (Huang et al., 2019; Mahmound et al., 2020).

Soon, fashion businesses will have to make decisions on investing in digital humans. For example, recently, the Fashion Innovation Agency at London College of Fashion, Microsoft, and Reactive Reality launched the Digital Human Stylist (Microsoft, 2020). This proof-of-concept demo demonstrates how artificially intelligent, personalized digital avatars can dole out customized style and wardrobe

tips, and lead to increased levels of sustainable consumption (Conti, 2020; Tilley, 2020). In another recent attempt, HoloMe partnered with Vogue Singapore on a photo shoot that brought actor Fiona Xie into readers' homes through AR (Ang 2020; McDowell, 2020b). However, for an industry that is one of the hardest hit as a result of COVID-19, with thousands of companies facing a fight to stay afloat (Vogue Business Team, 2020), it is important for fashion businesses to know whether consumers are willing to interact with digital humans prior to investing in such expensive technologies.

As such, in this paper, we quantitatively analyse consumer attitudes towards the propensity to interact with digital humans, in order to provide varied insights for the fashion industry (which are transferable to other industries too) on consumer's propensity to interact with digital humans based on demographics, platforms, and mobile operating systems. Our work is important, especially in the context of digital humans, because a digital human can be viewed as a stranger who presents the opportunity for synchronous online interaction. However, humans not only have different propensities when it comes to communicating with other humans, but also have a general tendency to avoid communication (Burgoon 1976; McCroskey and Richmond 1985; Liu, 2003; Wiertz and De Ruyter, 2007). As such, brands need evidence on consumers' willingness to interact with their digital counterparts. It would be interesting to uncover whether digital humans could help overcome communication hurdles.

To achieve our aim, we critically review innovative technologies in fashion business with a focus on human-computer interaction (HCI) and digital avatars to identify the factors affecting HCI. These are translated into several research questions that will underpin our study (see, Section 2). Next, we survey consumer attitudes towards digital humans to uncover insights to help fashion businesses seeking to diversify their operations with digital humans.

Our interest in this research was motivated by several aspects. First, as discussed above, COVID-19 has forced players in the fashion industry to shift to digital (McAlpine, 2020) or risk losing business owing to prolonged store closures resulting from government-imposed lockdowns (Borrelli, 2020). With consumers' retail habits changing (Borrelli, 2020), fashion brands must continue investing into new digital solutions to survive in the market. Therefore, researching into the viability of digital humans from a consumer perspective could offer useful information for

brands to consider. Second, the evolution of wireless technology has led to the introduction of 5G which is expected to enable more realistic AR experiences and transform digital fashion (McDowell, 2020b). In fact, 5G is expected to increase the quality of live-streamed digital humans via AR, enabling fashion brands to create the psychological sense of presence (McDowell, 2020b). Thus, it is very likely that more fashion brands would be encouraged to invest in digital human led solutions as they navigate through the various digital options available to them. Finally, research into human-computer interaction has attracted varied interest from academics over the years. For example, Dix (2009) studied human-computer interaction in general whilst Keeling and McGoldrick (2009) researched into interaction with avatars in the context of retail websites. Moon et al. (2013) studied the role of social interaction in avatar-based virtual shopping, and more recently, Bonetti et al. (2019a; 2019b) considered factors influencing the interaction with AR and immersive technologies in retail. Several other authors studied varied aspects of interaction with MR objects (see for example, Egges et al., 2007; Lindgren et al., 2016; El Hafi et al., 2020), but none of these studies considered digital humans, who are photo-realistic 3D human models. Our current research is timely, because to the best of our knowledge, there exists no published academic research that investigates how likely consumers are to interact with life-like digital humans that recent technology advancements have made possible. Accordingly, the findings from our research could benefit fashion brands by helping them to identify how consumers' propensity to interact with digital humans could differ based on demographic factors, choice of platforms, and users preferred mobile operating systems.

As a digital human represents an opportunity for interaction within an AR-based environment, we subscribe to Wiertz and de Ruyter's (2007) definition of online interaction propensity to define a consumer's propensity to interact with digital humans. Wiertz and de Ruyter (2007) defined online interaction propensity as 'a prevailing tendency of an individual to interact with relative strangers (i.e., people they have never met offline) in an online environment' (p. 358). We adapt this definition and define the propensity to interact with digital humans as 'a prevailing tendency of an individual to interact with relative strangers (such as digital humans, whom people have never met offline) within a mixed reality environment.

We believe the findings from this study would be vital in enabling stakeholders to come to conclusions on the allocation of limited resources to support fashion

business functions post-COVID-19. Where businesses make decisions to invest in digital humans, our findings can also guide the design, development, testing and marketing provisions related to digital human-based solutions. Besides, our research contributes current insights to the existing literature on how consumers interact with digital humans, where research tends still to be scarce.

The remainder of this paper is organised such that Section 2 presents the theoretical background of the paper. Section 3 presents the methodology whilst the results are presented in Section 4. A discussion compares our findings against existing literature through Section 5 and the paper ends with some conclusions in Section 6.

2. Literature Review

The literature review below analyses the latest technologies adopted by fashion businesses and the growing potential of digital humans. We then focus our review on human-computer interaction in digital environments and how it is enriched with innovative technologies. We also explore the factors affecting human-computer interaction.

2.1 Innovative technologies in fashion businesses

The rapid and continuous pace of technological change has led to increasing adoption of new technologies by consumers thus becoming part of their everyday lives. This phenomenon has been accelerated by COVID-19 pandemic, due to national lockdown restrictions involving spending longer time at home and limited visits to public places such as physical retail destinations (Accenture, 2020; Janssen and van der Voort, 2020). Such technologies range from computer desktops or laptops, tablets and smartphones, to innovative technologies including new mobile applications, AR, VR and MR applications, wearables, digital humans, chatbots and new ways of interacting amongst users and between users and firms (Bonetti et al, 2017, 2019b; Grewal et al, 2020; Pizzi et al, 2019; Smith, 2019; Jain and Werth, 2019). Innovative technologies can be defined as newly invented technologies that can be incremental, radical or disruptive, or existing technologies used in new ways to improve value for businesses and enhance life for humans (e.g., by making it more convenient) (IGI Global, 2020; Bonetti et al., 2019b; Hassani et al., 2017). The ongoing digital revolution has important consequences on the way fashion

businesses operate and how they interact with their consumers across channels. This has therefore spurred an increasing adoption of innovative technologies across points of interaction with the consumer, as they seek to enhance the shopping experience to gain a competitive advantage in this highly competitive and volatile sector (Bonetti et al., 2019b).

Of the developing forms of innovative technologies adopted by fashion businesses, this study focuses on digital humans as a form of cutting-edge MR technology that has a great potential for growth and being adopted by consumers and fashion businesses, as they operate through consumers' devices (e.g., phone screens, or AR glasses, or MR displays) in an MR environment (Terry, 2018; Jain and Werth, 2019). Furthermore, this is also the case considering businesses' increasing need to operate digitally whilst maintaining an interactive, inclusive and realistic environment and experience (Bonetti et al, 2019b; Pantano et al, 2017) to mirror the consumers' offline world. This form of technology also emerges to be extremely timely due to the rapidly changing environment and the more recent COVID-19 pandemic, which have acted as catalysts for change towards digitalization across all industries, with an increasing focus on consumer experience and service provision (Lee Yohn, 2020; Grewal et al., 2020; Carnevale and Hatak, 2020).

In these regards, the fashion industry has been experimenting heavily with digital fashion (see for example several projects undertaken collaboratively by the Fashion Innovation Agency (http://www.fialondon.com/projects/). Historically, from a fashion perspective, evidence indicates virtual humans were mainly used for marketing purposes with Fenty Beauty's use of Shudu (https://www.instagram.com/shudu.gram) making her account go viral (Katz, 2018). Balmain also recruited Shudu for their #BALMAINARMY campaign (Somfelean, 2019). However, several start-ups are developing digital humans for customer service applications with a focus on bringing the characters to life with high levels of visual quality (Katz, 2018). Paredes (2019) reported that an AI company called UneeQ was creating New Zealand's first digital human fashion model who will model the autumn/winter 2020 collection for Salasai (https://salasai.com/). More recently, Samsung launched its humanoid AI chatbot project, Neon, which was also marketed as a fashion model (Tibken, 2020). Peter Diamandis, founder of X Prize Foundation predicts the fashion industry will soon move on to shopping through virtual reality (VR) with the help of AI-powered (digital human) fashion advisors, and that digital

humans will be able to create an improved social experience (McDowell, 2020a). Having considered the potential of this cutting-edge technology, it is important to understand users' willingness to interact with it. The next section explores the human-computer interaction with innovative technologies.

2.2 Human-computer interaction with innovative technologies

A major theme in the existing literature relates to the way(s) in which users interact with technology devices and systems (see Bonetti et al, 2019b; Dix, 2009; Kjeldskov & Graham, 2003; Rogers, 2004). To make technology devices socially acceptable, developers need to provide interactions modality between human and technology as much realistic as possible (Carmigniani et al., 2011). Human-Computer Interaction (HCI) is the "study of the way in which computer technology influences human work and activities" (Dix, 2009, p. 1327). Past studies investigated HCI to support the design of technology systems, where key applications have focused on office work and desktop PCs, domestic appliances, devices and systems for leisure, the web, mobile devices, user interfaces for databases, information visualisation, etc. (Dix, 2009; Rogers, 2004). The quality of this interaction can be evaluated through laboratory experiments and field studies, thus where the users would normally interact with the technology in question (Dix, 2009; Kjeldskov and Graham, 2003; Papagiannidis et al., 2017), allowing researchers to reflect on a given interface to inform system building and design decisions to optimize interaction (Willems et al, 2017).

Consumers' acceptance of, and interaction with, technology devices in physical and online environments has received greater attention due to the growing adoption of technologies by consumer-oriented businesses across their points of touch with the consumer to enhance customer experience and increase competitiveness (Bonetti and Perry, 2017; Pizzi et al, 2019; Wiertz and De Ruyter, 2007). Several studies have focused on the interaction with mobile applications including social media whilst shopping and their impact on consumer perception and behaviour (Pantano and Gandini, 2017; Chen et al, 2019; Vazquez et al, 2017). Others have explored consumers' acceptance and interaction with technologies in physical retail settings, ranging from the consumers' mobile devices (Pantano and Priporas, 2016) to smart technologies in retail settings (Priporas et al, 2017; Grewal et al, 2020). Other scholars have investigated consumers' interaction with

commercial online communities (Wiertz and De Ruyter, 2007; Hammond, 2000; Burnett, 2000).

In a moment in time in which businesses are increasingly adopting innovative technologies to deliver new experiences to inspire and influence consumer behaviour (Grewal et al, 2020; Bonetti et al, 2019b), research on human- (or consumer-) computer interaction with innovative technologies in physical and online environments has expanded in recent years. Concerning AR technologies, Bonetti et al.'s (2019a; 2019b) exploratory study investigated consumers' interactions with immersive technologies in physical retail settings. Their results showed that consumers overall perceive interaction with the enhanced, more immersive store to be realistic; hedonic motivations emerged as drivers for interaction in the shopping environment enhanced with AR technologies; the augmented store appeared to stimulate brand engagement, increasing consumers' desire to shop at the retailer. However, there were few participants who felt the enhanced store needed a better and easier way to interact with products and products showcase. Within VR studies, Lombart et al (2019) investigated consumers' perceptions and purchase behaviour toward abnormal fruits and vegetables in an immersive VR grocery store. They found that consumers tend to purchase a similar number of products whatever their level of deformity; consumers' perceptions of the appearance and quality of the products depend on the degree of abnormality. Benbunan-Fich (2020) investigated users' satisfaction with interacting with wearable technologies. Findings indicated that the level of satisfaction depends on the interaction's quality and the degree of digitizing the physical activity; digitalization of the physical activity emerged to have different effects for different users. While some found data availability useful in general regardless of the level of accuracy, those looking for accurate data did not find this useful. Overall, the system's actual performance influences the users' judgements thus impacting on their degree of interaction with the wearable technology.

Dehghani et al. (2020) investigated the potential applications of windows MR (WMR) devices in service retailing, examining various forms of consumer perceptions and behaviours. Results from participants' interaction with holograms and their surroundings revealed that responsiveness of WMR applications interaction depends on user characteristics and on the environment's degree of appeal to the use. Users' perception that they can interact freely and realistically with WMR items emerged to impact on user satisfaction. Looking at chatbots studies, Sands et al

(2020) explored the effect of scripts on service experience and human-chatbots interaction. Findings showed that differences occur in generated effects and interaction dependent on the type of service script employed (education or entertainment); in particular, a significant interaction effect was found for emotion. An entertaining service script emerged to enhance emotion compared to an educational service script. This indicates that chatbot interactions can be tailored (concerning script delivery) to maximize emotion and subsequently consumer purchase intention and satisfaction.

Negative instances of HCI with innovative technologies have emerged too in recent studies. Strong anthropomorphic robot qualities lead users to have overly optimistic expectations about the robot's abilities which may be disappointed. That is, the more realistic a robot features are, the more a user expects it to behave like a real human (Wirtz et al., 2018). This argument is supported by the uncanny valley theory, which posits that the closer an artificial face resembles to a human face, the more it is preferred, up until the point when it is almost undistinguishable from a human's and it begins to look unnatural and creepy (Feldman et al., 2009). Such features can be unsettling and can prevent people from being willing to interact with robots (Tinkwell et al., 2011). Similarly, Gammoh et al. (2018) study on consumer perceptions of avatars in online advertising found that users with less knowledge of avatars were more likely to experience the phenomenon of the "uncanny valley". The authors recommended that retailers should refrain from creating human-like avatars, since AI's hyper-realism could potentially represent a negative factor preventing consumer interaction.

2.2.1 Human-computer interaction with digital avatars

Concerning consumers' interaction with digital humans, Grewal et al (2020) outline that AI can take either digital or robotic forms. The authors provide a conceptual framework of innovative in-store technologies ranking high in social presence which includes avatars. Combining high convenience and high social presence, the authors provide the example of Millie, an intelligent avatar that uses AI and engages as a store greeter, navigator, brand ambassador or personal stylist; the avatar engages consumers in conversation, encouraging them to try on items, offering recommendations and answering their questions. She was perceived as a realistic human avatar, through her appearance, interactivity, and mannerisms (TwentyBN,

2019). An avatar refers to a digital character representing an online user and that the user can interact with and talk to via text and voice chat functions. Although digital avatars have started to become more and more realistic, resembling real humans (i.e., Samsung's 'artificial human' project Neon) and that could be used for business purposes and entertainment, acting as guides, receptionists and more (The Verge, 2020), this cutting-edge technology is still being developed. Studies have been conducted on consumers interacting with avatars (Moon et al, 2013; Keeling and McGoldrick, 2008); however, avatars are not as humanised as digital humans that try to recreate parts of human interaction such as communication and emotional connection to approximate real humans.

Research on users' interaction with digital humans has started to emerge mainly in engineering and computer science contexts (Seymour et al, 2020; Fan et al, 2017; Jones et al, 2015) and the movie industry context (Hetherington and McRae, 2017). However, because the possibility to create digital humans is only just now becoming technically possible, research in this field is still scarce. There is a paucity of research that examines how likely consumers are to interact with digital humans in business settings. To these regards, Wiertz and De Ruyter (2007) defined interaction propensity in an online environment as: "prevailing tendency of an individual to interact with relative strangers (i.e., people they have never met offline [e.g., digital humans in the case of our study]) in an online environment" (p. 21).

From the literature review on consumers' interaction with innovative technologies it emerged that, despite the apparent importance of understanding consumers' likelihood to interact with digital humans, this crucial aspect has, to the best of our knowledge, received no previous research attention. Further research of this area is needed in a moment in time in which there is a growing potential that digital humans may be used by fashion businesses. This leads to the first research question for our study:

RQ1: How likely are consumers to interact with digital humans?

2.3 Factors affecting human-computer interaction

One of the key aspects emerging from the literature on HCI is that several factors may affect consumers' interaction with innovative technologies (Bonetti et al, 2017; 19). For example, research has focused on how consumers' demographics

concerning age influence their different requirements regarding interaction with technology. Research findings showed that younger generations growing up with various types of technologies at their disposal, ranging from personal technologies to technologies in retail settings, are more inclined to interact with technologies (Piotrowicz and Cuthbertson, 2014; Poncin and Mimoun, 2014; Huang and Hsu, 2014). Other demographic factors explored in existing studies concern countries or geographic regions. Pantano et al (2017), for instance, investigated the effect of customer interaction with AR technologies on consumer experience and buying behaviour within the online retail environment when virtually trying on glasses comparing two countries, Germany and Italy. Results across the two countries revealed cross-country similarities as well as dissimilarities. It emerged that aesthetic quality and interactivity as antecedents of perceived ease of use, and response time and quality of information as antecedents of perceived usefulness influence consumers' positive attitude when interacting with the technology in the enhanced e-commerce website, thus improving the online buying decision process.

Other studies have examined different interaction forms, including speech, touch, gestures and text (Dube and Arif, 2019; Karpor and Yusupov, 2018). Foehr and Germelmann (2020) focused on consumer interaction with smart voice-interaction technologies such as smart speakers, exploring how they build and maintain trust in their devices. Findings suggested that on one hand consumers relate their trust to the perceived personality of the technology's voice interface they interact with, on the other, they relate to non-anthropomorphism-based trust paths. Furthermore, important aspects to be considered in HCI concern the type of device used; these can vary from company-owned devices (e.g., self-checkouts, kiosks, digital screens, magic mirrors, robots, AR glasses, VR headsets in retail spaces) to consumer-owned personal devices (e.g., smartphones, smartwatches, tablets, laptops or computers, AR glasses, VR headsets) (Grewal et al, 2020; Bonetti et al, 2019a). Dacko (2016) examined the extent to which interaction with mobile AR apps on consumer-owned smartphones contributes to smart retail settings. The study revealed that user satisfaction is relatively high, and interaction with the technology provides experiential shopping benefits, including more efficient or better value shopping, more entertaining and visually appealing shopping, and the technology is believed to provide more complete product information, thus it is seen as influencing consumer behaviour.

Having identified these crucial factors affecting consumers' interaction with innovative technologies, it is important to consider them when investigating consumers' interaction with digital humans. These aspects have an important impact on businesses and customer experience since consumers strongly differ in terms of demographics, forms of interaction with technologies and devices used. Therefore, substantive research questions concern how such factors might affect consumers' interaction with digital humans. This leads to the following research questions:

RQ2. What is a consumer's most preferred form of interacting with digital humans?

RQ3. Which personal devices would consumers prefer for interacting with digital humans?

RQ4. How do the above preferences vary across consumer demographics?

3. Methodology

3.1 Research design

This research subscribes to a positivist philosophy (Creswell and Creswell, 2018) and a deductive approach via a mono-method quantitative methodology. A survey strategy was adopted with a questionnaire as the primary data collection tool. This approach in line with the practice in related previous studies such as Wiertz and De Ruyter (2007), Pizzi et al. (2019), Chen et al. (2019), Huang and Usu (2014), Lombart et al. (2019), Pantano et al. (2017) and Vasquez et al. (2017).

3.2 Survey design

The survey was made up of 14 questions including 6 demographic questions, 1 single-answer multiple choice question and several construct-based questions for measuring consumer propensity to interact with digital humans using 7-point Likert scales (1 – strongly disagree, 7 – strongly agree). Friedman and Amoo (1999) regard 7-point scales as highly reliable in comparison to 5-point scales with further evidence in recent studies relying on 7-point Likert scales (see, for example, Donnelly et al., 2020; Chen et al., 2019). The demographic questions covered the respondent's age,

country of residence, gender, employment status, income and current primary mobile device.

The survey was carefully designed to ensure respondents had a clear understanding of the concept of a digital human. This was achieved by presenting the definition of a digital human and a video of a Samsung Galaxy marketing campaign #DoWhatYouCant which utilised a digital human instead of a real human, as an example.

3.3 Measurements

We adapted Wiertz and de Ruyter's (2007) online interaction propensity scale as a proxy for propensity to interact with digital humans. As the original scale was developed for measuring online interaction propensity, we consulted experts at the Fashion Innovation Agency at London College of Fashion on the adapted scale to ensure it was relevant in the context of digital humans. They confirmed appropriateness of the scale for the issues investigated. The adapted scale included the following items: "In general, I would like to get involved in discussions with a digital human" (IDH1), "I am someone who would enjoy interacting with a like-minded digital human" (IDH2), "I am someone who would like to actively participate in a discussion with a digital human" (IDH3), and "In general, I would thoroughly enjoy exchanging ideas with a digital human" (IDH4). Moreover, we also investigated how consumers prefer to interact with digital humans, i.e., via speech, text or gestures.

3.4 Participants

Convenience sampling was used for data collection due to the lack of access to a sampling frame (Creswell and Creswell, 2018; Berenson et al., 2011). The use of non-probability sampling for quantitative research is common (Donnelley et al., 2020; Onwuegbuzie and Collins, 2007). Given our interest in finding results applicable to the wider fashion industry, it was important to keep the target population open-ended. The survey was posted through various social media channels including Facebook, Twitter, LinkedIn and Instagram.

3.5 Data analysis

The data was analysed using quantitative methods including both descriptive and inferential statistics (Analysis of Variance, T-tests, and Chi-Square Test for

Independence/Fisher's Exact test). Dispersion in Likert scale responses was measured using a statistic known as consensus which is built on Shannon Entropy (Tastle and Wierman, 2007; Shannon, 1948). Tastle and Wierman note that a complete lack of consensus (agreement) generates a value of 0, and a complete consensus yields a value of 1, and that consensus ($Cns(X)$) can be measured as:

$$Cns(X) = 1 + \sum_{i=1}^{n} p_i \log_2(1 - \frac{|X_i - \mu_x|}{d_x}),$$

where p_i is the probability of the outcome X_i (which ranges from 1-7 in this study), *n* is the number of categories being investigated, μ_x is the mean of X, and d_x is the width of X, $d_x = X_{max} - X_{min}$.

The reliability and validity of the survey were evaluated using several measures. First, piloting was carried out to ensure the survey questions were clear and understood by respondents. Secondly, the scale for propensity to interact with digital humans was adapted through existing literature. Thirdly, internal reliability was assessed following the final data collection via the use of Cronbach's alpha which indicated a high level of internal reliability (4 items; α = 0.95).

4. Findings and Analysis

4.1 Sample Demographics

The survey recorded responses from 357 individuals from 39 countries across the globe. First, the respondents were categorized into 4 main regions (see, Table 1) to ensure more statistically reliable findings. Table 2 presents a snapshot of the demographics underlying the sample.

Table 1. Classification of countries into regions.

Region	Countries
EMEA	Albania, Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Netherlands, Norway, Poland, Portugal, Romania, Slovenia, South Africa, Spain, Sweden Switzerland, and United Arab Emirates.
UK & Northern Ireland	United Kingdom
Americas	United States of America, Mexico, Canada, Chile, and Ecuador.
Asia Pacific	Sri Lanka, Australia, New Zealand, Armenia, India, Japan, Israel, and South Korea.

The sample was approximately equally split between gender with 50.1% males, 48.7% females and 1.2% who preferred not to be identified as male or female. Majority of the respondents were 18-24 years old (42.9%) whilst the second largest age category was 25-34 years old (38.7%). Most of the sample responses were recorded from people in the EMEA region (45.4%) whilst UK (24.1%), Americas (21.3%) and Asia Pacific (9.2%) followed in that order. The distribution of income was skewed with very few people (5.3%) earning £70,000 or more and 81.2% of the sample earning up to £39,000 or less. Majority of the respondents were employed (49.3%) with students (35.3%) forming the next largest group within the employment category. In line with global trends (Kantar Worldpanel, 2020) the most popular personal device, in terms of ownership, was an Android smartphone (61.1%) followed by iOS (38.9%).

Table 2. Summary of demographics

Demographic	Freq.	%	Demographic	Freq.	%
Gender			**Age**		
Male	174	50.1	18-24 Years Old	153	42.9
Female	179	48.7	25-34 Years Old	138	38.7
Other	4	1.2	35-44 Years Old	66	18.5
Regions			**Income**		
Americas	76	21.3	Less than £10,000	149	41.7
Asia Pacific	33	9.2	£10,000-£39,000	141	39.5
EMEA	162	45.4	£40,000-£69,000	48	13.4
UK & Northern Ireland	86	24.1	£70,000 or more	19	5.3
Employment Status			**Mobile Device Owned**		
Employed	176	49.3	Android	218	61.1
Students	126	35.3	iOS	139	38.9
Other	55	15.4			

Note: Freq. refers to the frequency. % shows the frequency as a percentage of the total.

4.2 Descriptive Statistics

Table 3 presents the descriptive statistics for the indicators measuring propensity to interact with digital humans. Across all indicators, at least more than 62% of respondents either somewhat agree, agree, or strongly agree that they are likely to interact with a digital human. This finding aligns with the modal responses which are also indicative of most respondents either agreeing or strongly agreeing that they would like to interact with digital humans. The consensus statistic ($Cns(X) = 0.56$) indicates that there is neither a complete lack of consensus in terms of attitudes towards interacting with digital humans nor a complete consensus across all

indicators. The fact that consensus is closer to 1 than 0 indicates these results are closer to complete agreement rather than complete disagreement. However, higher consensus values would be preferred.

As the indicators for measuring the propensity to interact with digital humans was found to be highly reliable based on Cronbach's alpha, we computed a combined scale for the propensity to interact with digital humans by averaging across the constructs (*M=4.71, SD = 1.54)*. Accordingly, on average, the propensity to interact with digital humans was rated closer towards somewhat agree rather than neutral. Thus, based on descriptive statistics, it appears that consumers are likely to interact with digital humans.

Table 3. Descriptive statistics for the indicators.

	%	%	%	%	%	%	%	M	Mode	$Cns(X)$
Indicator	**1**	**2**	**3**	**4**	**5**	**6**	**7**			
IDH1	5.6	7.8	8.4	11.2	29.7	24.9	12.3	4.76	5	0.56
IDH2	5.0	7.3	8.1	15.7	27.2	25.8	10.9	4.74	5	0.56
IDH3	6.2	8.7	9.0	11.8	28.9	24.9	10.6	4.66	5	0.56
IDH4	5.0	9.5	7.3	16.0	24.4	28.0	9.8	4.68	6	0.56

Note: M refers to the mean. The % columns show the frequency percentage. 1 – strongly disagree, 2 – disagree, 3 – somewhat disagree, 4 – neutral, 5 – somewhat agree, 6 – agree, 7 – strongly agree.

4.3 Inferential Statistics

First, we use a one sample T-test to determine whether the average responses for the propensity to interact with digital humans is significantly different from the neutral point *(M=4)* on the scale. Based on the findings, the consumers average propensity to interact with digital humans (*M=4.71, SD=1.54)* was significantly different from them having a neutral opinion, $t(356) = 8.943, p \leq 0.01$. Accordingly, in response to RQ1, we can conclude with 99% confidence that on average, consumers are significantly more likely to interact with a digital human than remain neutral or otherwise. This indicates that fashion businesses seeking to invest in digital human led solutions could consider it as a feasible option as there is evidence of consumers' willingness to interact.

Next, in line with RQ4, we seek to determine how the propensity to interact with digital humans may vary significantly across demographic factors. Table 4 below summarises these findings.

Table 4. The propensity to interact with digital humans based on demographics.

Demographic	M	SD	Demographic	M	SD
Gender			**Age**		
Male	4.94	1.47	18-24 Years Old	4.83	1.50
Female	4.46	1.58	25-34 Years Old	4.74	1.51
Other[x]	5.50	1.19	35-44 Years Old	4.36	1.66
Regions			**Income**		
Americas	5.18	1.28	Less than £10,000	4.64	1.58
Asia Pacific	4.62	1.67	£10,000-£39,000	4.83	1.43
EMEA	4.69	1.56	£40,000-£69,000	4.52	1.69
UK & Northern Ireland	4.36	1.57	£70,000 or more	4.80	1.59
Employment Status			**Mobile Device Owned**		
Employed	4.65	1.48	Android	4.74	1.56
Students	4.87	1.49	iOS	4.66	1.52
Other	4.54	1.81			

Note: *M is the mean. SD is the standard deviation. We use the SD in this table as the statistical tests used here consider the M and SD of data.* [x] indicates only 4 respondents belong to this category.

In terms of gender and the distribution of responses, we find that males (*M=4.94, SD=1.47*) are significantly more likely to interact with digital humans than females (*M=4.46, SD=1.58*) based on an ANOVA ([*F(2,354) = 4.967, p=0.007*]) and post hoc comparisons using a Tukey HSD test. However, it is important to note that all groups within gender have demonstrated positive attitudes towards interacting with digital humans. Thus, the findings indicate that males are significantly more positive towards their intention to interact with digital humans than their female counterparts. When comparing responses based on regions, we find statistically significant differences between the responses from people in the Americas with those from the EMEA and UK based on an ANOVA ([*F(3,353) = 4.021, p=0.008*]). Accordingly, post hoc comparisons using the Tukey HSD test confirmed that those from the Americas region are significantly more likely to interact with digital humans than those from the EMEA or the UK. These findings indicate that fashion brands planning on launching digital human-based solutions can expect far greater engagement from consumers in the Americas region than from those within the EMEA or the UK regions. A different marketing approach would be required to target and convince consumers in the EMEA or the UK. Concerning age, employment status, income categories, and mobile device owned (based on ANOVA or two-sample T-tests as relevant) we do not find evidence of any statistically significant differences between the respondent's propensity to interact with digital humans.

Accordingly, we conclude that gender and regions are the two most vital demographic factors to consider in relation to consumers propensity to interact with digital humans.

As there was sufficient evidence to conclude that consumers are likely to interact with digital humans, next, we analyse consumer preferences in terms of how they would like to interact with digital humans (RQ2). Table 5 presents some descriptive statistics. Based on a frequency analysis (not reported here), 51.5% of respondents rated the importance of speech interaction above neutral on the scale whilst the importance of text interaction was rated higher at 57.4% and lower for gestures at 46.5%. The results in Table 5 indicate that consumers would prefer if digital human led solutions allow for interaction using speech, text, and gestures. Whilst this would be the most inclusive way forward, given the complexities of programming such capabilities, it is possible that developers are not able to provide all three solutions at the expected standard initially.

Therefore, we went a step further and sought to determine the most preferred form of interaction by confronting respondents with the ability of selecting only one of the three interaction options. This was to enable stakeholders to determine the most important interaction feature they should focus on during launch. The findings showed that 51.5% selected speech as the most important, followed by text and gestures (Figure 1). In general, if confronted with only one form of interaction with digital humans, then the most preferred form of interaction with digital humans is via speech whilst the least preferred form of interaction is via gestures. It is vital that fashion brands ensure the speech interaction is at a very high standard.

Table 5. Descriptive statistics for consumer attitudes towards different forms of interaction with digital humans.

Indicator	**M**	**Mode**	$\boldsymbol{Cns(X)}$
The ability to talk and converse with a digital human is important to me (speech interaction)	4.30	6	0.56
The ability to type commands into a keypad and interact with a digital human is important to me (text interaction)	4.53	5	0.55
The ability to use gestures to communicate with a digital human is important to me	4.10	5	0.55

***Note**: 7-point Likert scales were used where 1 = strongly disagree and 7= strongly agree.*

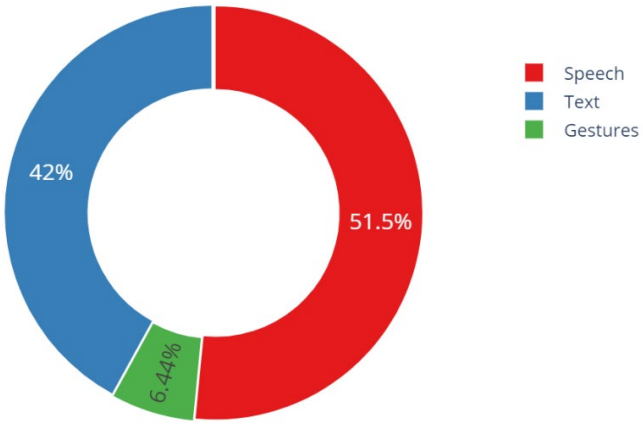

Figure 1. Distribution of most preferred forms of interaction with a digital human.

We also tested the most preferred forms of interaction with digital humans for statistically significant associations with the demographic variables using a Chi-Square test for independence. We found evidence for a statistically significant association between employment status and preferred forms of interaction based on a Chi-Square test ($\chi^2(4, N = 357) = 9.756, p = 0.04$). Accordingly, we find that majority of consumers who are students (49.2%) or employed (56.3%) are significantly associated with their preference for speech whilst majority of respondents in the other category (49.1%) prefers text interaction. Once fashion brands succeed in developing all three forms of interaction capabilities, these findings can help them with targeting consumers with more personalised adverts. Interestingly, out of all consumers who preferred gestures, the majority were students (56.5%). Furthermore, income categories are significantly associated with most preferred forms of interaction based on a Fisher's Exact test (p=0.09). These results show that more than 50% of respondents earning £10,000 or more associate themselves with speech as the most preferred form of interaction whilst those earning less than £10,000 have an almost identical preference between speech and text. These results can be associated with the fact that speech interaction is faster than text (Carey, 2016) and therefore saves time for those with busy work schedules.

Finally, we go a step further and analyse which personal devices consumers would prefer to use to interact with digital humans (RQ3). Respondents were able to choose multiple options between five different devices. Figure 2 summarises the consumers preferred personal device for interacting with digital humans. In total, 717 options were selected by 357 respondents. Thus, on average, it appears that each respondent prefers to use at least two devices to interact with digital humans.

However, the most popular device is a smartphone whilst the least popular device is a smartwatch.

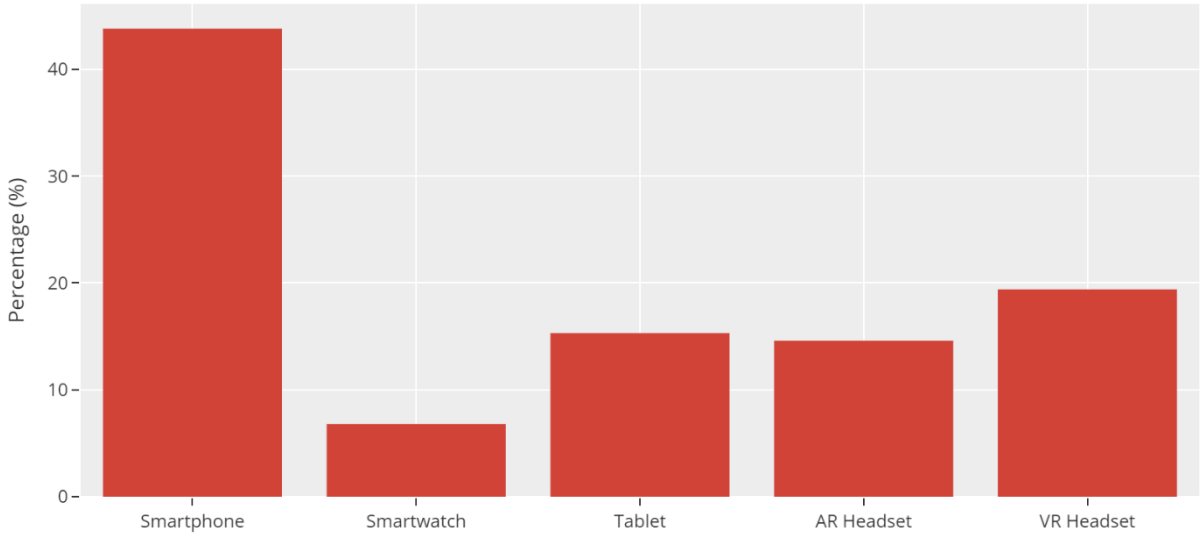

Figure 2. Consumers preferred personal devices for interacting with digital humans.

We analysed these choices further by demographics using a Chi-Square test for independence. This indicated the existence of statistically significant associations between preferred personal devices, and regions (χ^2(15, *N*=357) = 31.850, *p*=0.007), income levels (χ^2(15, *N*=357) = 24.283, *p*=0.06), and type of personal device currently owned (χ^2(15, *N*=357) = 15.880, *p*=0.007). The results in Tables 6-8 show that within regions, the Americas and UK have a similar structure in terms of the popularity of preferred devices for interacting with digital humans. Also, the VR Headset is the second most popular form of interaction in the Americas, EMEA and UK. Interestingly, 53.1% of the 49 respondents who wish to use a Smartwatch were from the EMEA region. Out of all who preferred Tablets as a form of interaction, 40% were from the EMEA region and 30% from the Americas regions. In comparison, AR and VR headsets are comparatively more popular in the EMEA region. Also, Android users prefer VR and AR headsets most after smartphones for interacting with digital humans. Furthermore, regardless of income levels, regions or the current type of mobile phone used, smartphones continue to remain the most popular device consumers wish to use to interact with digital humans whilst smartwatches were the least popular option.

Table 6. Ranking of consumers' preferred devices for IDH by region.

Rank	Americas	Asia Pacific	EMEA	UK

1	Smartphone	Smartphone	Smartphone	Smartphone
2	VR Headset	AR Headset	VR Headset	VR Headset
3	Tablet	Tablet | VR Headset	AR Headset	Tablet
4	AR Headset	NA	Tablet	AR Headset
5	Smartwatch	Smartwatch	Smartwatch	Smartwatch

Table 7. Ranking of consumers' preferred devices for IDH based on income levels.

Rank	Less than £10,000	£10,000-£39,000	£40,000-£69,000	£70,000 and more
1	Smartphone	Smartphone	Smartphone	Smartphone
2	VR Headset	VR Headset	VR Headset = AR Headset	Tablet
3	AR Headset	Tablet	NA	VR Headset
4	Tablet	AR Headset	Tablet	AR Headset
5	Smartwatch	Smartwatch	Smartwatch	Smartwatch

Table 8. Ranking of consumers' preferred devices for IDH based on personal device owned.

Rank	Android	iOS
1	Smartphone	Smartphone
2	VR Headset	Tablet
3	AR Headset	VR Headset
4	Tablet	AR Headset
5	Smartwatch	Smartwatch

5. Discussion

Our study was motivated by the need to understand consumers' likelihood to interact with digital humans. Furthermore, we explored several factors that may affect consumers' interaction with digital humans, in terms of demographics, forms of interaction with technologies and devices used (Bonetti et al, 2017; 19; Poncin and Mimoun, 2014; Huang and Hsu, 2014; Pantano et al, 2017; Karpor and Yusupov, 2018; Dacko, 2016). In addressing these issues, we have examined important aspects of this innovative form of technology, and strategic opportunities and implications for businesses have emerged. Our findings highlight key points derived from a broad and varied sample of potential consumers as users of digital human technology, and across a broad set of forms of interaction and personal devices. We reveal how consumers' interaction with digital humans may change the way businesses interact with consumers, in terms of sales channels and communication channels, which may have implications for the future of several academic disciplines and their practice. Building on the explanatory findings, the following section provides an evaluative discussion of the findings, guided by the research questions that informed the study.

Our findings across a broad and varied sample of participants indicated consumers' likelihood and propensity to interact with digital humans. In the case of

this specific technology which ranks high in social presence, concerning intelligence traits in engaging and interacting with users as a possible brand ambassador or personal stylist (e.g., offering recommendations on items and answering questions), having humanized aspects is key to make digital humans socially acceptable (Grewal et al, 2020; Carmigniani et al, 2011). Moreover, this contributes to making the interaction informative as well as entertaining (Bonetti et al, 2019a, 2019b; Dacko, 2016); this is in line with previous studies showing both hedonic and utilitarian motivations for interacting with digital avatars (Grewal et al, 2020). These were key aspects of the findings, to achieve consumers' likelihood and propensity to interact with digital humans.

Furthermore, another important point that requires attention is that the interaction modality between human and technology needs to be as much realistic as possible (Bonetti et al, 2019a, 2019b; Carmigniani et al., 2011). Our findings showed that participants' most preferred form of interaction with digital humans is via speech, whilst the least preferred form of interaction is via gestures. This is related to the fact that voice-interaction technologies are characterized by immediacy and ease of use, and these are forms of technology currently adopted and used by consumers in their everyday lives (Foehr and Germelmann, 2020; Karpor and Yusupov, 2018). Therefore, these traits contribute to making this way of interacting with the technology realistic and intuitive, thus contributing to consumers' acceptance of, and interaction with, the technology. Still of relevance to this aspect is consumers' preference of personal devices to interact with digital humans; here, smartphones emerged to be the most popular device consumers wish to use to interact with digital humans, whilst smartwatches were the least popular. This is related to consumers most wildly adopted forms of personal devices (i.e., smartphones) and to aspects of the device concerning the size of screen and interaction modalities, where visibility and colours play an important role for the presentation of digital humans and interaction with it, thus contributing to making the experience realistic (Bonetti et al, 2019a, 2019b).

Finally, our findings revealed the impact of demographic factors on consumers' likelihood to interact with digital humans. Concerning gender, findings showed that males are significantly more likely to interact with digital humans than females. Concerning regions, respondents from the Americas region are significantly more likely to interact with digital humans than those from the EMEA or the UK. This

indicates that gender and geographic regions play a key role on consumers' likelihood to interact with digital humans; this is in line with existing studies indicating that these factors affect consumers' acceptance and interaction with innovative technologies (Bonetti et al, 2017; 19; Pantano et al, 2017). However, differently from existing studies indicating that consumers' demographics concerning age influence their different requirements regarding interaction with technology (Piotrowicz and Cuthbertson, 2014; Poncin and Mimoun, 2014; Huang and Hsu, 2014), our findings revealed that age does not influence respondent's propensity to interact with digital humans. This emerged being the case also with employment status, mobile device owned and income categories. Differently from this, when analysing the impact of consumer demographics on how they would like to interact with digital humans, employment status and income categories emerged to play a key role; concerning consumers' preferences of personal devices to interact with digital humans, geographic regions had a strong influence on these aspects. These findings, therefore, have key implications for technology developers, designers and marketers of digital humans, and for fashion businesses considering adopting them.

6. Conclusions, Contributions and Future Research

Our findings highlighted that consumers' responses to forms of digital humans have potentially serious consequences for how fashion business is practised and for several academic disciplines. In a period when fashion businesses need to make important decisions to survive in response to increasing competition and changing market trends, especially post COVID-19, our findings can help make important decisions concerning the investment in digital human-based solutions. This study contributes to academics and practitioners with greater knowledge and understanding of pressing issues for successful futures and innovation of businesses.

6.1 Theoretical Contributions and Managerial Implications

We contribute to the existing literature in multiple ways. First, our study extends the existing literature on innovation with technology in business (Bonetti et al, 2017, 2019; Grewal et al, 2020; Pizzi et al, 2019) to the specific case of digital humans as innovative consumer-facing technologies, by providing knowledge on consumers' propensity to interact with digital humans considering key factors of influence. These

include demographic factors, forms of interaction, consumers' personal devices for interaction, and key traits of digital humans.

Second, we contribute to the existing literature on HCI (Rogers, 2004) by extending existing research on a generic user's interaction with technology by way of examining consumers' interaction with technology (consumer-computer interaction or CCI). Thus, we contribute to the literature on CCI with innovative technologies where research has recently started to grow (Bonetti et al., 2019a, 2019b; Lombart et al., 2019; Benbunan-Fich, 2020; Sands et al, 2020). We contribute to the specific field of CCI by focusing on digital humans as a form of innovative technology, where research in the business setting is still limited. This extends previous research on a generic user's interaction with digital humans in engineering and computer science contexts (Seymour et al, 2020; Fan et al, 2017; Jones et al, 2015) and the movie industry context (Hetherington and McRae, 2017), by examining consumers' likelihood to interact with digital humans.

Thirdly, we go a step further with descriptive statistics and inferential statistics and explore preferences concerning consumers' attitudes towards different forms of interaction with digital humans and personal devices for interaction. We then investigate how demographic factors influence consumers' propensity to interact with digital humans, how they influence forms of interaction, and how they influence choice of personal device for interaction. This further extends existing research on the factors affecting HCI and more precisely CCI (Bonetti et al., 2017; 19; Pantano et al, 2017; Piotrowicz and Cuthbertson, 2014; Poncin and Mimoun, 2014; Huang and Hsu, 2014) by focusing on CCI with digital humans.

In terms of industry implications, our research findings unveil positive consumer attitudes towards interacting with digital humans, and how several factors impact on that. This provides business stakeholders with new perspectives and statistically significant insights on a specific new technology to be adopted, integrated and marketed within their practices, thus also providing details on how to implement the new technology. For example, from a design perspective, stakeholders should give priority to developing quality speech and text forms of interaction, designing interactive software for smartphones. Likewise, examples of insights for the marketing perspective could be the need to tailor marketing activities to engage more females, 35-44-year-olds and consumers in the UK who are less likely to interact with digital humans. Also, the insights indicating the easiest market

to penetrate (e.g., 18-24-year-olds in the Americas) and that consumers with Android devices are more likely to want to interact with digital humans using VR and AR headsets can also be beneficial. These insights are particularly relevant in the current circumstances of changing consumer behaviour and propensity towards online forms of interaction (both social and commercial) due to the rapidly evolving technological and business landscape. Businesses willing to further engage with customers by enhancing their service and experience provision across channels of interaction should, therefore, consider these types of innovative technologies to stay competitive in a constantly evolving marketplace, especially post COVID-19.

6.2 Limitations and Future Research

The study also has some limitations. The inability to access a sampling frame resulted in us having to rely on non-probability sampling for this research. However, we sought to obtain a representative sample to the best of our ability. The use of digital humans is not widespread practice at present. Thus, most participants have not experienced digital humans in person and had to rely on our varied efforts using multimedia to showcase the experience offered by digital humans. This could have potentially impacted the responses within.

The volatile period of social, technological and economic change continues to have a significant impact on how fashion businesses can engage and interact with consumers. This has important repercussions on several academic disciplines and their practice. Therefore, further research is needed in this area. Below we outline topics and important issues for future research, cutting across academic disciplines including - but not limited to - retailing, marketing, strategic management, HCI (see Table 9).

Table 9. Summary of important issues worthy of further research.

Topic	**Important areas for future research**
Trust in digital humans	• Exploring consumer trust in digital humans, and the degree to which consumers' attitudes and perceptions towards digital humans might change over time after introducing digital humans. • Assessing factors influencing the adoption of digital human-based products.

User characteristics	• Examining key characteristics of consumers that may have a key impact on the perception and attitudes towards digital humans. • Investigating how the above might change over time after introducing digital humans.
Sustainability in fashion industry	• Investigating consumer attitudes and perceptions on the sustainability aspects of digital humans and digital clothing in fashion. • Researching to what extent digital humans and digital clothing can promote sustainable consumption.
User experience satisfaction	• Measuring user experience satisfaction when assisted by a digital human (including e.g., advice provided; degree of personalisation; user goals; a priori expectations, etc.)
Branding and user satisfaction	• Assessing user perception of degree of alignment between digital human and the brand it represents. • Assessing the influence of user initial perception of a brand on user expectation of features of digital human employed by the brand (e.g. positive/ negative perception).
Strategic management	• Investigating strategic reasons for businesses' use of digital humans (e.g., experiential; operational; brand identity). • Analysing multiple key internal and external factors to fashion businesses influencing their adoption of digital humans. • Measuring the impact of digital human adoption on firm performance. • Assessing whether changes in designed experience by introducing digital humans might alienate core customer groups (and if so, under which circumstances and in what ways).

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