

Consumer interaction with cutting-edge technologies:

Implications for future research

Abstract

This article provides an overview of extant literature addressing consumer interaction with cutting-edge technologies. Six focal cutting-edge technologies are identified: artificial intelligence, augmented reality, virtual reality, wearable technology, robotics and big data analytics. Our analysis shows research on consumer interaction with cutting-edge technologies is at a nascent stage, and there are several gaps requiring attention. To further advance knowledge, our article offers avenues for future interdisciplinary research addressing implications of consumer interaction with cutting-edge technologies. More specifically, we propose six main areas for future research namely: rethinking consumer behaviour models, identifying behavioural differences among different generations of consumers, understanding how consumers interact with automated services, ethics, privacy and the blackbox, consumer security concerns and consumer interaction with new-age technologies during and after a major global crisis such as the COVID-19 pandemic.

Keywords: Consumer interaction; cutting-edge technologies; artificial intelligence; virtual reality and augmented reality; robotics; wearable technology; big data analytics

1. Introduction

The emergence of cutting-edge technologies has revolutionised industries, transformed customer experiences and spurred academic interest. Techopedia (2019) defines *cutting-edge technology* as “technological devices, techniques or achievements that employ the most current and high-level IT developments; in other words, technology at the frontiers of knowledge”. In the customer experience and marketing literatures, cutting edge technologies are also referred to as new age (e.g. Kumar, Ramachandran & Kumar, 2020) and emerging (e.g. Krafft, Sajtos & Haenlein, 2020) technologies. These new technologies are interrelated, and Gartner (2020) Hype Cycle for Emerging Technologies identifies a succinct set of 30 emerging technologies and trends that will have significant impact on business, society and people over the next five to ten years. However, examining the relevance and implications of the entire set of emerging technologies and trends are beyond the scope of this article and instead we focus on customer-oriented technologies. In particular, throughout the rest of this paper, we use the terms “cutting-edge”, “emerging” and “new age” technologies interchangeably to refer to six noteworthy technologies that are dramatically transforming the customer experience: artificial intelligence (AI), augmented reality (AR), virtual reality (VR), wearable technology, robots and big data analytics (BDA).

New technologies had profound effects on the practice of marketing (Grewal et al., 2020a). They are revolutionising the way customers interact with companies. For example, cutting-edge technologies have enabled consumers to enjoy a more targeted, personalised, enjoyable and efficient experience (Papagiannidis et al., 2017). In addition, emerging technologies have the power to analyse and process huge amounts of data, including information on human behaviour and emotions, from different sources, with the aim of delivering meaningful

customer experiences (Kathayat, 2018). Despite recent investigations addressing consumers' acceptance and adoption of new age technologies (e.g. Manis & Choi, 2019; Pizzi, Vannucci & Aiello, 2019), studies on consumer interaction and engagement with these technologies remains scarce. In particular, to advance theory and knowledge, interdisciplinary research is needed at the intersection of information systems (IS) and marketing. Accordingly, in this article we (i) provide an overview of research on consumer interaction with cutting-edge technologies; and ii) identify directions for future interdisciplinary research. The next section explores prior consumer research that have studied artificial intelligence (AI), augmented reality (AR), virtual reality (VR), wearable technology, robots and big data analytics (BDA). Next, we identify directions for future research with the aim of advancing our knowledge of new-age technologies.

2. Overview of consumer research on cutting-edge technologies

2.1 Artificial intelligence

In the most widely accepted definition, Brooks (1991) notes that “artificial intelligence is intended to make computers do things, that when done by people, are described as having indicated intelligence.” AI has the capability of imitating humans, carrying out tasks in an ‘intelligent’ way (Kumar et al., 2020) and encompass emotions, self-awareness, reasoning, creativity, logic and critical thinking (De Bruyn et al., 2020). Humanised AI can potentially combine cognitive, emotional and social intelligence (Kaplan & Haenlein, 2019). AI is impacting on the management of customer relationships and the practice of marketing in general (Libai et al. 2020). For example, predictive analytics applications can be deployed to analyse customers' current and future behaviour, personalise the service offering and recommend products to consumers (Zaki, 2019; Borges et al., 2020; Ameen et al., 2021a). For

Kumar et al. (2016), AI-enabled recommendation agents can provide insights into how customer behave, enhance customer experiences, improve increase satisfaction and loyalty by offering superior customised products and services.

Recent research focusses on analysing the impact of different types of AI-enabled technologies on various aspects of consumer behaviour such as engagement, satisfaction and enjoyment. For example, Prentice and Nguyen (2020) compared humanic service experience and automated AI customer service and found no differences in terms of consumer engagement and loyalty. Brill et al. (2019) found that customers are satisfied with artificial intelligence applications. In their study of children's interactions with AI-enabled voice assistants, such as Amazon's Alexa and Apple's Siri, Aeschlimann et al. (2020) conclude that differences exist in information-sharing among children when they interact with human versus AI-enabled voice assistants. Pizzi et al. (2019) further identify a significant relationship between digital assistants' analytical skills and customer interaction. Rese et al. (2020) show that both utilitarian and hedonic factors have significant positive effects on the acceptance of the text-based "Emma" chatbot used in fashion retailing and integrated into Facebook Messenger.

Despite the current and potential uses and benefits of AI, some issues in relation to the AI-human interaction, given its complexity, remain underexplored. For example, the lack of human intervention can affect emotions associated with AI-enabled customer experience, whether they are positive, negative or mixed. Customer autonomy is another issue associated with AI. For example, during the use of chatbots or when receiving product recommendations based on AI analytics, consumers have limited control of the situation. In addition, De Bruyn et al. (2020) note that many challenges still exist, for example, marketing ethics and issues associated with the "blackbox" nature of AI as it remains impervious of knowledge transfer.

2.2 Virtual reality and augmented reality

VR is an entirely synthetic environment, which may or may not mimic the real world, providing an immersive experience (Loureiro et al., 2019). Research highlights how VR can be used to transform customer experiences through vividness and interactivity (Loureiro et al., 2019). The immersion associated with VR technology allows users to better focus on their experience and expand their perception of time, leading to higher satisfaction levels (Rudd, Vohs, & Aaker, 2012). Recent studies show an emphasis on understanding the effects of VR experiences on consumer/user behaviour such as emotional reactions. For example, Martínez-Navarro et al. (2019) reveal that emotions experienced in a virtual store affect customers' sense of presence. Pizzi et al. (2019) demonstrate that a virtual store brand experience, using VR, allows customers to feel a higher level of presence in comparison to the physical store experience.

Jung et al. (2019) further explore how virtual experiences shape customer behaviour. Virtual experiences characterised in terms of positive feelings of joy, excitement, freedom and escape from social hierarchies help consumers to feel empowered in a VR environment. Kang, Shin and Ponto (2020) note that 3D VR stores experience can be made stylish and attractive to successfully influence consumer decision-making. The immersive effects of VR, according to Meißner et al. (2020), can significantly affect customers' choices in three ways: variety-seeking, price-sensitivity and satisfaction with the choice made. VR can also assist shoppers suffering from negative feelings of crowding in shopping malls. Van Kerrebroeck, Brengman and Willems (2017) explains that the content and length of the VR experience can be adapted in accordance to shoppers' state of mind. While VR has witnessed extensive use in areas such as retailing and tourism, it suffers from limitations that can be addressed by AR technology.

AR is characterised by digital and real content superimposed on users' real surroundings (Flavián et al., 2019). McLean and Wilson (2019) show that, similar to VR, AR can lead to stronger brand engagement and higher levels of satisfaction. In a mixed reality context, customers are present in the real world, with digital content incorporated into their surroundings, and customers have the option of interacting with either the physical (real) or digital content. From a marketing perspective, AR helps to enhance the customer experience, decision-making, and responses (Hilken et al., 2018). Furthermore, AR enable the 'virtual try on' experience, bringing stores and products to customers' homes. For example, Yim et al. (2017) examined consumers' evaluations of AR-based virtual try-on product presentations. Consumers with an unfavourable body image prefer to use AR-based virtual try-on, but no differences were reported among consumers with a favourable body image.

Recent studies (e.g. Tussyadiah, Jung & tom Dieck, 2018; Chylinski et al., 2020) examine various aspects consumers' engagement and interaction with AR such as holograms and glasses. For example, Carrozzi et al. (2019) demonstrate that customising AR-based holograms allows customers to feel a psychological ownership of digital products. AR glasses extend consumers' natural abilities by improving their perceptual skills and experiences (Tussyadiah, Jung & tom Dieck, 2018). Other potential extension of AR is the creation of an AR-based social network as the technology offers opportunities for immersive reality. In general, consumers find AR-based mobile applications easy to use due to their familiarity with smartphones (Goebert & Greenhalgh,2020).

2.3 Robotics

Service robots are defined as “system-based autonomous and adaptable interfaces that interact, communicate and deliver service to an organization’s customers” (Wirtz et al., 2018, p. 909). Various humanoid robots are in use around the world across a number of industries such as retailing, tourism and hospitality. In fact, Grewal et al. (2020b) and Bertacchini et al. (2017) note that robots can transform customer experiences in the retail and service settings. Robotic technologies have extraordinary performance in terms of speed, data storing, and processing capabilities (Xiao & Kumar, 2021) and are programmed to learn from customers using machine learning and big data analytics. Robots increase efficiency, reduce cost as are best deployed for fixed and routine tasks.

One of the main issues surrounding the use and development of robotic technologies is whether robots should look like machines or take anthropomorphised forms (Thomaz et al. 2020). Other concerns, as Xiao & Kumar (2021) note, are the risk and uncertainty when interacting with service robots given the unpredictability of their actions. Hence, trust remains a major challenge, but consumer anthropomorphism (i.e. assigning human traits to robots) increase trust and enjoyment (van Pinxteren et al., 2019). A growing body of research focusses on the human-robot interactions. For example, Piçarra and Giger (2018) identify robots’ warmth, appearance and competence as important factors for better interactions. Yu and Ngan (2019) observe gender and cultural differences in terms of how consumers perceive robot warmth. For Desideri et al. (2019), emotions and trust play critical roles in human-robot relationship.

2.4 Wearable technology

Wearable technologies, such as smart clothing, smart glasses and smart watches, involve embedding sensors and transmission chips into ordinary objects that can be worn on the body

(Jung, Kim & Choi, 2016). Wearables are examples of self-tracking technologies (STT) used to measure and record various aspects of our lives (Al-Emran et al., 2020). The use of wearable technology has been mainly associated with healthcare, and applications in the marketing domain is emerging (Ferreira et al., 2021). For example, Google glasses can embed personalised advertisement (Park & Skoric, 2017). At the same time, adoption of wearables, in the form of health and fitness devices, is on the rise with recent research (e.g. Zakariah et al. 2021) investigating how consumers integrate self-tracking technologies in their daily life. Other studies (e.g. Wu, Wu and Chang (2016) focus on factors determining adoption of wearable technology, with a lack of research addressing issues related to the post adoption stage, for example, long term health benefits of self-tracking daily routines and exercises.

In their study, Gu, Wei and Xu (2016) identify privacy concerns, propensity to trust, performance expectancy, facilitating conditions and hedonic motivation as key determinants of consumer trust in wearable technology. More recent studies (e.g. Salahuddin and Romeo, 2020) focus on customers and developers' expectations of the quality and features of wearable technology. Differences exist between the two groups with developers emphasising material selection, ways of combining electronics with clothing, and battery life, while customers focus on product safety, product functionality, privacy and the security of their personal data. Despite the growth of wearables in consumers daily lives, Ferreira et al. (2021) in their review, note marketers face challenges and argue that positioning should emphasise the perceived utility of the devices. In addition, there are ethical and privacy concerns related to mining, surveillance and tracking of data from consumer wearable devices (Park & Skoric, 2017).

2.5 Big data analytics

Big data refers to “data sets that are so large (terabytes to exabytes), unstructured, and complex (from genome analysis, political science, sensor, social media, or smartphone apps to Internet-based gadgets data) that require advanced and unique technologies to store, manage, analyze, and visualize” (Xu, Frankwick & Ramirez, 2016, p. 1562). Big data consumer analytics has a major influence on the practice of marketing (Erevelles et al., 2016). The deployment of big data analytics (BDA) offer companies unique insights behavioural patterns, transform customer experiences and can be used to predict future behaviour (Chae et al., 2020; Holmlund et al., 2020). Big data analytics capture customers’ emotional, social, sensory and cognitive responses from multiple touchpoints (e.g. social media platforms and online reviews), allowing companies to offer offering personalised experiences to their customers (Anshari et al., 2019; McColl-Kennedy et al., 2019). In addition, BDA is helping companies with smarter marketing decisions in terms of product development, service design and product recommendations (Jagtap & Duong, 2019).

Despite the advantages of BDA, there are still challenges for marketers and researchers to address in terms of data quality, complexity, velocity, heterogeneity, security, privacy and management (Lee, 2017). For example, Eastin et al. (2016) note that advertisers seek to exploit big data gleaned from customers personal mobile devices. Eastin et al. (2016) study reveal that concerns about perceived control and unauthorized access to personal information have a significant negative influence on m-commerce activity (such as compare product prices, research product features, and purchase goods or services online. Moe and Ratchford (2018) explain that obtaining big data is not a problem, but it is still challenging to analyse every consumer interaction in terms of cognitive and hedonic behaviours. In addition, in their review

on big data analytics in the context of social media, Ghani et al. (2019) identify five key issues that remain to be addressed: (1) data quality; (2) data locality; (3) velocity; (4) data availability; and (5) natural language processing. Sheth and Kellstadt (2020), to further advance knowledge, call for additional research in the area of BDA and consumer behaviour to address issues related to text mining, biometric data, video analytics, emoji analytics, pattern recognition and forensic research.

3. Directions for future research

To further advance our understanding of consumer interaction with cutting-edge technologies, we have identified several areas for future research grouped under six categories: rethinking consumer behaviour models; behavioural differences among different generations of consumers; consumer interaction with automated services; ethics, privacy and the black box; consumer security concerns; and consumer interaction with new-age technologies during and after a major global crisis. Table 1 summarises the key questions we propose in relation to each of the six areas we identified for future research.

Table 1. Key avenues for future research on consumer interaction with cutting-edge technologies

Future Research Areas	Key research questions
Rethinking consumer behaviour models	<ul style="list-style-type: none"> ▪ How can loyalty and satisfaction be maintained when consumers use multiple and complex cutting-edge technologies as part of their shopping journey? ▪ What are the precise points of interaction between consumers and cutting-edge technologies that can explain satisfaction and brand loyalty? ▪ Can consumer satisfaction and loyalty be increased when brands integrate wearable technology as part of their marketing strategy? ▪ Can consumer emotional security, self-image and self-confidence be enhanced through interaction with cutting-edge technologies?
Behavioural differences among different generations of consumers	<ul style="list-style-type: none"> ▪ What are the key behavioural differences between millennials and Generation Z consumers during their interaction with cutting-edge technologies? ▪ How can the behaviour of the younger generations (e.g. Generation Z) influence the sequence and order of cutting-edge technologies that brands introduce during the shopping experience? ▪ Are there cross-cultural and cross-national differences influencing how Generation X, millennial and Generation Z consumers behave in virtual, augmented and pure mixed reality environments? ▪ What are the differences between Generation X, millennial and Generation Z consumers' emotions when interacting with different cutting-edge technologies? How can the integration of sentiment analysis and machine learning help in analysing such emotions?
Consumer interaction with automated services	<ul style="list-style-type: none"> ▪ What types of emotions (e.g. anger, fear, anticipation, trust, surprise, sadness, joy and disgust) do consumers experience at different points of interaction with automated services? How can the integration of sentiment analysis and machine learning help in analysing such emotions? ▪ What is the impact of time on consumer emotional responses towards automated services? ▪ Can consumers experience mixed emotions towards a particular automated service? If yes, how do these mixed emotions affect purchase decisions, word of mouth and brand loyalty? ▪ What is the impact of consumers' culture on their behaviour when interacting with cutting-edge technologies? ▪ What are the long-term and short-term impacts of sudden and unexpected changes in consumer behaviour on how automated services work and respond to enquiries?

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- How does behavioural responses differ depending consumers interact with automated services online versus in-store?
 - How do human autonomy and reactance orientation affect the way consumers interact with automated services?
 - How does consumer culture, in terms of having a master, partner or servant relationship with AI-agents (such as voice-controlled smart devices), affect his or her experience?
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- Can consumers with ethical or privacy concerns still develop positive behaviours in their interaction with cutting-edge technologies, and if so, how?
 - How can rules, policies, and legislation be updated to cover the privacy and ethical issues that may arise due to consumer misbehaviour combined with complications related to cutting-edge technology?
- Ethics, privacy and the black box
- What are the key differences in privacy and ethical concerns among Generation X, millennials and Generation Z when interacting with AI-based applications, VR and AR, robotics or wearable technology?
 - How do consumers perceive the ‘personalisation–privacy paradox’ during their interaction with cutting-edge technologies?
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- Consumer security concerns
- What are the long-term consequences of behaviour change among different consumers with serious security concerns about one or more cutting-edge technologies?
 - How can security concerns shape consumer behaviour when interacting with AI-enabled applications and machine learning; for example, chatbots?
 - How do security concerns shape the behaviour of younger consumers when interacting with one or more cutting-edge technologies?
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- Consumer interaction with new-age technologies during a major global crisis
- How are fear and health concerns shaping consumer interactions with cutting-edge technologies during and after the COVID-19 pandemic?
 - How has consumer interaction with new-age technologies changed as a result of COVID-19?
 - How can consumers exploit new and innovative ways of using technologies, such as wearables, VR, AR and robots, to adjust to the “new normal” imposed by COVID-19?
 - How are changes in consumer emotions during and after the COVID-19 pandemic affecting their interaction with cutting-edge technologies?
 - How can consumers protect their personal data when targeted by COVID-19 related phishing and smishing scams?
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3.1 Rethinking consumer behaviour models

The majority of prior studies addressing human-computer interaction in the fields of information systems and marketing focus on the idea that technology is a force offered by companies/brands to users/consumers, who should accept, adopt, use, or exploit it further. While this may be true for new adopters, consumers interact with technology in different ways and in different contexts. Kumar et al. (2020) explain that consumers are increasingly seeking to influence and control the technology around them, rather than passively allowing technology to shape their behaviours. In addition, recent studies agree that technology is shaping various aspects of consumer behaviour (e.g. Hoyer et al., 2020; Paul & Rosenbaum, 2020). We propose rethinking consumer behaviour models when studying people's interaction with cutting-edge technologies.

In reality, customers are likely to experience several technologies at the same time (Barwitz & Maas, 2018). However, to date, previous studies mainly focus on consumers' interaction with one technology at a time; for example, chatbots, VR, AR, robots or wearable technology (e.g. Goebert & Greenhalgh, 2020; Rese et al., 2020; Grewal et al., 2020b). Rodríguez-Torrico, Cabezudo and San-Martín's (2017) study is one exception, addressing how two individual traits – impulsiveness and the need for touch – influence the use of online and mobile devices in omnichannel shopping. Hence, it is important to understand, for example, how loyalty and satisfaction can be maintained when consumers use multiple complex cutting-edge technologies. Furthermore, recent studies (e.g. Brill et al., 2019) model satisfaction and loyalty *after* consumers had experience with emerging technologies. No research can be identified that capture the precise point of interaction between consumers and cutting-edge technologies during their experience and analyse how this can lead to satisfaction and brand loyalty.

In addition, recent studies on wearable technology mainly focus on general use or adoption-related issues, such as usefulness, trust, privacy and security concerns (e.g. Gu et al., 2016; Chuah et al., 2016; Wu et al., 2016). However, there is a knowledge gap in terms of how consumers interact with wearable technology during the shopping experience and how this interaction may (or may not) lead to satisfaction and loyalty towards a brand. Further research should also investigate the use of cutting-edge technologies to enhance consumer emotional security, self-image and self-confidence.

3.2 Behavioural differences among different generations of consumers

Our analysis reveals a lack of research on generational marketing in the context of cutting-edge technologies. The new generation of consumers, such as young millennials and Generation Z, are not just tech savvy but are tech natives (Ameen & Anand, 2020). Generation Z consumers are true digital natives, spending more time on their mobile devices compared to other generations (Criteo, 2018). They are risk-averse in their attitude and behaviour (Khamis & Zaatarti, 2019). Furthermore, individuals who are part of Generation Z tend to be more responsible and pragmatic than millennials (Francis & Hoefel, 2018). Generation Z consumers are more informed, read reviews, share their views, expect personalised services and products.

Compared to millennials, Generation Z consumers are more likely to display different behavioural pattern when interacting with cutting-edge technologies. However, a solid understanding of differences in these generations' expectations and interaction with various cutting-edge technologies is still lacking. Hence, there is a need for additional research to identify key behavioural differences between millennials and Generation Z consumers during their interaction with new technologies. Future research can also investigate how the behaviour of younger generations (e.g. Generation Z) determine the sequence and order of cutting-edge

technologies brands introduce during the shopping experience. For example, it would be interesting to study how a young consumer with a smartwatch, smartphone, VR headset, and Siri and/or Alexa will behave if he/she had to search for a product, service or brand; which technology will the consumer use first/last and why?

Recent studies focus on consumer interaction with VR and AR technologies in a number of contexts such as shopping malls, remote rehabilitation, virtual brand experience, sports marketing and other shopping experiences (e.g. Van Kerrebroeck et al., 2017; Meißner et al., 2020; Goebert & Greenhalgh, 2020). However, researchers have yet to empirically test the effects of macro-level issues, such as cross-cultural and cross-national differences in terms of how Generation X, millennials and Generation Z consumers behave in virtual, augmented and pure mixed reality environments.

3.3 Consumer interaction with automated services

Recent studies highlight that the future of marketing is tightly linked with automated services enabled by AI, such as chatbots and digital assistants (such as Siri and Alexa) (e.g. Brill et al., 2019; Rese et al., 2020; De Bruyn et al., 2020). Shank et al. (2019) investigate people's qualitative descriptions of a personal encounter with AI. However, no research investigates the types of emotions (e.g. anger, fear, anticipation, trust, surprise, sadness, joy and disgust) that different group of consumers experience during their interaction with automated services. Future studies are needed on consumers' (e.g. Generation X, millennials and Generation Z) emotional experiences when encountering new technologies using a combination of quantitative and qualitative methods or by integrating sentiment analysis and machine learning.

In addition, consumers experience mixed emotions during their interaction with automated services but it is not clear how these mixed emotions affect purchase decisions, word of mouth and brand loyalty. Also, when interacting with cutting-edge technologies, the impact of time on consumer emotions remains an underexplored area and there is a need to study the impact of culture on consumers' behavioural responses.

AI-enabled services rely on data collected from users (Kumar et al., 2016). Unexpected changes in terms of how consumers behave and respond can cause problems when interacting with such services (Janarthanam, 2020). For example, a customer may respond to a chatbot in an unanticipated manner such as asking for the wrong information or providing the wrong answer. Hence, future studies can focus on the long-term and short-term impact of sudden and unexpected changes in consumer behavioural responses on how automated services work and respond to enquiries.

Furthermore, recent research mainly focuses on the online environments, for example, consumer engagement with chatbots on a website (Rese et al., 2020). However, consumer interaction with automated services can also take place in physical locations such as stores. Some retail brands (e.g. cosmetics) have introduced automated checkouts, robots and virtual artist kiosks. Therefore, it is important to understand the nature of consumer interaction with automated services online versus in-store environments.

Technologies such as AI are based on autonomy, contradicting with the human nature of being in control of a situation. Hence, future research can investigate the effects of autonomy and reactance orientation on how consumers interact with automated services. Additional studies can also investigate how consumers' culture in terms of having a master, partner or servant

relationship with AI agents (such as voice-controlled smart devices) can affect their experiences.

3.4 Ethics, privacy and the black box

Some recent studies investigate the ethical, moral and trust issues associated with the use of cutting-edge technologies (such as AI). While the “black box” nature of these systems allows accurate predictions and enhanced personalisation, the mechanisms of how they work and the information they process are highly complex (Adadi & Berrada, 2018). Wirtz et al. (2018) made some predictions about the future of service marketing with the presence and use of service robots. The introduction of service robots presents new ethical and moral challenges. Rivas et al. (2018) found that people are unable to distinguish whether they are interacting with, for example AI- and ML-based chatbots or with a human being. Hence, it is important to educate users (consumers) about how chatbots work and who is responsible and accountable for associated moral and ethical issues.

Another key area is to investigate whether consumers with ethical or privacy concerns can still display positive behaviours during their interaction with cutting-edge technologies, and if so, how. Having ethical concerns about a certain system or process may not always lead to a person discontinuing its use or developing strong negative attitude or behaviour. Even if that does happen, behaviour can change over time (Soliman & Rinta-Kahila, 2020). Hence, there is a need to assess changes in behaviour after consumers have expressed ethical concerns. Furthermore, although new regulations such as the General Data Protection Regulation (GDPR) aim to protect consumers’ privacy and security, it does not fully account for the complexity and ambiguity associated with cutting-edge technologies in relation to consumer misbehaviour that damages or disrupts data privacy and data protection of others. Hence, there

is a need for future studies to identify such issues and provide recommendations to improve existing regulations. In addition, future research can focus on how consumers' perceive the 'personalisation–privacy paradox' during their interaction with cutting-edge technologies.

3.5 Consumer security concerns

The six cutting-edge technologies discussed in this article are associated with complicated and, in some cases (such as AI), undiscovered issues requiring further investigation. Recent studies (e.g. Salahuddin & Romeo, 2020) conclude that consumer security concerns are important determinants of cutting-edge technologies adoption. Also, security concerns influence strategies companies use to keep customers' data secure (Gupta et al., 2020; Ameen et al., 2021b). However, it is not clear how security concerns shape consumer behaviour. Research is needed to understand the consequences of behavioural changes among consumers with serious security concerns when using cutting-edge technologies. Future studies should examine how security concerns may result in consumers modifying (temporary or permanent) their behaviour when interacting with, for example, AI-enabled applications and machine learning such as chatbots. Moreover, recent studies (e.g. Duffy et al., 2018) suggest that younger generations of consumers (e.g. Generation Z) are less concerned about security and privacy issues. However, more research is needed in the context of younger generations of consumers use of single or multiple cutting-edge technologies.

3.6 Consumer interaction with new-age technologies during a major global crisis

In late 2019, the world was in the early stages of the COVID-19 health pandemic. The COVID-19 pandemic has disrupted livelihoods, threatened recent advances in health and caused major loss of life. The pandemic also has a significant impact on social life, consumption patterns and the global economy (Ågerfalk et al., 2020). Consumption practices have shifted in new and

unexpected ways, for example, widespread panic buying and consumption displacement (Hall et al., 2020). In addition, there is a remarkable transformation in terms of how consumers interact with different technologies, in and beyond the context of shopping (Beunoyer, Dupéré & Guitton, 2020).

These rapid changes have opened up new avenues for research. For example, future studies can analyse how fear and health concerns are shaping consumer interactions with cutting-edge technologies (during and post COVID-19). In addition, as consumers are likely to experience a range of mixed emotions during the pandemic and in its aftermath (Brockway, 2020), we call for additional research to analyse the role of emotions on consumers' interactions with cutting-edge technologies. COVID-19 was a wake-up call for technologies to facilitate consumers daily routines, from shopping to staying in touch with loved ones. Future studies can investigate how consumers exploit new ways of using existing technologies, such as wearables, VR, AR and robots, to adjust to the "new normal" imposed by COVID-19. Finally, COVID-19 related phishing and smishing scams have been on the rise since the start of the pandemic. A area for future research is to investigate how consumers identify and respond to phishing and smishing. For example, how AI and machine learning can assist consumers in detecting these scams.

4. Conclusion

Our article focuses on six emerging technologies that significantly impact consumer experiences. Research on how consumers interact and engage with new-age technologies is still in its infancy. We encourage researchers to study the relevance and implications of these technologies on aspects such as consumer ethics, emotions, privacy, security, and brand loyalty among others. Researchers addressing the interplay between consumers and cutting-edge technologies would benefit from working in multidisciplinary teams. Our study has some

limitations that need to be acknowledged. First, our article does not provide a systematic review of the literature but offers an overview of recent studies on consumer interaction with cutting-edge technologies. Future studies can follow state of the art practices (e.g. systematic reviews or bibliometric studies) to integrate extant knowledge across multiple theoretical, methodological and disciplinary perspectives. Second, our paper focuses on six key customer oriented cutting-edge technologies. Future studies should consider other technologies that have implications for consumers and marketing in general, such as biometrics, facial recognition, smart mirrors, Internet of things, eye tracking, blockchain and 3D printing.

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