

## Exploring the frontiers in reality-enhanced service communication: from augmented and virtual reality to neuro-enhanced reality

Article (Accepted Version)

Hilken, Tim, Chylinski, Mathew, de Ruyter, Ko, Heller, Jonas and Keeling, Debbie Isobel (2022) Exploring the frontiers in reality-enhanced service communication: from augmented and virtual reality to neuro-enhanced reality. *Journal of Service Management*. ISSN 1757-5818

This version is available from Sussex Research Online: <http://sro.sussex.ac.uk/id/eprint/105285/>

This document is made available in accordance with publisher policies and may differ from the published version or from the version of record. If you wish to cite this item you are advised to consult the publisher's version. Please see the URL above for details on accessing the published version.

### **Copyright and reuse:**

Sussex Research Online is a digital repository of the research output of the University.

Copyright and all moral rights to the version of the paper presented here belong to the individual author(s) and/or other copyright owners. To the extent reasonable and practicable, the material made available in SRO has been checked for eligibility before being made available.

Copies of full text items generally can be reproduced, displayed or performed and given to third parties in any format or medium for personal research or study, educational, or not-for-profit purposes without prior permission or charge, provided that the authors, title and full bibliographic details are credited, a hyperlink and/or URL is given for the original metadata page and the content is not changed in any way.

# Exploring the frontiers in reality-enhanced service communication: from augmented and virtual reality to neuro-enhanced reality

Tim Hilken<sup>1\*</sup>, Mathew Chylinski<sup>2</sup>, Ko de Ruyter<sup>2,3</sup>, Jonas Heller<sup>1</sup>, and Debbie I. Keeling<sup>4</sup>

1 Department of Marketing and Supply Chain Management, Maastricht University, Tongersestraat 53, 6211LM Maastricht, The Netherlands

2 UNSW Business School, University of New South Wales, Sydney, Australia

3 King's Business School, King's College London, United Kingdom

4 University of Sussex Business School, University of Sussex, United Kingdom

\* Corresponding author.

E-mail addresses: t.hilken@maastrichtuniversity.nl (T. Hilken), m.chylinski@unsw.edu.au, (M. Chylinski), ko.de\_ruyter@kcl.ac.uk (K. de Ruyter), j.heller@maastrichtuniversity.nl (J. Heller), D.I.Keeling@sussex.ac.uk (D.I. Keeling)

Keywords – Service communication, augmented reality, virtual reality, neuro-enhanced reality, neuromarketing

Paper type – Research paper

# Exploring the frontiers in reality-enhanced service communication: from augmented and virtual reality to neuro-enhanced reality

## Abstract

**Purpose** – We explore neuro-enhanced reality (NeR) as a novel approach for enhancing service communication between customers, frontline employees, and service organizations that extends beyond current state-of-the-art approaches based on augmented reality (AR) and virtual reality (VR) technologies.

**Design/methodology/approach** – We first take stock of research on reality-enhanced service communication with AR and VR. We then complement these insights with emerging neuroscientific research to conceptualize how NeR enables innovative forms of service communication. On this basis, we develop a research agenda to guide the future study and managerial exploitation of NeR.

**Findings** – AR and VR already offer unique affordances for digital-to-physical communication, but these can be extended with NeR. Specifically, NeR supports neuro-to-digital and digital-to-neuro communication based on neuroimaging (e.g., controlling digital content through thought) and neurostimulation (e.g., eliciting brain responses based on digital content). This provides a basis for outlining possible applications of NeR across service settings.

**Originality** – We advance knowledge on reality-enhanced service communication with AR and VR, whilst also demonstrating how neuroscientific research can be extended from understanding brain activity to generating novel service interactions.

**Keywords** – Service communication, augmented reality, virtual reality, neuro-enhanced reality, neuromarketing

**Paper type** – Research paper

## 1. Introduction

There is consensus amongst service scholars and practitioners that communication is integral for the (co-)creation of service experiences that provide value to both customers and service providers (Gustafsson *et al.*, 2015; Keeling *et al.*, 2021). Researchers thus emphasize the importance of facilitating communication across the customer journey (i.e., pre-, core-, and post-service) to manage expectations, ensure service quality and satisfaction, and prevent service gaps or failures (Følstad and Kvale, 2018). At the same time, technology is rapidly transforming the very nature of communication, providing novel means and modes through which customers and service providers can interact (Larivière *et al.*, 2017).

Most recently, augmented reality (AR) and virtual reality (VR) have emerged as enablers of reality-enhanced communication, where digital and physical service experiences are seamlessly blended (Hilken *et al.*, 2021; de Keyser *et al.*, 2019). For instance, with AR, customers can visualize 3D furniture holograms from IKEA in their home to decide on the best design (Hilken *et al.*, 2020) or receive virtual wayfinding instructions through the servicescape at a trade fair (Gäthke, 2020). With VR, students and teachers can meet in a virtual classroom at MIT (Kaser *et al.*, 2019) or travel companions can tour a Shangri-La resort and interact with the frontline staff before booking (Bogicevic *et al.*, 2019). While the benefits of AR/VR-enhanced communication are well documented, wider adoption is still impeded by the reliance on traditional control interfaces (e.g., touchscreens or handheld controllers). Indeed, both anecdotal evidence (Hern, 2017) and recent market reports (Gartner, 2018) suggest that customers often find the use of AR and VR cumbersome and difficult to integrate in daily life.

A potential answer to these shortcomings involves interfaces that offer greater technological embodiment, considered as the next step in reality-enhanced communication (Flavián *et al.*, 2019). So-called Neuro-enhanced Reality (NeR) that utilizes neuroscientific methods to enable communication through brain-computer interfaces (BCIs; Wolpaw, 2013)

1  
2  
3 is heralded as the progression of AR and VR (Adweek, 2021) and is driven by companies  
4 such as Elon Musk's Neuralink. Unlike technologies that require users to interact with  
5 external interfaces exclusively through their senses (e.g., a touchscreen), NeR interfaces  
6 directly with the human brain and thus partly bypasses the intermediate stages of sensory  
7 perception (Vansteensel and Jarosiewicz, 2020). For instance, next-generation BCIs allow  
8 users to control movements of digital objects or characters simply by thinking of moving their  
9 hand (McFarland *et al.*, 2010), and can even simulate 'touch' of an object that is not  
10 physically present via direct stimulation of brain regions (Stocco *et al.*, 2014; Lee *et al.*,  
11 2017). While such examples still seem futuristic, the potential of NeR for service  
12 communication is growing. For instance, in healthcare settings neurofeedback training has  
13 already progressed to an established service offering (Sitaram *et al.*, 2017), while gaming and  
14 education have become the testing grounds for many consumer-grade BCIs, such as EEG  
15 devices that fit into a baseball cap (NextMind) or a pair of headphones (Neurable) and can be  
16 controlled through a smartphone app (Sawangjai, *et al.*, 2019).

17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60  
Despite these developments, research on NeR in service settings is lacking. The wider  
neuromarketing literature has largely focused on using neuroscientific methods to understand  
the impact of marketing activities, for example measuring brain activity when customers view  
differently branded products (Pozharliev *et al.*, 2015). NeR takes a different path by  
generating novel affordances for digital-to-neuro and neuro-to-digital communication  
(Blankertz *et al.*, 2016), which extend beyond those currently offered by AR and VR. Thus,  
the purpose and contribution of this paper is to: (1) synthesize current knowledge of service  
communication with AR and VR; and (2) conceptualize NeR's capacity for further enhancing  
AR/VR-based service communication. On this basis, we propose a research agenda that is  
nested in emerging neuroscientific research and can serve as a manifesto for the avant-garde  
of marketing scholarship on reality-enhanced service communication. We identify  
opportunities for enhancing service, but also highlight challenges related to customer

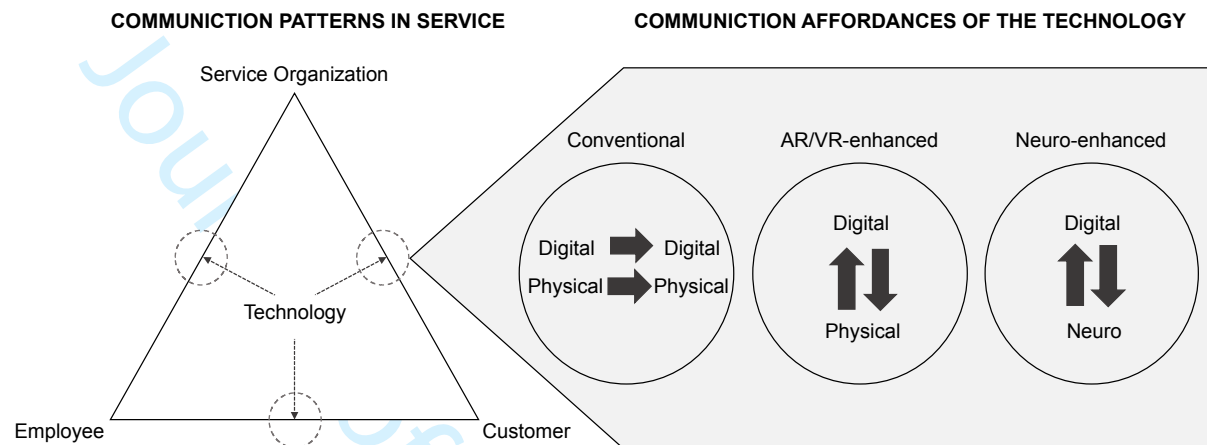
1  
2  
3 acceptance, privacy, and ethics, to inspire researchers and practitioners to pursue value-adding  
4 and responsible ways of developing and using NeR technology.  
5  
6  
7  
8  
9

## 10 **2. Conceptual underpinnings: technology-enabled service communication**

11  
12 Following foundational research (Dance, 1970), we broadly view communication as  
13 the production, exchange, processing, and effect of information, in the form of signs, symbols  
14 or signal systems, between communicators to achieve desired goals. In a service context,  
15 communicators are typically customers, frontline employees (FLEs), and service  
16 organizations that interact with the goal of (co-)creating value (Ballantyne and Varey, 2005).  
17  
18 As shown in the left-hand side of Figure 1, we focus on dyadic communication in the well-  
19 known services triangle (Wilson *et al.*, 2016), whilst acknowledging that communication  
20 patterns in increasingly complex service networks might extend beyond these archetypes.  
21  
22  
23  
24  
25  
26  
27  
28  
29

30  
31 Technology plays a crucial mediating role in this framework (Carr, 2020), described in  
32 terms of “communication affordances” that capture the relationship between the user and the  
33 interface as well as the resulting possibilities for action (Evans *et al.*, 2017). As we depict in  
34 the right-hand side of Figure 1, communication affordances are rapidly expanding due to  
35 technological developments. Conventional (self-)service technologies, including websites,  
36 online chatbots, or social media, traditionally impose a division between digital and physical  
37 aspects of service (Wunderlich *et al.*, 2013). In contrast, AR and VR afford ‘hyperreal’  
38 communication (Edvardsson *et al.*, 2005) in which the physical and digital are seamlessly  
39 integrated (Hilken *et al.*, 2018). NeR promises to advance such communication even further,  
40 based on increased technological embodiment through the use BCIs (Flavián *et al.*, 2019).  
41  
42 Specifically, NeR provides affordances based on communicators’ neurological input, which  
43 might supplement – and in the future partly substitute – sensory interaction with external  
44 interfaces such as a smartphone or headset. Against this backdrop, we first establish the  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

current state-of-the-art of AR/VR-enhanced service communication, and then discuss its potential progression towards neuro-enhanced service communication.



**Figure 1.** Service communication flows between actors and interfaces

### 3. AR- and VR-enhanced service communication

Research demonstrates that AR and VR enhance communication between customers, FLEs, and service organizations by blending digital and physical aspects of service. We discuss this potential in the following section and summarize selected research in Table 1.

#### 3.1 Augmented Reality (AR)

AR enables users to communicate with – and within – their immediate physical surroundings, but through mobile or wearable devices (e.g., smartphones or headsets) they can visually enhance this communication by projecting digital content (e.g., images or animations) into their view of reality. For instance, Vodafone’s FLEs can use AR to ‘draw’ servicing instructions on a customer’s WiFi router, or customers can use the IKEA app to ‘place’ furniture holograms into their homes. Communication in AR is thus based on affordances for projecting digital content into the physical environment (Hilken *et al.*, 2018) and simulating physical control or customization of this content (Carrozzi *et al.*, 2019; Heller *et al.*, 2019a). More recently, ‘visual search’ features in AR also enable new affordances by

1  
2  
3 recognizing physical objects (e.g., a sofa in a customer's home) and projecting matching  
4 digital content (e.g., a reading lamp) into the environment (Chylinski *et al.*, 2020).  
5  
6

7  
8 Service organizations use AR to better communicate with customers, reducing service  
9 intangibility in (automated) frontline encounters (e.g., AR-based restaurant menus; Heller *et*  
10 *al.*, 2019a), providing a greater service scope online (e.g., virtual try-on of apparel; Hilken *et*  
11 *al.*, 2017), improving brand perceptions (e.g., in-store animations; Plotkina *et al.*, 2021),  
12 educating customers (e.g., in art galleries; tom Dieck *et al.*, 2018), or supporting servicescape  
13 navigation (e.g., at trade fairs; Gäthke, 2020). Customer-to-customer communication is also  
14 enhanced through AR's affordances for 'image-enhanced' communication (e.g., projecting  
15 suggested interior designs into a friend's home; Hilken *et al.*, 2020). Furthermore, although  
16 not yet researched, AR likely 'augments' FLE-to-customer communication (Larivière *et al.*,  
17 2017,) for example, when a FLE uses a virtual mirror to showcase different makeup or  
18 hairstyles before performing the service. In similar vein, service organizations leverage AR to  
19 enhance communication with employees, primarily in industrial settings, where AR provides  
20 guidance for maintenance activities (Jetter *et al.*, 2018).  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36

### 37 38 3.2 Virtual Reality (VR)

39  
40 VR supports communication amongst users that are immersed in a virtual environment  
41 (Bogicevic *et al.*, 2019; Hudson *et al.*, 2019. For example, using an Oculus Rift headset or a  
42 smartphone placed into Google's do-it-yourself cardboard headset, customers can 'meet' their  
43 real-estate agent at a Sotheby's virtual open house event and jointly tour the premises (Pleyers  
44 and Poncin, 2020). Communication in VR is based on affordances for navigating the virtual  
45 environment and interacting with the objects or actors therein (Cowan and Ketron, 2019).  
46  
47 Further, VR can represent real or imagined worlds (Manis and Choi, 2019), such that  
48 communication can take place in replicas of actual servicescapes (e.g., stores or hotels) or  
49 fantasy-based environments (e.g., gamified virtual worlds). In this way, VR might also  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60



1  
2  
3 support communication about services that require simulation of hypotheticals or the future  
4  
5 (e.g., wealth scenarios at retirement age).  
6

7  
8 With VR, service organizations can better communicate service quality to customers  
9  
10 (e.g., at a hotel; Bogicevic *et al.*, 2019), bridge distance to physical servicescapes (e.g., tourist  
11 attractions; Itani and Hollebeek, 2020), and advertise for transformative services (e.g.,  
12 charitable donations; Kandaurova and Lee, 2019). Fueled by the Covid-19 pandemic,  
13 customer-to-customer and FLE-to-customer communication in VR is also growing. For  
14 example, students and teachers can meet in VR and immerse themselves into different  
15 environments to ‘ground’ their discussions (Pellas *et al.*, 2021). Further, VR enables  
16 coordination between service organizations (e.g., in buyer-supplier relations; Boyd and Koles,  
17 2019) or the training of employees (e.g., communication with patients; Saab *et al.*, 2021).  
18  
19

### 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60

3.3 Shortcomings of AR and VR interfaces

31 Communication with AR and VR requires sensory interaction with external interfaces,  
32 most commonly through physical touch or movement on touchscreen devices or handheld  
33 controllers (Flavián *et al.*, 2019). These interfaces enable customers to ‘offload’ some of their  
34 input to a service to the digital interface (Heller *et al.*, 2019a). However, they still require  
35 customers to commit physical and mental effort in communicating with the interface (Heller  
36 *et al.*, 2021), for example when using a touchscreen to ‘place’ AR content in the physical  
37 environment (Scholz and Smith, 2016) or a controller to ‘move’ through a VR environment  
38 (Cowan and Ketron, 2019). This implies that customers must be willing and able to invest  
39 such effort, which is a premise that, in practice, many service organizations have found not to  
40 be the case (Keeling *et al.*, 2019). Interfaces are thus rapidly evolving to provide new  
41 communication affordances based on gesture or voice commands (Heller *et al.*, 2019b), haptic  
42 feedback (e.g., HaptX gloves), and olfactory simulation (Nakamoto *et al.*, 2020). NeR  
43 promises to extend these developments even further, as we explore in the following section.

**Table 1.** Illustrative examples of research on AR- and VR-enhanced service communication

Reference	Service context	Key findings	Potential for enhancing service communication	Example application & devices
<b>Augmented Reality (AR)</b>				
Gäthke (2020)	Complex servicescapes	Compared to a traditional 2D map, AR-based navigation reduces complexity and leads to higher overall service satisfaction.	Customers are relieved of some mental/physical effort and can better communicate with other customers and/or service providers.	London Gatwick Airport passenger app; smartphone or tablet
Heller <i>et al.</i> (2019a)	Frontline service interactions	AR use leads to positive WOM and choice of higher value offerings, due to greater processing fluency and decision comfort.	Service providers can better communicate the value of their offerings at the online and offline service frontline.	QReal restaurant menus; smartphone or tablet
Heller <i>et al.</i> (2019b)	Multisensory service experiences	Gesture (vs. voice) control of an AR interface reduces mental intangibility and increases customers' WTP.	AR supports advanced communication modalities such as gesture-based control of digital content, which increases the tangibility of service offerings.	Microsoft HoloLens Studio; wearable smartglasses
Heller <i>et al.</i> (2021)	Service automation	AR service automation can be described through a five-stage technology-enabled engagement process.	Service providers can stimulate engagement with automated services, and reduce their intangibility, by communicating these through AR technology.	Orange after sales support app VodafoneZiggo WiFi assistant; smartphone or tablet
Hilken <i>et al.</i> (2017)	Online service experience	AR enables simulated physical control and environmental embedding of service offerings, which increases the value of the online service experience.	Service providers can provide an expanded service scope online, thus enhancing online communication with and by customers.	Mister Spex online try-on; smartphone, tablet, or desktop pc
Hilken <i>et al.</i> (2020)	Shared online decision making	Communicating purchase advice through AR-enhanced visuals leads to social empowerment and decision-making comfort for those involved.	AR supports customers in communicating and making shared decisions about products or services in online settings.	Akzo Nobel Dulux Visualizer; smartphone or tablet
Plotkina <i>et al.</i> (2021)	Service brand personality	Non-location-specific and product-oriented AR apps lead to more exciting, sincere, competent, and sophisticated service brand associations.	Service providers can better convey their intended brand image/personality through the pleasurable and playful nature of AR.	Instagram AR filters; smartphone or tablet
tom Dieck <i>et al.</i> (2018)	Tourism	Wearable AR solutions help visitors to see connections between paintings and personalize their learning experience.	Service providers can better 'educate' customers, but wearable AR suffers from a lack of visitor-to-visitor engagement and social acceptability.	The Smithsonian 'Skin & Bone'; smartphone or tablet
<b>Virtual Reality (VR)</b>				

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46

Boyd and Koles (2019)	B2B buyer-supplier interactions	VR has significant potential to improve B2B interactions in the post-purchase phase.	B2B service providers can use VR to better coordinate and integrate their resources with buyers, and hence create value-in-use for them.	Airbus cabin design; headset
Bogicevic <i>et al.</i> (2019)	Tourism	An online VR-preview supports mental imagery of a physical servicescape and leads to more favorable brand experience.	Service providers can better communicate the quality of their service (servicecapes) when customers are physically distant.	Shangri-La resort tours; smartphone or headset
Hudson <i>et al.</i> (2019)	Tourism	The use of VR in a physical servicescape leads to immersion and, in turn, positive effects on satisfaction and loyalty.	Service providers can communicate additional, or highly experiential information to customers in addition to a primarily physical core service.	VR in the Vineyard wine tasting; smartphone or headset
Itani and Hollebeek (2021)	Tourism	Social distancing increases (decreases) visitors' intent to use VR (in-person) tours during the covid-19 pandemic.	Service providers can communicate and deliver service through VR, replacing physical service to some extent (during the covid-19 pandemic).	Google Tour Creator; smartphone or headset
Kandaurova and Lee (2019)	Transformative services	VR increases intentions to donate time and money, by stimulating sensed empathy, guilt, and responsibility.	Customers can better communicate the perspective of the beneficiaries of their service to potential donors.	UNICEF VR campaigns; smartphone or headset
Pleyers and Poncin (2020)	Real estate brokerage	Presenting real estate properties in VR, stimulates positive attitudes toward both the offering and the service provider.	Service providers can better communicate the quality of their service (servicecapes) when customers are physically distant.	Sotheby's Realty virtual open houses; smartphone or headset
Tussyadiah <i>et al.</i> (2018)	Tourism	VR increases enjoyment and leads to a stronger liking, preference, and intention to visit a tourist destination.	Service providers can better communicate the quality of their service (servicecapes) when customers are physically distant.	Prague VR 'City Walk'; smartphone or headset

#### 4. Neuro-enhanced service communication

Advancements in BCIs point towards a possible extension of the communication affordances of AR and VR, based on the use of more embodied devices (e.g., wearable sensors or implants; Flavián *et al.*, 2019). This provides a vision for the future, where the integration of AR/VR with BCIs results in novel forms of neuro-enhanced service communication. In the following, we first conceptualize NeR based on contemporary neuroscientific literature before discussing its implications for reality-enhanced service communication.

##### 4.1 Conceptualizing neuro-enhanced reality

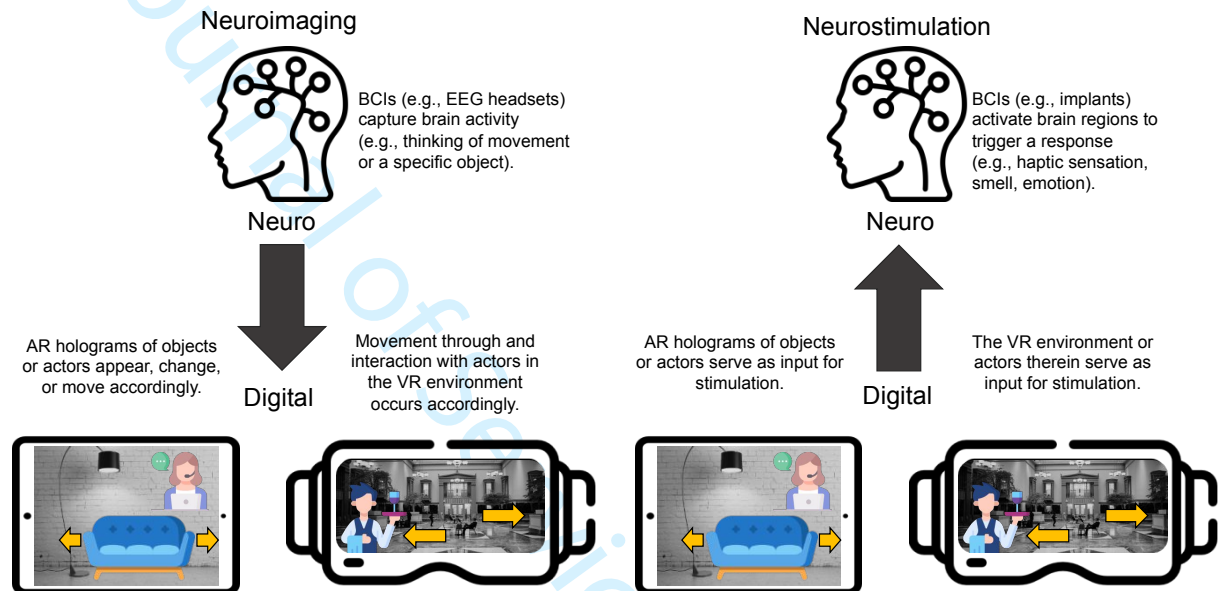
We define NeR as an extension of existing reality-enhancing technologies (AR or VR) through the application of neuroscientific methods that offer affordances for more seamless communication. The research scope of NeR represents a subset of the broader neuromarketing literature, yet is unique in two respects. First, while neuromarketing research focuses on understanding customer reactions to marketing stimuli (e.g., brain responses to viewing certain products; Pozharliev *et al.*, 2015), NeR is focused on generating novel connections between a customer's neural states and digital content (Blankertz *et al.*, 2016). Second, BCIs, such as (wearable) EEGs, play a central role in NeR and distinguish it from biophysical modes of communication (e.g., eye tracking, skin conductance, or heart and sleep pattern monitoring), which only indirectly reflect brain activity (Wolpaw, 2013).

From a technological perspective, NeR is based on two types of neuroscientific methods: (i) those that measure brain activity, which we call neuroimaging; and (ii) those that generate brain activity, which we call neurostimulation. With regards to neuroimaging, EEG methods have progressed towards consumer-grade applications. Companies such as Emotive and Neuroable have launched wearable EEG headsets that translate brain activity into curated and readably interpretable information (e.g., stress level scores)—similar to how fitness trackers like FitBit convey information about movement and calories burned. Beyond such

1  
2  
3 tracking abilities, neuroimaging allows users to communicate simply by thinking of control  
4 commands. For instance, EEG sensors that ‘read’ activity of the motor neurons in the brain  
5 enable users to control digital content (e.g., a cursor on a screen, a virtual character in a video  
6 game), by thinking of moving their left or right hand, moving their foot, or clenching a fist  
7 (Doud *et al.*, 2011; Gilja *et al.*, 2012; McFarland *et al.*, 2010, Lalor *et al.*, 2005). In this way,  
8 neuroimaging bypasses part of the sensory stages of communication (Vansteensel and  
9 Jarosiewicz, 2020), allowing users to substitute some physical control over interfaces such as  
10 manipulating content on a touchscreen or navigating a virtual environment with a controller.  
11 These affordances for direct communication between the user’s brain and digital content  
12 represent what we call “neuro-to-digital” communication, where the customer’s neural  
13 activity is translated into a response in the digital service environment.  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27

28 Neurostimulation, in contrast, comprises BCIs that directly activate a user’s brain  
29 regions based on input from the digital service environment. Such stimulation may be  
30 experienced as proximal sensations involving tactile feelings on the skin (Stocco *et al.*, 2014;  
31 Lee *et al.*, 2017), patterns displayed in the visual field (Caspi *et al.*, 2021), a sense of smell  
32 (Holbrook *et al.*, 2019), or specific bodily reactions (e.g., tear production; Park *et al.*, 2019).  
33 As these sensations are generated through neural stimulation, they present opportunities for  
34 digitally transmitting sensory experiences and addressing long-standing limitations of online  
35 services that have struggled to convey tactile, somatosensory, or olfactory sensations (Petit *et*  
36 *al.*, 2019). Neurostimulation can be achieved in non-invasive ways using transcranial  
37 magnetic stimulation (tMS) and transcranial focused ultrasound (tFUS), which activate brain  
38 regions through energy pulses. However, companies like Neuralink are also working on  
39 invasive BCIs, where electrodes can be implanted in the brain with the goal of increasing the  
40 speed of communication by bypassing sensory bottlenecks. Customer acceptance of invasive  
41 BCIs remains to be seen, however, the scope of neurostimulation involves affordances for  
42 what we call “digital-to-neural” communication – that is, translating digital service stimuli  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

directly into neural activity within the customer's brain. Existing methods of neurostimulation are still restricted to laboratory or medical contexts but will likely make their way towards the wider market (Wexler, 2020), with far-reaching ethical implications that we discuss later in the paper.



**Figure 2.** Neuro-to-digital and digital-to-neuro service communication

#### 4.2 Advancing reality-enhanced service communication

Taken together, neuroimaging and neurostimulation enable new affordances for neuro-to-digital and digital-to-neuro communication (Figure 2). NeR thus promises to enhance service communication between customers, FLEs, and service organizations beyond what is currently possible with AR and VR, as we outline in the following and illustrate with examples from different service contexts in Table 2.

##### 4.2.1 Neuro-to-digital (neuroimaging)

In the near future, we envisage AR and VR interfaces being supplemented with neuroimaging BCIs. To date, communication with AR and VR is often restricted to handheld devices that limit interactivity and can disrupt immersion, especially with multiple users (Hudson *et al.*, 2019). Relatedly, research has shown that although customers can form

1  
2  
3 feelings of ownership towards AR holograms (Carrozzi *et al.*, 2019), they are always aware  
4 that these are only interacted with ‘on-screen’. In contrast NeR, would enable customers to  
5  
6 that these are only interacted with ‘on-screen’. In contrast NeR, would enable customers to  
7  
8 control AR holograms or navigate VR environments simply by thinking of control or  
9  
10 movements; or use visual search features by merely thinking of an object in the servicescape  
11  
12 to activate suggested alternatives, complements, or use instructions. A need for this type of  
13  
14 “sensory-free” control is driven by the transition from handheld to wearable AR and VR  
15  
16 devices (Flavián *et al.*, 2019). Microsoft’s HoloLens is a prime example of a headset that  
17  
18 innovates control modes to allow greater mobility (Heller *et al.*, 2019b), yet faces adoption  
19  
20 barriers related to ergonomics and ease-of-use as well as customer concerns about wearing  
21  
22 headsets in public (Rauschnabel *et al.*, 2018). In similar vein, communication in VR is  
23  
24 hampered when users need to follow a pre-defined route or use a handheld controller to  
25  
26 navigate the environment – while actual ‘walking’ requires dedicated spaces that are often not  
27  
28 available in the servicescape (e.g., a VR space in-store or the customer’s home).  
29  
30  
31

32  
33 We thus see neuroimaging as a way of enabling more seamless service  
34  
35 communication, not only for customers, but also FLEs. From after-sales service, training and  
36  
37 education to medical settings, FLEs typically engage in tasks that require physical movement,  
38  
39 for example when demonstrating a product, teaching a skill, or operating on a patient. In these  
40  
41 settings, sensory-based controls of AR and VR interfaces may interfere with the performance  
42  
43 of these tasks. NeR changes this, for example, when an architect wearing a VR headset with  
44  
45 an integrated BCI ‘walks’ customers through the construction site from the comfort of their  
46  
47 office, while potential design changes appear when mentioned in conversation; or a surgeon  
48  
49 who while operating brings up AR imagery over the patient’s body to communicate to an  
50  
51 assistant a precise spot to make an incision. Substitution of sensory-based controls with NeR  
52  
53 thus offers unique affordances for improved communication in settings where operating a  
54  
55 physical interface may interfere with effective service delivery.  
56  
57  
58  
59  
60

#### 4.2.2 Digital-to-neuro (neurostimulation)

1  
2  
3 In the more intermediate future, we envisage NeR interfaces that offer an expanded  
4 range of sensations through neurostimulation. While AR and VR already offer enhanced  
5 visual and auditory information in many service settings, they struggle to support the full  
6 range of communication modes. For instance, even though AR improves the ‘tangibility’ of  
7 digital service communications (Heller *et al.*, 2021), those sensations rely on imprecise  
8 inferences a customer makes from observing the position, motion, and auditory properties of  
9 AR holograms. Actual sensations of haptics, weight, temperature, smell, and taste are  
10 typically not available in online settings (Petit *et al.*, 2019). We thus anticipate that the  
11 motivation for integrating neurostimulation into AR and VR comes from the need to expand  
12 the range of sensations during online service communications. For example, in the case of a  
13 VR tour of a holiday resort, neurostimulation might allow a customer to not only ‘see’ what  
14 the lobby, rooms, and spa, might look like, but also ‘feel’ the textures of the furniture or smell  
15 the scent of the freshly prepared breakfast at the hotel’s restaurant.  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32

33 For FLEs, neurostimulation might be used to modulate alertness, mood, reaction time,  
34 or creativity (Wexler, 2018), although ongoing debate in the literature about the efficacy and  
35 responsible use of such neurostimulation means more research is needed to substantiate its  
36 application in service settings (Wexler and Thibault, 2019). That is, while cognitive  
37 enhancement through neurostimulation holds significant potential, it requires careful  
38 management, especially when attempting to motivate or empower employees, or persuade  
39 customers to make decisions (e.g., donating to a charity by triggering guilt; Kandaurova and  
40 Lee, 2019). The ethical considerations underlying such applications of NeR are not yet  
41 developed and likely will be outpaced by the rapidly evolving technology.  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60



**Table 2.** Potential progression of reality-enhanced service communication

Service & Communicators	Conventional	AR/VR-enhanced	NeR <i>Neuroimaging</i>	NeR <i>Neurostimulation</i>
Hotel <i>Service organization-customer</i>	Customers can browse the website or contact the service organization through email, phone, or text-chat; when physically at the hotel, they can examine the servicescape and interact with staff.	Customers can virtually preview the servicescape using a VR headset; when physically visiting the hotel, they can use AR on their smartphone to point at QR codes for wayfinding support.	Customers can navigate in VR without physically interacting with a device – instead they can imagine moving through the servicescape; at the hotel, they can get AR wayfinding support only by thinking “where do I go now?”	Customers can additionally hear the atmosphere in the lobby, smell and taste the food at the restaurant and feel the comfort of the hotel beds during a VR tour; at the hotel, they can experience multisensory AR enhancements (e.g., virtual characters that really ‘come to life’ at a Disney resort).
Call center <i>FLE-customer</i>	FLEs can provide advice pre-purchase or troubleshoot post-purchase through text-based chat, phone call, or videoconferencing.	FLEs can meet customers in virtual spaces (VR) or ‘see what the customer sees’ (AR), and visually enhance this view (e.g., with holograms or instructions).	FLEs can communicate advice more seamlessly, for example suggesting a product simply by thinking of it, or let visual instructions appear in AR and VR as they are mentioned in conversation.	FLEs can better understand and emphasize, by experiencing sensory aspects of the customer’s circumstances (e.g., the atmosphere in a living room to be redecorated) or even customers’ emotions (e.g., joy, frustration) themselves.
Professional training <i>Service organization-FLE</i>	Service organizations can provide classroom or on-the-job training, as well as supporting online formats (e.g., instructional videos or online workshops).	Service organizations can communicate educational content to FLEs by simulating events in VR or enhancing physical spaces with AR-based instructions.	Service organizations can better monitor FLEs’ learning and improve in-class communication; participants can create and shape AR or VR content simply by thinking about it or mentioning it in conversation.	Service organizations can augment the communication and learning process by letting participants experience each other’s perspectives in a discussion or by neutrally emphasizing certain stimuli to support learning outcomes.

## 5. Setting the research agenda for neuro-enhanced service communication

To drive the vision of NeR in service communication, research is needed that extends our understanding of how customers, FLEs, and service organizations can most effectively and responsibly make use of neuroimaging and neurostimulation applications to meet their needs. We thus formulate a research agenda, in which we propose key directions along three

1  
2  
3 main themes (i.e., the efficacy, acceptance, and ethical implications of NeR) to advance  
4  
5 scholarly knowledge and guide the managerial use of NeR.  
6

### 7 8 *5.1 Efficacy of NeR*

9  
10 *Determining the scope of experience:* NeR offers affordances for enhanced service  
11 communication and value outcomes, but as technology can also decrease user well-being  
12 (e.g., interfering with in-person communication; Čaić *et al.*, 2018), not all of these  
13 opportunities will necessarily be embraced by customers (Keeling *et al.*, 2019). Moreover,  
14 given technical challenges at this early developmental stage of BCIs, applications of NeR  
15 must initially be evaluated on their efficacy in delivering value-adding experiences (Wexler  
16 and Thibault, 2019). As such, the research agenda should begin with scoping the NeR  
17 experience, for instance by determining what types of control through neuroimaging will  
18 improve convenience and decision making, whilst avoiding neural overload, interference with  
19 other brain activities, or potential misalignments (e.g., accidentally triggering unintended  
20 actions in AR or VR).  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33

34  
35 For neurostimulation, research should map which sensory experiences (e.g., smell,  
36 taste, touch) to stimulate in different service encounters. A simple ‘more-is-better’ logic is  
37 unlikely to be successful, such that literature on multisensory experiences (Mahr *et al.*, 2019)  
38 must serve as a guiding framework. Relatedly, it is pertinent to understand how customers  
39 will respond to neural-induced sensations, and how these new ways of communicating might  
40 affect social interactions among customers (e.g., are they exchanged like current WOM  
41 conversations on social media?). Finally, as service communication is increasingly performed  
42 by AI (van Pinxteren *et al.*, 2020), NeR raises new questions related to machine agency (e.g.,  
43 will customers accept neural input from non-humans?) and require current frameworks of  
44 human–AI interaction (Sundar, 2020) to be updated to account for NeR.  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57

58 *Mapping service applications:* To move NeR from laboratory to market applications,  
59 research should assess which service settings are suitable for deploying neuro-enhanced  
60

1  
2  
3 communication. Currently, there is a strong focus on healthcare settings where applications of  
4  
5 neuroimaging and neurostimulation are a natural progression (e.g., to overcome physical  
6  
7 disabilities). While we note potential applications in services contexts such as hotels, call  
8  
9 centers, and education, more systematic study based on service design methods such as actor  
10  
11 network maps and context interviews (Patrício *et al.*, 2020), would offer user-centered  
12  
13 insights into settings poised for transformation towards NeR.  
14  
15

16  
17 *Integrating NeR into service systems:* Relatedly, once NeR has found wider application  
18  
19 across service settings, research on how to integrate this novel technology into the overall  
20  
21 service system is needed. That is, researchers should study, for example, how to best connect  
22  
23 the BCIs of customers with FLEs, or, within a service organization, an entire workforce.  
24  
25 Research on smart services, such as smart homes, identifies important mechanisms related to  
26  
27 controllability, visibility, and autonomy in such seamlessly connectivity (Gonçalves *et al.*,  
28  
29 2020) and thus might serve as a basis for future research.  
30  
31

## 32 33 5.2 Acceptance of NeR

34  
35 *Identifying the customer-NeR 'fit':* We must better understand which customers are  
36  
37 most likely to make use of neuroimaging or neurostimulation. Current AR/VR literature  
38  
39 offers a valuable starting point, for example identifying customer preferences for visual  
40  
41 processing as a pertinent customer trait (Hilken *et al.*, 2017). For NeR, future studies could  
42  
43 consider whether customers who, for example, prefer effortless goal pursuit (locomotion)  
44  
45 might be more inclined to use NeR due to the seamless experience it affords, when compared  
46  
47 to those relying on more in-depth processing (assessment; Kruglanski *et al.*, 2001) – or  
48  
49 whether these effects might be reversed such that assessors find their processing simplified  
50  
51 through NeR. Such insights would enable service managers to match customers more  
52  
53 appropriately with neuro-enhanced communication.  
54  
55  
56

57  
58 *Understanding device adoption:* More research is needed to identify the drivers of  
59  
60 customer willingness to adopt wearable NeR devices. For AR and VR such adoption has been

1  
2  
3 subdued due to a lack of social acceptability (Rauschnabel *et al.*, 2018), but there is rapid  
4  
5 progression towards more unobtrusive devices such as NextMind's EEG sensor which fits  
6  
7 into baseball cap or Neurable's EEG which is integrated within a pair of headphones.  
8  
9 Relatedly, as technological embodiment progresses towards implants such as those of  
10  
11 Neuralink, the question of who will embrace such invasive devices arises. In the healthcare  
12  
13 context, patient motivations are seemingly often clear (e.g., overcoming physical disabilities)  
14  
15 but in practice are more complicated as competing motivations come into play. Further, an  
16  
17 understanding of customer adoption for improving everyday services is yet to be researched.  
18  
19 Current research on motivations for "biohacking", such as extracting own DNA or developing  
20  
21 do-it-yourself biotech devices might inform such inquiry (Meyer and Vergnaud, 2020).  
22  
23

24  
25  
26 *Establishing role readiness:* Customer and FLE ability to use novel NeR interfaces likely  
27  
28 requires training and associated service communication. Indeed, current BCI applications  
29  
30 already require training effort and involve a learning curve (Roc *et al.*, 2021), so determining  
31  
32 which users have the 'right' role readiness (i.e., role clarity, motivation, ability; Larivière *et*  
33  
34 *al.*, 2017) is crucial. Relatedly, research should identify ways of effectively 'onboarding'  
35  
36 customers, for example, into the use of neuroimaging controls or sensations generated through  
37  
38 neurostimulation.  
39  
40

### 41 42 5.3 Ethical implications of NeR 43

44  
45 As NeR interfaces directly with the human brain, it presents unprecedented ethical  
46  
47 considerations, particularly with regards to the collection, use, storage, and influence of what  
48  
49 is perhaps the most personal 'data' there is: a person's neural processes in the mind. Thus,  
50  
51 while developments in NeR hold unique potential for improving service, and ultimately  
52  
53 customer and employee well-being, regulatory oversight is required to ensure neuroimaging  
54  
55 does not culminate in the ultimate commodification of personal data (i.e., 'surveillance  
56  
57 capitalism'; Zuboff, 2019), while neurostimulation is applied in ways that do not deceive or  
58  
59 manipulate the user (Wexler and Thibault, 2019). Hence, we raise a cautionary note,  
60

1  
2  
3 emphasizing the need for research into regulatory and customer (and employee) sovereignty  
4 implications of NeR, and the importance of responsible marketing. We advocate an approach  
5 that is framed around user consent and decision-making autonomy.  
6  
7  
8

9  
10 *Determining right to access:* Neuroimaging introduces the question of who can ‘read’  
11 a user’s brain activity. Customers are already accustomed to conducting a calculus where they  
12 weigh the benefits and costs of improved convenience or personalization in exchange for their  
13 data (Kim *et al.*, 2019). Yet, more research is needed to determine to what extent the  
14 convenience of having neural information available (e.g., for ‘more mindful working’ as  
15 advertised by Neurale) or using neuroimaging to control AR/VR applications, outweighs the  
16 perceived sacrifice of sharing this data with service organizations (and potentially third  
17 parties). Continued study should also consider in how far current privacy practices such as the  
18 GDPR principles must be updated with regards to specifying and limiting the type and extent  
19 of data collection (e.g., which brain activity will not be measured), the intended purpose (e.g.,  
20 only for the focal service encounter), and potential for longer-term storage (e.g., in a  
21 database). Finally, potential dangers of BCIs being hacked must be considered from the  
22 outset, to build greater security and trust among customers. Complex services providers (e.g.,  
23 health and social care) are constantly grappling with such issues and learning from their  
24 experiences and solutions could be a fruitful starting point for future research.  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43

44 *Explicating cognitive enhancement:* Neurostimulation implies ‘write’ access to a  
45 person’s brain which can enhance service communication, but also holds potential for  
46 misleading or even manipulating users (Wexler and Thibault, 2019). For instance, marketers  
47 could ‘neurally’ overstate actual reality when providing sensory input (e.g., the scent at  
48 tropical vacation resort). Customers often expect some puffery in marketing communications,  
49 but in NeR this becomes exceedingly difficult to detect. Research has already identified  
50 customer concerns about a ‘biased perception of reality’ when using AR technology  
51 (Lammerding *et al.*, 2020), so more insights on how to effectively communicate the (non-)  
52  
53  
54  
55  
56  
57  
58  
59  
60

1  
2  
3 authenticity of neuro-enhanced communications are needed. Furthermore, neurostimulation  
4 enables so-called ‘cognitive enhancement’ such as stimulating brain areas for increased  
5  
6 creativity (Weinberger *et al.*, 2018), which could be used for persuasion or to elicit certain  
7  
8 emotions that drive purchase behavior, implying a potential loss of customer autonomy.  
9  
10 Research should thus identify situations in which cognitive enhancement is conducive to  
11  
12 customer well-being and develop guidelines for transparent opt-in procedures.  
13  
14  
15

16  
17 *Ensuring responsible marketing:* The previously discussed points suggest a pressing  
18  
19 need for more research on holistic frameworks for responsible marketing with NeR, not only  
20  
21 to guide service practice, but to inform policymaking at the societal level (de Ruyter *et al.*,  
22  
23 2022). Current regulatory frameworks are unlikely to accurately capture the full ethical  
24  
25 implications of NeR, so future research should take an interdisciplinary view on marketing  
26  
27 ethics (Mahr *et al.*, 2020) to guide the development of codes of conduct for the collection,  
28  
29 use, and storage of personal data, as well as the active influencing of neural processes.  
30  
31  
32  
33

## 34 35 **6. Conclusion**

36  
37 As service providers increasingly predicate their business strategies upon the use of  
38  
39 new technologies and formats to enhance services communication, there is a clear need to  
40  
41 continuously examine the frontier of current technological developments. Within only a short  
42  
43 period of time, AR and VR have established themselves as strategic service tools. The signs  
44  
45 are that NeR might follow a similar development trajectory. By taking a multidisciplinary  
46  
47 perspective, combining research at the intersection of services management, communication,  
48  
49 and neuroscience, we outline a vision of what NeR ‘can become’ by identifying key  
50  
51 opportunities, while also emphasizing the need for considering what it ‘should become’ by  
52  
53 pinpointing key obstacles and the unique ethical considerations that accompany this  
54  
55 technology. We believe that now is the right time to start addressing these issues, through  
56  
57  
58  
59  
60

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

future research, to guide researchers and practitioners in developing and using NeR in value-adding and responsible ways.

Journal of Service Management



## References

- Adweek (2021), "Why the fusion of humans and machines is the future", available at: <https://www.adweek.com/brand-marketing/why-the-fusion-of-humans-and-machines-is-the-future/> (accessed 20 October 2021)
- Ballantyne, D. and Varey, R. J. (2006), "Creating value-in-use through marketing interaction: the exchange logic of relating, communicating and knowing," *Marketing Theory*, Vol. 6 No. 3, pp. 335-348.
- Blankertz, B., Acqualagna, L., Dähne, S., Haufe, S., Schultze-Kraft, M., Sturm, I., ... and Müller, K. R. (2016), "The Berlin Brain-Computer Interface: Progress Beyond Communication and Control", *Frontiers in Neuroscience*, Vol. 10, pp. 530-530.
- Bogicevic, V., Seo, S., Kandampully, J. A., Liu, S. Q., and Rudd, N. A. (2019), "Virtual reality presence as a preamble of tourism experience: The role of mental imagery", *Tourism Management*, Vol. 74, pp. 55-64.
- Boyd, D. E. and Koles, B. (2019), "Virtual reality and its impact on B2B marketing: A value-in-use perspective", *Journal of Business Research*, Vol. 100, pp. 590-598.
- Čaić, M., Odekerken-Schröder, G., and Mahr, D. (2018), „Service robots: value co-creation and co-destruction in elderly care networks”, *Journal of Service Management*, Vol. 29, No. 2, pp. 178-205.
- Carr, C. T. (2020), "CMC is dead, long live CMC!: Situating computer-mediated communication scholarship beyond the digital age", *Journal of Computer-Mediated Communication*, Vol. 25, No. 1, pp. 9-22.
- Carrozzi, A., Chylinski, M., Heller, J., Hilken, T., Keeling, D. I., and de Ruyter, K. (2019), "What's Mine Is a Hologram? How Shared Augmented Reality Augments Psychological Ownership", *Journal of Interactive Marketing*, Vol. 48, pp. 71-88.
- Caspi, A., Barry, M. P., Patel, U. K., Salas, M. A., Dorn, J. D., Roy, A., ... and Pouratian, N. (2021), "Eye movements and the perceived location of phosphenes generated by intracranial primary visual cortex stimulation in the blind", *Brain Stimulation*, Vol. 14, No. 4, pp. 851-860.
- Chylinski, M., Heller, J., Hilken, T., Keeling, D. I., Mahr, D., and de Ruyter, K. (2020), "Augmented reality marketing: A technology-enabled approach to situated customer experience", *Australasian Marketing Journal (AMJ)*, Vol. 28, No. 4, pp. 374-384.
- Cowan, K. and Ketron, S. (2019), "Prioritizing marketing research in virtual reality: development of an immersion/fantasy typology", *European Journal of Marketing*, Vol. 53, No. 8, pp. 1585-1611.
- Dance, F. E. (1970), "The "concept" of communication. *Journal of communication*", Vol. 20, No. 2, pp. 201-210.



1  
2  
3 De Keyser, A., Köcher, S., Verbeeck, C., and Kandampully, J. (2019), "Frontline Service  
4 Technology infusion: conceptual archetypes and future research directions", *Journal of*  
5 *Service Management*, Vol. 30, No. 1, pp. 156-183.

6  
7  
8 de Ruyter, K., Keeling, D. I., Plangger, K., Montecchi, M., Scott, M. L., and Dahl, D. W.  
9 (2022), "Reimagining marketing strategy: driving the debate on grand challenges", *Journal of*  
10 *the Academy of Marketing Science*, Vol. 50, No. 1, pp. 13-21.

11  
12 Doud, A. J., Lucas, J. P., Pisansky, M. T., and He, B. (2011), "Continuous three-dimensional  
13 control of a virtual helicopter using a motor imagery based brain-computer interface", *PloS*  
14 *one*, Vol. 6, No. 10, e26322.

15  
16  
17 Edvardsson, B., Enquist, B., and Johnston, R. (2005), "Cocreating customer value through  
18 hyperreality in the prepurchase service experience", *Journal of Service Research*, Vol. 8, No.  
19 2, pp. 149-161.

20  
21  
22 Evans, S. K., Pearce, K. E., Vitak, J., and Treem, J. W. (2017), "Explicating affordances: A  
23 conceptual framework for understanding affordances in communication research", *Journal of*  
24 *Computer-Mediated Communication*, Vol. 22, No. 1, pp. 35-52.

25  
26 Flavián, C., Ibáñez-Sánchez, S., and Orús, C. (2019), "The impact of virtual, augmented and  
27 mixed reality technologies on the customer experience", *Journal of Business Research*, Vol.  
28 100, pp. 547-560.

29  
30  
31 Følstad, A. and Kvale, K. (2018), "Customer journeys: a systematic literature  
32 review", *Journal of Service Theory and Practice*, Vol. 28, No. 2, pp. 196-227.

33  
34  
35 Gäthke, J. (2020), "The impact of augmented reality on overall service satisfaction in  
36 elaborate servicescapes", *Journal of Service Management*, Vol. 31, No. 2, pp. 227-246.

37  
38  
39 Gartner (2018), "3 reasons why VR and AR are slow to take off", available at:  
40 <https://www.gartner.com/smarterwithgartner/3-reasons-why-vr-and-ar-are-slow-to-take-off>  
(accessed 15 October 2021)

41  
42  
43 Gilja, V., Nuyujukian, P., Chestek, C. A., Cunningham, J. P., Byron, M. Y., Fan, J. M., ... and  
44 Shenoy, K. V. (2012), "A high-performance neural prosthesis enabled by control algorithm  
45 design", *Nature Neuroscience*, Vol. 15, No. 12, pp. 1752-1757.

46  
47  
48 Gonçalves, L., Patrício, L., Teixeira, J. G., and Wunderlich, N. V. (2020), "Understanding the  
49 customer experience with smart services", *Journal of Service Management*, Vol. 31, No. 4,  
50 pp. 723-744.

51  
52  
53 Gustafsson, A., Kristensson, P., and Witell, L. (2012), "Customer co-creation in service  
54 innovation: a matter of communication?", *Journal of Service Management*, Vol. 23, No. 3, pp.  
55 311-327.

56  
57  
58 Heller, J., Chylinski, M., de Ruyter, K., Mahr, D., and Keeling, D. I. (2019a), "Let Me  
59 Imagine That for You: Transforming the Retail Frontline Through Augmenting Customer  
60 Mental Imagery Ability", *Journal of Retailing*, Vol. 95, No. 2, pp. 94-114.

1  
2  
3 Heller, J., Chylinski, M., de Ruyter, K., Mahr, D., and Keeling, D. I. (2019b), "Touching the  
4 Untouchable: Exploring Multi-Sensory Augmented Reality in the Context of Online  
5 Retailing", *Journal of Retailing*, Vol. 95, No. 4, pp. 219-234.  
6

7  
8 Heller, J., Chylinski, M., de Ruyter, K., Keeling, D. I., Hilken, T., and Mahr, D. (2021),  
9 "Tangible service automation: Decomposing the technology-enabled engagement process  
10 (TEEP) for augmented reality", *Journal of Service Research*, Vol. 24, No. 1, pp. 84-103.  
11

12  
13 Hern, A. (2017), "I tried to work all day in a VR headset and it was horrible", available at:  
14 [https://www.theguardian.com/technology/2017/jan/05/i-tried-to-work-all-day-in-a-vr-headset-](https://www.theguardian.com/technology/2017/jan/05/i-tried-to-work-all-day-in-a-vr-headset-so-you-never-have-to)  
15 [so-you-never-have-to](https://www.theguardian.com/technology/2017/jan/05/i-tried-to-work-all-day-in-a-vr-headset-so-you-never-have-to) (accessed 12 October 2021)  
16

17  
18 Hilken, T., Keeling, D. I., de Ruyter, K., Mahr, D., and Chylinski, M. (2020), "Seeing eye to  
19 eye: social augmented reality and shared decision making in the marketplace", *Journal of the*  
20 *Academy of Marketing Science*, Vol. 48, No. 2, pp. 143-164.  
21

22  
23 Hilken, T., Heller, J., Chylinski, M., Keeling, D. I., Mahr, D., and de Ruyter, K. (2018),  
24 "Making omnichannel an augmented reality: the current and future state of the art", *Journal*  
25 *of Research in Interactive Marketing*, Vol. 12, No. 4, pp. 509-523.  
26

27  
28 Hilken, T., de Ruyter, K., Chylinski, M., Mahr, D., and Keeling, D. I. (2017), "Augmenting  
29 the eye of the beholder: exploring the strategic potential of augmented reality to enhance  
30 online service experiences," *Journal of the Academy of Marketing Science*, Vol. 45, No. 6, pp.  
31 884-905.  
32

33  
34 Hilken, T., Chylinski, M., Keeling, D. I., Heller, J., de Ruyter, K., & Mahr, D. (2021), "How  
35 to strategically choose or combine augmented and virtual reality for improved online  
36 experiential retailing," *Psychology & Marketing*, Vol. 39, No. 3, pp. 495-507.  
37

38  
39 Holbrook, E. H., Puram, S. V., See, R. B., Tripp, A. G., and Nair, D. G. (2019), "Induction of  
40 smell through transthemoid electrical stimulation of the olfactory bulb", *International Forum*  
41 *of Allergy & Rhinology*, Vol. 9, No. 2, pp. 158-164.  
42

43  
44 Hudson, S., Matson-Barkat, S., Pallamin, N., and Jegou, G. (2019), "With or without you?  
45 Interaction and immersion in a virtual reality experience," *Journal of Business Research*, Vol.  
46 100, pp. 459-468.  
47

48  
49 Itani, O. S. and Hollebeek, L. D. (2021), "Light at the end of the tunnel: Visitors' virtual  
50 reality (versus in-person) attraction site tour-related behavioral intentions during and post-  
51 COVID-19", *Tourism Management*, Vol. 84, 104290.  
52

53  
54 Jetter, J., Eimecke, J., and Rese, A. (2018), "Augmented reality tools for industrial  
55 applications: What are potential key performance indicators and who benefits?", *Computers*  
56 *in Human Behavior*, Vol. 87, pp. 18-33.  
57

58  
59 Kandaurova, M. and Lee, S. H. M. (2019), "The effects of Virtual Reality (VR) on charitable  
60 giving: The role of empathy, guilt, responsibility, and social exclusion", *Journal of Business*  
*Research*, Vol. 100, 571-580.  
61

62  
63 Kaser, D., Grijalva, K., and Thompson, M. (2019). *Envisioning Virtual Reality: A Toolkit for*  
*Implementing VR in Education*. Lulu Press, Inc.  
64

1  
2  
3  
4 Keeling, D. I., de Ruyter, K., Mousavi, S., and Laing, A. (2019), "Technology push without a  
5 patient pull: examining digital unengagement (DU) with online health services", *European*  
6 *Journal of Marketing*, Vol. 53, No. 9, pp. 1701-1732.

7 Keeling, D. I., Keeling, K., de Ruyter, K., and Laing, A. (2021), "How value co-creation and  
8 co-destruction unfolds: a longitudinal perspective on dialogic engagement in health services  
9 interactions", *Journal of the Academy of Marketing Science*, Vol. 49, No. 2, pp. 236-257.

10  
11  
12 Kim, D., Park, K., Park, Y., and Ahn, J. H. (2019), "Willingness to provide personal  
13 information: Perspective of privacy calculus in IoT services", *Computers in Human*  
14 *Behavior*, Vol. 92, pp. 273-281.

15  
16  
17 Kruglanski, A. W., Thompson, E. P., Higgins, E. T., Atash, M., Pierro, A., Shah, J. Y., and  
18 Spiegel, S. (2000), "To" do the right thing" or to" just do it": locomotion and assessment as  
19 distinct self-regulatory imperatives", *Journal of personality and social psychology*, Vol. 79,  
20 No. 5, pp. 793-815.

21  
22  
23 Lalor, E. C., Kelly, S. P., Finucane, C., Burke, R., Smith, R., Reilly, R. B., and Mcdarby, G.  
24 (2005), "Steady-state VEP-based brain-computer interface control in an immersive 3D  
25 gaming environment", *EURASIP Journal on Advances in Signal Processing*, 2005, No. 19,  
26 pp. 1-9.

27  
28  
29 Lammerding, L., Hilken, T., Mahr, D., and Heller, J. (2021), "Too Real for Comfort:  
30 Measuring Consumers' Augmented Reality Information Privacy Concerns", *Augmented*  
31 *Reality and Virtual Reality: New Trends in Immersive Technology*, pp. 95-108.

32  
33 Larivière, B., Bowen, D., Andreassen, T. W., Kunz, W., Sirianni, N. J., Voss, C., ... & De  
34 Keyser, A. (2017), "Service Encounter 2.0: An investigation into the roles of technology,  
35 employees and customers", *Journal of Business Research*, Vol. 79, pp. 238-246.

36  
37  
38 Lee, W., Kim, S., Kim, B., Lee, C., Chung, Y. A., Kim, L., and Yoo, S. S. (2017), "Non-  
39 invasive transmission of sensorimotor information in humans using an EEG/focused  
40 ultrasound brain-to-brain interface", *PloS one*, Vol. 12, No. 6, e0178476.

41  
42 Mahr, D., Čaić, M., and Odekerken-Schröder, G. (2020), „An Interdisciplinary View of  
43 Marketing Ethics", In *The SAGE Handbook of Marketing Ethics* (pp. 58-73). SAGE.

44  
45  
46 Mahr, D., Stead, S., and Odekerken-Schröder, G. (2019), "Making SENSE of Customer  
47 Service Experiences: A Text Mining Review", *Journal of Services Marketing*, Vol. 33, No. 1,  
48 pp. 88-103.

49  
50  
51 McFarland, D. J., Sarnacki, W. A., and Wolpaw, J. R. (2010), "Electroencephalographic  
52 (EEG) control of three-dimensional movement", *Journal of Neural Engineering*, Vol. 7, No.  
53 3, 036007.

54  
55  
56 Meyer, M. and Vergnaud, F. (2020), "The rise of biohacking: Tracing the emergence and  
57 evolution of DIY biology through online discussions", *Technological Forecasting and Social*  
58 *Change*, Vol. 160, 120206.

1  
2  
3 Nakamoto, T., Hirasawa, T., and Hanyu, Y. (2020), "Virtual environment with smell using  
4 wearable olfactory display and computational fluid dynamics simulation", in 2020 IEEE  
5 Conference on Virtual Reality and 3D User Interfaces (VR) (pp. 713-720).  
6

7  
8 Park, J. K., Cremers, S., and Kossler, A. L. (2019), "Neurostimulation for tear  
9 production", *Current Opinion in Ophthalmology*, Vol. 30, No. 5, pp. 386-394.  
10

11 Patricio, L., Sangiorgi, D., Mahr, D., Čaić, M., Kalantari, S., and Sundar, S. (2020),  
12 "Leveraging service design for healthcare transformation: toward people-centered, integrated,  
13 and technology-enabled healthcare systems", *Journal of Service Management*, Vol. 31, No. 5,  
14 pp. 889-909.  
15

16  
17 Pellas, N., Mystakidis, S., and Kazanidis, I. (2021), "Immersive Virtual Reality in K-12 and  
18 Higher Education: A systematic review of the last decade scientific literature", *Virtual  
19 Reality*, pp. 1-27.  
20

21 Plotkina, D., Dinsmore, J. and Racat, M. (2021), "Improving service brand personality with  
22 augmented reality marketing", *Journal of Services Marketing*, in press.  
23

24  
25 Pleyers, G. and Poncin, I. (2020), "Non-immersive virtual reality technologies in real estate:  
26 How customer experience drives attitudes toward properties and the service  
27 provider", *Journal of Retailing and Consumer Services*, Vol. 57, 102175.  
28

29  
30 Pozharliev, R., Verbeke, W. J., Van Strien, J. W., and Bagozzi, R. P. (2015), "Merely being  
31 with you increases my attention to luxury products: Using EEG to understand consumers'  
32 emotional experience with luxury branded products", *Journal of Marketing Research*, Vol.  
33 52, No. 4, pp. 546-558.  
34

35  
36 Petit, O., Velasco, C., and Spence, C. (2019), "Digital sensory marketing: Integrating new  
37 technologies into multisensory online experience", *Journal of Interactive Marketing*, Vol. 45,  
38 pp. 42-61.  
39

40 Rauschnabel, P. A., He, J., and Ro, Y. K. (2018), "Antecedents to the adoption of augmented  
41 reality smart glasses: A closer look at privacy risks", *Journal of Business Research*, Vol. 92,  
42 pp. 374-384.  
43

44  
45 Roc, A., Pillette, L., Mladenovic, J., Benaroch, C., N'Kaoua, B., Jeunet, C., and Lotte, F.  
46 (2021), "A review of user training methods in brain computer interfaces based on mental  
47 tasks", *Journal of Neural Engineering*, Vol. 18, No. 1, 011002.  
48

49  
50 Saab, M. M., Landers, M., Murphy, D., O'Mahony, B., Cooke, E., O'Driscoll, M., and  
51 Hegarty, J. (2021). "Nursing students' views of using virtual reality in healthcare: A  
52 qualitative study", *Journal of Clinical Nursing*, in press.  
53

54  
55 Sawangjai, P., Hompoonsup, S., Leelaarporn, P., Kongwudhikunakorn, S., and  
56 Wilaiprasitporn, T. (2019), "Consumer grade EEG measuring sensors as research tools: A  
57 review", *IEEE Sensors Journal*, Vol. 20, No. 8, pp. 3996-4024.  
58

59  
60 Scholz, J. and Smith, A. N. (2016), "Augmented reality: Designing immersive experiences  
that maximize consumer engagement", *Business Horizons*, Vol. 59, No. 2, pp. 149-161.

1  
2  
3 Sitaram, R., Ros, T., Stoeckel, L., Haller, S., Scharnowski, F., Lewis-Peacock, J., ... and  
4 Sulzer, J. (2017), "Closed-loop brain training: the science of neurofeedback", *Nature Reviews*  
5 *Neuroscience*, Vol. 18, No. 2, pp. 86-100.

7  
8 Stocco, A., Prat, C. S., Losey, D. M., Cronin, J. A., Wu, J., Abernethy, J. A., and Rao, R. P.  
9 (2015), "Playing 20 questions with the mind: collaborative problem solving by humans using  
10 a brain-to-brain interface", *PloS one*, Vol. 10, No. 9, e0137303.

12  
13 Sundar, S. S. (2020), „Rise of machine agency: A framework for studying the psychology of  
14 Human–AI Interaction (HAI)“, *Journal of Computer-Mediated Communication*, Vol. 25, No.  
15 1, pp. 74-88.

17  
18 tom Dieck, M. C., Jung, T. H., and tom Dieck, D. (2018), "Enhancing art gallery visitors'  
19 learning experience using wearable augmented reality: generic learning outcomes  
20 perspective", *Current Issues in Tourism*, Vol. 21, No. 17, pp. 2014-2034.

22  
23 Tussyadiah, I. P., Wang, D., Jung, T. H., and tom Dieck, M. C. (2018), "Virtual reality,  
24 presence, and attitude change: Empirical evidence from tourism", *Tourism Management*, Vol  
25 66, pp. 140-154.

27  
28 van Pinxteren, M. M., Pluymaekers, M., and Lemmink, J. G. (2020), "Human-like  
29 communication in conversational agents: a literature review and research agenda", *Journal of*  
30 *Service Management*, Vol. 31, No. 2, pp. 203-225.

32  
33 Vansteensel, M. J. and Jarosiewicz, B. (2020), "Brain-computer interfaces for  
34 communication", in *Handbook of clinical neurology*, Vol. 168, pp. 67-85, Elsevier.

35  
36 Weinberger, A. B., Cortes, R. A., Green, A. E., and Giordano, J. (2018), "Neuroethical and  
37 Social Implications of Using Transcranial Electrical Stimulation to Augment Creative  
38 Cognition", *Creativity Research Journal*, Vol. 30, No. 3, pp. 249-255.

39  
40 Wexler, A. (2020), "Do-it-yourself and direct-to-consumer neurostimulation",  
41 In *Developments in Neuroethics and Bioethics*, Vol. 3, pp. 127-155, Academic Press.

42  
43 Wexler, A. and Thibault, R. (2019), "Mind-reading or misleading? Assessing direct-to-  
44 consumer electroencephalography (EEG) devices marketed for wellness and their ethical and  
45 regulatory implications", *Journal of Cognitive Enhancement*, Vol. 3, No. 1, pp. 131-137.

47  
48 Wexler, A. (2018), "Who uses direct-to-consumer brain stimulation products, and why? A  
49 study of home users of tDCS devices", *Journal of Cognitive Enhancement*, Vol. 2, No. 1, pp.  
50 114-134.

51  
52 Wilson, Alan, Valerie A. Zeithaml, Mary Jo Bitner, and Dwayne D. Gremler (2016), *Services*  
53 *Marketing: Integrating Customer Focus Across the Firm*. New York: McGraw-Hill.

54  
55 Wolpaw, J. R. (2013), "Brain–computer interfaces", In *Handbook of Clinical Neurology*, Vol.  
56 110, pp. 67-74, Elsevier.

58  
59 Wunderlich, N. V., Wangenheim, F. V., and Bitner, M. J. (2013), „High tech and high touch:  
60 a framework for understanding user attitudes and behaviors related to smart interactive  
services", *Journal of Service Research*, Vol. 16, No. 1, pp. 3-20.

Zuboff, S. (2019), "Surveillance capitalism and the challenge of collective action", In *New labor forum*, Vol. 28, No. 1, pp. 10-29, Sage CA: Los Angeles, CA: SAGE Publications.

Journal of Service Management

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60