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

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Keywords – Service communication, augmented reality, virtual reality, neuro-enhanced reality, neuromarketing
Paper type – Research paper

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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.

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

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 acceptance, privacy, and ethics, to inspire researchers and practitioners to pursue value-adding and responsible ways of developing and using NeR technology.

2. Conceptual underpinnings: technology-enabled service communication

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

Technology plays a crucial mediating role in this framework (Carr, 2020), described in terms of "communication affordances" that capture the relationship between the user and the interface as well as the resulting possibilities for action (Evans *et al.*, 2017). As we depict in the right-hand side of Figure 1, communication affordances are rapidly expanding due to technological developments. Conventional (self-)service technologies, including websites, online chatbots, or social media, traditionally impose a division between digital and physical aspects of service (Wünderlich *et al.*, 2013). In contrast, AR and VR afford 'hyperreal' communication (Edvardsson *et al.*, 2005) in which the physical and digital are seamlessly integrated (Hilken *et al.*, 2018). NeR promises to advance such communication even further, based on increased technological embodiment through the use BCIs (Flavián *et al.*, 2019). Specifically, NeR provides affordances based on communicators' neurological input, which might supplement – and in the future partly substitute – sensory interaction with external interfaces such as a smartphone or headset. Against this backdrop, we first establish the current state-of-the-art of AR/VR-enhanced service communication, and then discuss its potential progression towards neuro-enhanced service communication.

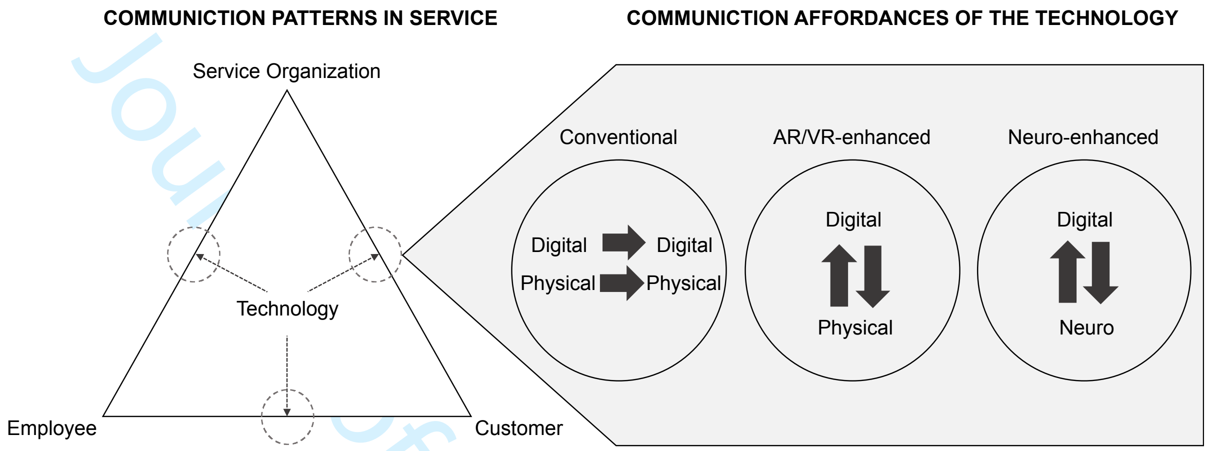

Figure 1. Service communication flows between actors and interfaces

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

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

3.2 Virtual Reality (VR)

VR supports communication amongst users that are immersed in a virtual environment (Bogicevic *et al.*, 2019; Hudson *et al.*, 2019. For example, using an Oculus Rift headset or a smartphone placed into Google's do-it-yourself cardboard headset, customers can 'meet' their real-estate agent at a Sotheby's virtual open house event and jointly tour the premises (Pleyers and Poncin, 2020). Communication in VR is based on affordances for navigating the virtual environment and interacting with the objects or actors therein (Cowan and Ketron, 2019). Further, VR can represent real or imagined worlds (Manis and Choi, 2019), such that communication can take place in replicas of actual servicescapes (e.g., stores or hotels) or fantasy-based environments (e.g., gamified virtual worlds). In this way, VR might also support communication about services that require simulation of hypotheticals or the future (e.g., wealth scenarios at retirement age).

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

3.3 Shortcomings of AR and VR interfaces

Communication with AR and VR requires sensory interaction with external interfaces, most commonly through physical touch or movement on touchscreen devices or handheld controllers (Flavián *et al.*, 2019). These interfaces enable customers to 'offload' some of their input to a service to the digital interface (Heller *et al.*, 2019a). However, they still require customers to commit physical and mental effort in communicating with the interface (Heller *et al.*, 2021), for example when using a touchscreen to 'place' AR content in the physical environment (Scholz and Smith, 2016) or a controller to 'move' through a VR environment (Cowan and Ketron, 2019). This implies that customers must be willing and able to invest such effort, which is a premise that, in practice, many service organizations have found not to be the case (Keeling *et al.*, 2019). Interfaces are thus rapidly evolving to provide new communication affordances based on gesture or voice commands (Heller *et al.*, 2019b), haptic feedback (e.g., HaptX gloves), and olfactory simulation (Nakamoto *et al.*, 2020). NeR 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**
Augmented Reality (AR)				
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 *et al.* (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 *et al.* (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 *et al.* (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 *et al.* (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 *et al.* (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 *et al.* (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 *et al.* (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
Virtual Reality (VR)				

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 *et al.* (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 *et al.* (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 *et al.* (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 Neurable 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 tracking abilities, neuroimaging allows users to communicate simply by thinking of control commands. For instance, EEG sensors that 'read' activity of the motor neurons in the brain enable users to control digital content (e.g., a cursor on a screen, a virtual character in a video game), by thinking of moving their left or right hand, moving their foot, or clenching a fist (Doud *et al.*, 2011; Gilja *et al.*, 2012; McFarland *et al.*, 2010, Lalor *et al.*, 2005). In this way, neuroimaging bypasses part of the sensory stages of communication (Vansteensel and Jarosiewicz, 2020), allowing users to substitute some physical control over interfaces such as manipulating content on a touchscreen or navigating a virtual environment with a controller. These affordances for direct communication between the user's brain and digital content represent what we call "neuro-to-digital" communication, where the customer's neural activity is translated into a response in the digital service environment.

Neurostimulation, in contrast, comprises BCIs that directly activate a user's brain regions based on input from the digital service environment. Such stimulation may be experienced as proximal sensations involving tactile feelings on the skin (Stocco *et al.*, 2014; Lee *et al.*, 2017), patterns displayed in the visual field (Caspi *et al.*, 2021), a sense of smell (Holbrook *et al.*, 2019), or specific bodily reactions (e.g., tear production; Park *et al.*, 2019). As these sensations are generated through neural stimulation, they present opportunities for digitally transmitting sensory experiences and addressing long-standing limitations of online services that have struggled to convey tactile, somatosensory, or olfactory sensations (Petit *et al.*, 2019). Neurostimulation can been achieved in non-invasive ways using transcranial magnetic stimulation (tMS) and transcranial focused ultrasound (tFUS), which activate brain regions through energy pulses. However, companies like Neuralink are also working on invasive BCIs, where electrodes can be implanted in the brain with the goal of increasing the speed of communication by bypassing sensory bottlenecks. Customer acceptance of invasive BCIs remains to be seen, however, the scope of neurostimulation involves affordances for what we call "digital-to-neural" communication – that is, translating digital service stimuli 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.

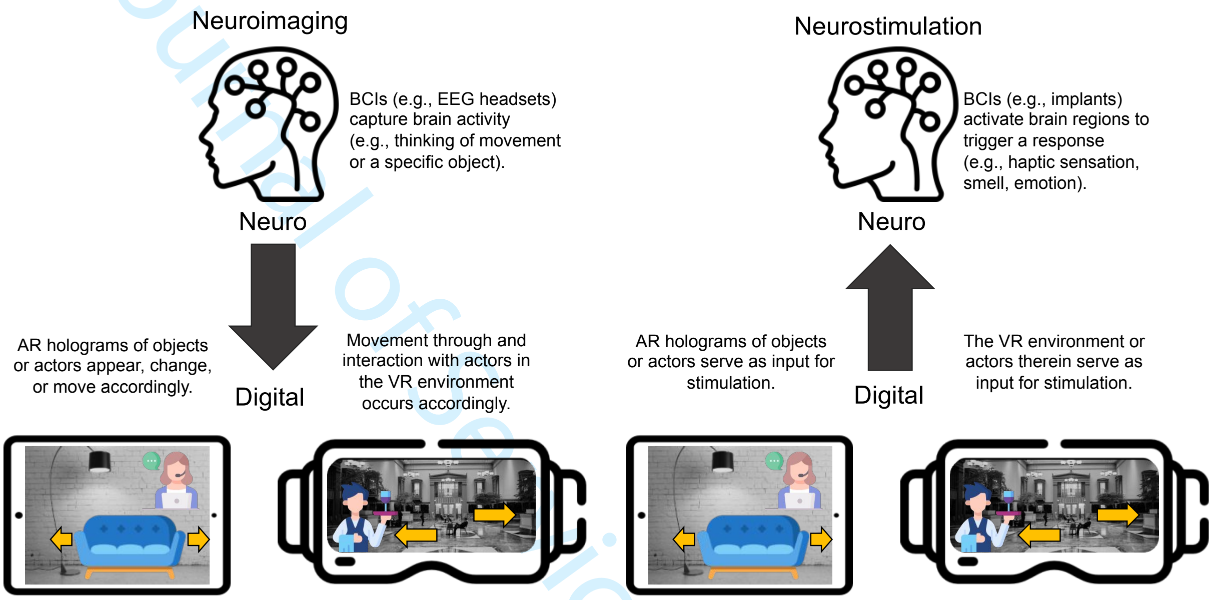

Figure 2. Neuro-to-digital and digital-to-neuro service communication

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 feelings of ownership towards AR holograms (Carrozzi *et al.*, 2019), they are always aware that these are only interacted with 'on-screen'. In contrast NeR, would enable customers to control AR holograms or navigate VR environments simply by thinking of control or movements; or use visual search features by merely thinking of an object in the servicescape to activate suggested alternatives, complements, or use instructions. A need for this type of "sensory-free" control is driven by the transition from handheld to wearable AR and VR devices (Flavián *et al.*, 2019). Microsoft's HoloLens is a prime example of a headset that innovates control modes to allow greater mobility (Heller *et al.*, 2019b), yet faces adoption barriers related to ergonomics and ease-of-use as well as customer concerns about wearing headsets in public (Rauschnabel *et al.*, 2018). In similar vein, communication in VR is hampered when users need to follow a pre-defined route or use a handheld controller to navigate the environment – while actual 'walking' requires dedicated spaces that are often not available in the servicescape (e.g., a VR space in-store or the customer's home).

We thus see neuroimaging as a way of enabling more seamless service communication, not only for customers, but also FLEs. From after-sales service, training and education to medical settings, FLEs typically engage in tasks that require physical movement, for example when demonstrating a product, teaching a skill, or operating on a patient. In these settings, sensory-based controls of AR and VR interfaces may interfere with the performance of these tasks. NeR changes this, for example, when an architect wearing a VR headset with an integrated BCI 'walks' customers through the construction site from the comfort of their office, while potential design changes appear when mentioned in conversation; or a surgeon who while operating brings up AR imagery over the patient's body to communicate to an assistant a precise spot to make an incision. Substitution of sensory-based controls with NeR thus offers unique affordances for improved communication in settings where operating a physical interface may interfere with effective service delivery.

4.2.2 Digital-to-neuro (neurostimulation)

In the more intermediate future, we envisage NeR interfaces that offer an expanded range of sensations through neurostimulation. While AR and VR already offer enhanced visual and auditory information in many service settings, they struggle to support the full range of communication modes. For instance, even though AR improves the 'tangibility' of digital service communications (Heller *et al.*, 2021), those sensations rely on imprecise inferences a customer makes from observing the position, motion, and auditory properties of AR holograms. Actual sensations of haptics, weight, temperature, smell, and taste are typically not available in online settings (Petit *et al.*, 2019). We thus anticipate that the motivation for integrating neurostimulation into AR and VR comes from the need to expand the range of sensations during online service communications. For example, in the case of a VR tour of a holiday resort, neurostimulation might allow a customer to not only 'see' what the lobby, rooms, and spa, might look like, but also 'feel' the textures of the furniture or smell the scent of the freshly prepared breakfast at the hotel's restaurant.

For FLEs, neurostimulation might be used to modulate alertness, mood, reaction time, or creativity (Wexler, 2018), although ongoing debate in the literature about the efficacy and responsible use of such neurostimulation means more research is needed to substantiate its application in service settings (Wexler and Thibault, 2019). That is, while cognitive enhancement through neurostimulation holds significant potential, it requires careful management, especially when attempting to motivate or empower employees, or persuade customers to make decisions (e.g., donating to a charity by triggering guilt; Kandaurova and Lee, 2019). The ethical considerations underlying such applications of NeR are not yet developed and likely will be outpaced by the rapidly evolving technology.

Table 2. Potential progression of reality-enhanced service communication

Service & Communicators	Conventional	AR/VR-enhanced	NeR *Neuroimaging*	NeR *Neurostimulation*
Hotel *Service organization-customer*	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 *FLE-customer*	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 *Service organization-FLE*	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 main themes (i.e., the efficacy, acceptance, and ethical implications of NeR) to advance scholarly knowledge and guide the managerial use of NeR.

5.1 Efficacy of NeR

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

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

Mapping service applications: To move NeR from laboratory to market applications, research should assess which service settings are suitable for deploying neuro-enhanced communication. Currently, there is a strong focus on healthcare settings where applications of neuroimaging and neurostimulation are a natural progression (e.g., to overcome physical disabilities). While we note potential applications in services contexts such as hotels, call centers, and education, more systematic study based on service design methods such as actor network maps and context interviews (Patrício *et al.*, *2020*), would offer user-centered insights into settings poised for transformation towards NeR.

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

5.2 Acceptance of NeR

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

Understanding device adoption: More research is needed to identify the drivers of customer willingness to adopt wearable NeR devices. For AR and VR such adoption has been subdued due to a lack of social acceptability (Rauschnabel *et al.*, 2018), but there is rapid progression towards more unobtrusive devices such as NextMind's EEG sensor which fits into baseball cap or Neurable's EEG which is integrated within a pair of headphones. Relatedly, as technological embodiment progresses towards implants such as those of Neuralink, the question of who will embrace such invasive devices arises. In the healthcare context, patient motivations are seemingly often clear (e.g., overcoming physical disabilities) but in practice are more complicated as competing motivations come into play. Further, an understanding of customer adoption for improving everyday services is yet to be researched. Current research on motivations for "biohacking", such as extracting own DNA or developing do-it-yourself biotech devices might inform such inquiry (Meyer and Vergnaud, 2020).

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

5.3 Ethical implications of NeR

As NeR interfaces directly with the human brain, it presents unprecedented ethical considerations, particularly with regards to the collection, use, storage, and influence of what is perhaps the most personal 'data' there is: a person's neural processes in the mind. Thus, while developments in NeR hold unique potential for improving service, and ultimately customer and employee well-being, regulatory oversight is required to ensure neuroimaging does not culminate in the ultimate commodification of personal data (i.e., 'surveillance capitalism'; Zuboff, 2019), while neurostimulation is applied in ways that do not deceive or manipulate the user (Wexler and Thibault, 2019). Hence, we raise a cautionary note, emphasizing the need for research into regulatory and customer (and employee) sovereignty implications of NeR, and the importance of responsible marketing. We advocate an approach that is framed around user consent and decision-making autonomy.

Determining right to access: Neuroimaging introduces the question of who can 'read' a user's brain activity. Customers are already accustomed to conducting a calculus where they weigh the benefits and costs of improved convenience or personalization in exchange for their data (Kim *et al.*, 2019). Yet, more research is needed to determine to what extent the convenience of having neural information available (e.g., for 'more mindful working' as advertised by Neurable) or using neuroimaging to control AR/VR applications, outweighs the perceived sacrifice of sharing this data with service organizations (and potentially third parties). Continued study should also consider in how far current privacy practices such as the GDPR principles must be updated with regards to specifying and limiting the type and extent of data collection (e.g., which brain activity will not be measured), the intended purpose (e.g., only for the focal service encounter), and potential for longer-term storage (e.g., in a database). Finally, potential dangers of BCIs being hacked must be considered from the outset, to build greater security and trust among customers. Complex services providers (e.g., health and social care) are constantly grappling with such issues and learning from their experiences and solutions could be a fruitful starting point for future research.

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

authenticity of neuro-enhanced communications are needed. Furthermore, neurostimulation enables so-called 'cognitive enhancement' such as stimulating brain areas for increased creativity (Weinberger *et al.*, 2018), which could be used for persuasion or to elicit certain emotions that drive purchase behavior, implying a potential loss of customer autonomy. Research should thus identify situations in which cognitive enhancement is conducive to customer well-being and develop guidelines for transparent opt-in procedures.

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

6. Conclusion

As service providers increasingly predicate their business strategies upon the use of new technologies and formats to enhance services communication, there is a clear need to continuously examine the frontier of current technological developments. Within only a short period of time, AR and VR have established themselves as strategic service tools. The signs are that NeR might follow a similar development trajectory. By taking a multidisciplinary perspective, combining research at the intersection of services management, communication, and neuroscience, we outline a vision of what NeR 'can become' by identifying key opportunities, while also emphasizing the need for considering what it 'should become' by pinpointing key obstacles and the unique ethical considerations that accompany this technology. We believe that now is the right time to start addressing these issues, through future research, to guide researchers and practitioners in developing and using NeR in value-adding and responsible ways.

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