Verhulst, N., De Keyser, A., Gustafsson, A., Shams, P., & Van Vaerenbergh, Y. (2019). Neuroscience in service research: an overview and discussion of its possibilities. *Journal of Service Management*. http://dx.doi.org/10.1108/JOSM-05-2019-0135

NEUROSCIENCE IN SERVICE RESEARCH: AN OVERVIEW AND DISCUSSION OF ITS POSSIBILITIES

Nanouk VERHULST
Vrij Universiteit Brussels (VUB), Belgium
UGent, Belgium

Arne DE KEYSER
EDHEC Business School, France

Anders GUSTAFSSON
Norwegian Business School, Norway

Poja SHAMS
Karlstad Business School, Sweden

Yves VAN VAERENBERGH
KU Leuven, Belgium

*** Authors' surnames are written in capital letters ***

Nanouk VERHULST is Doctor Assistant in the Business Department at the Vrije Universiteit Brussels (VUB). Contact information: Pleinlaan 2, 1050 Elsene, Belgium. Tel. +32 486 48 96 74, E-mail: nanouk.verhulst@vub.be

Arne DE KEYSER is Assistant Professor of Marketing at the Department of Marketing, EDHEC Business School, France. Contact information: 24 Avenue Gustave Delory, CS 50411, 59057 Roubaix Cedex 1, France, Tel. +32494233493, E-mail: arne.dekeyser@edhec.edu

Anders GUSTAFSSON is Professor of Marketing at the Norwegian Business School. Contact information: Nydalsveien 37, 0484 Oslo, Norway, Tel. +4746410191, E-mail: anders.gustafsson@bi.no

Poja SHAMS is Assistant Professor at Karlstad Business School. Contact information: Universitetsgatan 2, 651 88 Karlstad, Sweden, Sweden, Tel. + 05470021 48, E-mail: poja.shams@kau.se

Yves VAN VAERENBERGH is Associate Professor of Marketing at the Department of Marketing, KU Leuven, Belgium. Contact information: Warmoesberg 26, 1000 Brussels, Belgium. Tel.: +32 2 609 82 89, E-mail: Yves.VanVaerenbergh@kuleuven.be

NEUROSCIENCE IN SERVICE RESEARCH: AN OVERVIEW AND DISCUSSION OF ITS POSSIBILITIES

STRUCTURED ABSTRACT

Purpose: The paper discusses recent developments in neuroscientific methods and demonstrates its potential for the service field. This work is a call to action for more service researchers to adopt promising and increasingly accessible neuro-tools that allow the service field to benefit from neuroscience theories and insights.

Design/methodology/approach: The paper synthesizes key literature from a variety of domains (e.g., neuroscience, consumer neuroscience, organizational neuroscience) to provide an in-depth background to start applying neuro-tools. Specifically, this paper outlines the most important neuro-tools today and discusses their theoretical and empirical value.

Findings: To date, the use of neuro-tools in the service field is limited. This is surprising given the great potential they hold to advance service research. To stimulate the use of neuro-tools in the service area, the authors provide a roadmap to enable neuroscientific service studies and conclude with a discussion on promising areas (e.g., service experience, servicescape) ripe for neuroscientific input.

Originality/value: The paper offers service researchers a starting point to understand the potential benefits of adopting the neuroscientific method and shows their complementarity with traditional service research methods like surveys, experiments, and qualitative research. In addition, this paper may also help reviewers and editors to better assess the quality of neuro-studies in service.

Keywords: neuroscience, bodily changes, service experience, servicescape, employee, customer

INTRODUCTION

The neuroscientific method has shown valuable to advance a wide variety of scientific (sub)domains including consumer behavior, organizational behavior, and psychology (e.g., Butler *et al.*, 2016; Camerer and Yoon, 2015; Harris *et al.*, 2018; Murray and Antonakis, 2019). In the service field, however, we have only found a few initial neuroscience applications (e.g., Boshoff, 2012, 2017; Huneke *et al.*, 2015). Recently, several calls have been launched to fuse service research with neuroscientific insights (e.g., De Keyser *et al.*, 2015; Lemon and Verhoef, 2016; Van Vaerenbergh *et al.*, 2019). Other papers call for employing more objective data to measure actual responses, thereby suggesting neuroscientific methods as one potential way forward (e.g., Kumar *et al.*, 2013; Morales *et al.*, 2017). Therefore, we believe the time is ripe for service researchers to adopt neuro-tools. The overall purpose of this paper is to encourage service researchers to engage in multidisciplinary research efforts that adopt neuroscientific methods and provide them with the proper background to guide them in these efforts. This paper has four main goals (see also Figure 1).

First, we introduce the neuroscientific method by proposing a framework that links the neuro-tools to the service domain (see Figure 2) and provide an overview of the most commonly used neuro-tools. *Second*, we discuss the theoretical and empirical value of neuroscience service research, specifically through enhancing our understanding of (1) internal processes and mechanisms, (2) individual/group differences, and (3) behavioral predictions. *Third*, we offer a practical guide for implementing neuro-tools in service research with the cost/benefit trade-off of implementation, challenges with setting-up, conducting and analyzing a neuro-study, and the combination of neuro-tools with traditional tools. Finally, the *fourth* goal is to provide concrete future research opportunities to use neuro-tools for service research, with a particular focus on the impact of external and internal cues, and the service experience and its dynamics.

INSERT FIGURE 1 AROUND HERE

THE NEUROSCIENTIFIC METHOD

Capturing changes in the brain activity, peripheral system, and the neurotransmitters & hormonal system

Neuroscience studies the nervous system and its link to behavior (Society of Neuroscience, 1969). This paper focuses on the neuroscientific study of changes in the human body at three vital levels – (1) the brain, (2) the peripheral system, and (3) the neurotransmitters and hormonal system (see Figure 2; e.g., Cacioppo *et al.*, 2016; Lim, 2018). *Brain activity changes* involve (de)activation of certain brain regions. Changes are either related to higher/lower activity in a specific brain part (i.e., activation) and/or changes in which specific part is active or not (i.e., localization; Kenning *et al.*, 2007). *Peripheral system changes* reflect physiological alterations outside of the brain and spinal cord (Hubbard, 1974), such as increased sweat production, pupil dilation/contraction, heart rate variations, and muscle activation (Cacioppo *et al.*, 2016). *Neurotransmitter and hormone system changes* involve biochemical changes in the body or brain, including varying levels of oxytocin, serotonin, dopamine, testosterone, and cortisol (Von Bohlen and Halbach, 2006).

These changes in the human body result from an individual's interaction with internal cues and/or the external environment (Cacioppo *et al.*, 2016). These changes are generally automatic and happen unconsciously (Bargh, 2002; Jänig, 1989). Ample academic literature provides evidence for the strong impact of bodily changes on various cognitive, affective, and behavioral processes (e.g., Barrett *et al.*, 2007; James, 1894; Laird and Lacasse, 2014). Therefore, any insight that can be generated into these automatic and largely unconscious processes may advance our knowledge of customer and employee behavior.

In service research, the servicescape model by Bitner (1992) offers a great starting point to capture the larger environment in which service customers and employees are embedded. This model posits that external cues (i.e., stimuli) trigger bodily changes within customers and employees, which ultimately impact important outcomes like satisfaction and well-being. To complement Bitner's servicescape model, we identify a series of internal cues driving bodily changes (e.g., Critchley and Harrison, 2013). While both sets of cues – external and internal – interrelate, this discussion is outside the scope of this paper.

INSERT FIGURE 2 AROUND HERE

External cues reside in the environment outside an individual, and can largely be classified as cues in the physical (e.g., sound, color, layout, symbols; Bitner, 1992) or social servicescape (e.g., someone coming closer, emotions displayed by others; Rosenbaum and Massiah, 2011; Rosenbaum and Montoya, 2007). External cues impact a wide variety of changes in our body and brain (See Figure 2) that subsequently impact cognitive, affective and behavioral outcomes (Barrett *et al.*, 2007; James, 1894; Laird and Lacasse, 2014). For instance, an employee gently touching a customer may lead to increased customer oxytocin levels, which in turn may impact customer feelings of trust (e.g., Ellingsen *et al.*, 2014; Morhenn *et al.*, 2008). Similarly, customers finding themselves in a crowded service environment may start sweating, indicating arousal and triggering impulse buying (Maeng *et al.*, 2013; Mattila and Wirtz, 2008).

Internal cues occur within an individual's body, and reflect feelings such as hunger, sexual desire, heart rate changes, and varying hormone levels (e.g., Barrett *et al.*, 2007; James, 1894; Laird and Lacasse, 2014). In addition, they also include cognitive cues (e.g., internal representations in memory, internal anxiety; Kiyonaga and Egner, 2014; Unnewehr *et al.*, 1996), and stable bodily traits (e.g., genetics; Shaw and Bagozzi, 2018). Internal cues mostly result from the human body trying to find balance, a process called homeostasis in physiology (Critchley and Harrison, 2013; Widmaier *et al.*, 2018). Similar to their external counterparts, internal cues are proven to drive various outcomes (Barrett *et al.*, 2007; James, 1894; Laird and Lacasse, 2014). Feelings of hunger, for instance, benefit strategic decision making (Ridder *et al.*, 2014), but also increase unethical behavior at work (Yam *et al.*, 2014). Similarly, genetics have been shown to impact cooperative behavior (Millet and De Witte, 2006) and preference for utilitarian or hedonic options (Simonson and Sela, 2010).

In the following paragraphs, we outline three broad categories of neuro-tools that enable researchers to capture brain, peripheral system and neurotransmitter and hormone system changes resulting from the identified external and internal cues. Neuro-tools largely fall in three groups (see Figure 2; Dimoka *et al.*, 2012; Kenning and Plassmann, 2005; Mauss and Robinson, 2009): (1) neuroimaging tools, which measure changes in the brain, (2) neurophysiological tools, which measure changes in the peripheral system; and (3) biochemical tools to measure changes in hormone and neurotransmitter levels. We introduce only the most relevant tools for service research. For tool-specific exemplary studies, we refer the reader to Harris *et al.* (2018), who have elegantly summarized key studies for each tool. For more technical discussions, we refer the reader to neuroscientific and psychology journals such as *Frontiers in Neuroscience*, *Nature Reviews Neuroscience*, *Annual Review of Neuroscience, Annual Review of Psychology, Social Cognitive and Affective Neuroscience* (SCAN), *Cognitive*, *Affective and Behavioral Neuroscience* (CABN), and *Psychological Bulletin*.

Neuro-tools: an introduction

Capturing the brain – Neuroimaging tools. Neuroimaging tools measure changes in brain activation and activity location (e.g., motor area, language area, hippocampus) in response to internal or external cues (see Figure 2). The methods vary in their ability to quickly measure activity in a specific brain area (temporal resolution) and ability to differentiate between different regions in the brain (spatial resolution; Kenning *et al.*, 2007). As a result, researchers often need to make a trade-off between temporal resolution or spatial resolution (Harris *et al.*, 2018). Temporal resolution becomes essential when the focus of a study lies on studying dynamic cues such as during a service experience composed of different touchpoints that follow one another. Spatial resolution matters if the researchers are interested in activity in a specific brain location, such as when they want to investigate if the same brain area is activated when making an actual choice versus making a hypothetical choice (e.g., Kang *et al.*, 2011). Here, we discuss only electroencephalography (EEG) and functional magnetic resonance imaging (fMRI). Other neuroimaging tools exist but fall outside the scope of this paper. We gladly refer to reader to Ahlert *et al.* (2006), Harris *et al.* (2018), Jack *et al.* (2019), Kenning and Plassmann (2005), Krampe *et al.* (2018), and Morin (2011) for a discussion of Positron-emission tomography (PET), magnetoencephalography (MEG), steady states topography (SST), transcranial magnetic stimulation (TMS), functional transcranial Doppler sonography (fTCS), optogenetics, and functional near-infrared spectroscopy.

EEG measures voltage fluctuation at the surface of the brain (Kenning and Plassmann, 2005; Ohme *et al.*, 2011) and can accurately detect temporal changes in brain activity (Ahlert *et al.*, 2006; Kenning and Plassmann, 2005). This technique is mostly used to investigate affective and cognitive processes (e.g., Lin *et al.*, 2018; Ohme *et al.*, 2010). While EEG has many potential applications for service research, a particularly interesting one to measure affective processes is frontal brain asymmetry, where electrodes are positioned on the frontal part of the scalp (Cacioppo *et al.*, 2000; Ohme *et al.*, 2009). Frontal brain asymmetry can capture approach-avoidance behavior following a stimulus (Mauss and Robinson, 2009). Approach behavior is associated with positive emotions, such as engagement, interest, and happiness, whereas avoidance is associated with negative emotions, such as disinterest, disengagement, fear, and disgust (Davidson *et al.*, 1990).

The availability of ‘plug and play’-devices on the market make EEG appealing for service research (e.g., Emotiv EPOC; Byrom *et al.*, 2018). These mobile EEG systems cater to academics and/or practitioners without comprehensive training in neuroscience and psychology. While these systems might not be suitable to study complicated processes, plug and play devices can be very useful to study consumers and employees in real-life settings (Sazonov and Neuman, 2014). These devices do not require a complex installation of sensors on the skull or extremely complicated data-analysis, instead they offer headsets that are easily placed on the skull and return relatively straightforward data (Byrom *et al.*, 2018).

fMRI is the most powerful neuroimaging tool currently available. This tool captures the change of blood flow in the brain and has great spatial resolution. Recent studies show that fMRI is able to shed light on subconscious processes such as affective aspects of consumer behavior (e.g., desirability; Venkatraman *et al.*, 2012), but may also be used to investigate memory or complex cognitive tasks (e.g., decision-making; Critchley, 2009; Solnais *et al.*, 2013). Service research could use fMRI to study brain responses and better understand affective and cognitive reactions to specific service situations. Also, fMRI is ideal to study the neural basis of individual differences (Jack *et al.*, 2019). However, we caution that still many limitations are at hand (Kenning *et al.*, 2007). For instance, fMRI only allows rather simple designs, since it relies on many repetitions of a cue (to reduce noise), thus compared to EEG its temporal resolution is lower. Furthermore, fMRI- studies can only be conducted in a lab, are very expensive, and typically suffer from low statistical power (Button *et al.*, 2013).

Capturing the peripheral system – neurophysiological tools. Neurophysiological tools aim to capture changes in the peripheral system, such as sweat responses, pupil dilation, heart rate, and muscle activation. Specifically, these tools are particularly useful to determine whether a person is feeling positive or negative, aroused or not, and/or whether the person will approach or avoid something (Barrett, 2006; Cacioppo *et al.*, 2000; Mauss and Robinson, 2009). Indeed, neurophysiological tools are extensively used in emotion research and often combined with each other (Bell *et al.*, 2018). The most prevalent neurophysiological tools are galvanic skin response (GSR), cardiovascular measures, electromyography (EMG), and eye tracking (Harris *et al.*, 2018; Mauss and Robinson, 2009; Poels and Dewitte, 2006).

GSR captures activity in the sweat glands, which indicates physiological arousal and is measured by electrodes or sensors placed on the skin (Caruelle *et al.*, 2019; Christopoulos *et al.*, 2019; Ohme *et al.*, 2009). GSR is suitable to, amongst other things, investigate attentional and emotional processes (Dawson *et al.*, 2016). For example, GSR could be used to real-time monitoring of stressful or emotionally arousing moments during a service experience or at work (e.g., Boshoff, 2017; Mozos *et al.*, 2017). Easy-to-use and wearable options are already available (e.g., iMotions; Empatica E4), as well as non-contact (i.e., no skin contact needed) techniques (e.g., thermal imaging measures; webcam; Dawson *et al.*, 2016; Krzywicki *et al.*, 2014.; Rohrbaugh, 2016).

Cardiovascular tools measure heart rate or related measures by means of electrodes or sensors (e.g., electrocardiogram- ECG, photoplethysmography- PPG; Massaro and Pecchia, 2019). Heart rate is not only linked to physiological arousal but is also connected to affect (Lang *et al.*, 1993; Poels and Dewitte, 2006) and cognitive processes (e.g., reasoning; Berntson, *et al.*, 2016; Massaro and Pecchia, 2019). For example, cardiovascular measures allow tracking attention toward specific vocal information during a service encounter or work meeting (Poels and Dewitte, 2006). Again, multiple plug and play devices exist (e.g., Shimmer). For example, Fitbit markets various wearable devices that measure heart rate and track physical activity. While a Fitbit or similar products are currently still too inaccurate for use in academic research, the rapid increases in their accuracy will soon make them appropriate for research purposes (e.g., Maijers *et al.*, 2018). Further, techniques to measure cardiovascular changes that do not need skin contact, such as a webcam, are also gaining ground (Fernandes *et al.*, 2017; Lemay *et al.*, 2014; Monkaresi *et al.*, 2014; Poh *et al.*, 2011).

EMG measures changes in muscle activity (i.e., is a muscle contracting or not?; Fridlund and Cacioppo 1986). The most interesting application for service research is facial EMG (fEMG), which assesses facial muscle activity directly connected to emotional states (Dimberg and Petterson, 2000; Fridlund and Cacioppo, 1986; Larsen *et al.*, 2003). The fEMG registers negative emotions (e.g., frowning), or positive emotions (e.g., smiling). fEMG could prove valuable to study mimicry (i.e., automatic matching of expressions) during social interactions, for example when during a meeting or service encounter two humans show the same emotional valence and when does valence not align. Today, facial recognition software offers a plug and play alternative to measure specific emotions (e.g., happiness; anger; Lewinski *et al.*, 2014). Compared to fEMG, facial recognition software is relatively easy to use. A camera or webcam is sufficient hardware to measure muscle changes (e.g., Facereader; Lewinski *et al.*, 2014). Although the output provided by the software can be used directly, only very intense emotions can be tracked. Current packages are not yet able to accurately detect subtle emotions (e.g., Yitzhak *et al.*, 2017).

Eye tracking systems are used to measure the position and movement of the eyes and to measure pupil dilation and amount of blinking (Harris *et al.*, 2018; Ohme *et al.*, 2011). Eye movement data is mainly used to track attention, for instance when viewing commercials (e.g., Wedel and Pieters, 2008). Further, pupil dilation is an automatic physiological reaction, linked to attention (Hoeks and Levelt, 1993), arousal (Bradley *et al.*, 2008), mental effort and workload (Brookings *et al.*, 1996). Eye tracking data has many potential applications in service research, for example to investigate where attention is focused on during a service experience. Next to highly advanced lab-based eye tracking devices, several cheap and easy to use solutions exist, such as wireless glasses and mobile phone applications that make use of the frontal camera (e.g., GazeCapture, Right Eye; Byrom *et al.*, 2018).

Capturing the neurotransmitters and hormone system – biochemical tools. Biochemical measurement tools seek to capture the level of neurotransmitters or hormones present in the body or brain. Examples are cortisol, oxytocin, and testosterone. Neurotransmitter and hormones can affect behavior (e.g., buying behavior; Lichters *et al.*, 2015) and psychological processes (e.g., mood, trust) dramatically (Ramsøy and Skov, 2010; for reviews see Rilling and Sanfey, 2011; Von Bohlen and Halbach, 2006).

Biochemical tools. Researchers mainly rely on blood draws, saliva swabs, and urine samples to capture the amount of neurotransmitters or hormones in humans (e.g., Buckert *et al.*, 2014; Lovallo and Buchanan, 2016). Important to note is these biochemical tools (e.g., blood draw) measure *specific* biochemicals in the body, hence not all biochemicals can be measured by each tool (e.g., a saliva swap). Measuring biochemicals can help understanding particular processes better, since the presence of increased or decreased biochemical levels can be linked to different behavior and processes. For example, serotonin is related to mood regulation (e.g., Lichters *et al.*, 2015), dopamine in reward processes (e.g., Schultz, 2017), and cortisol is linked to stress responses (e.g., Akinola and Mendes, 2012). We gladly refer to reader to Rilling and Sanfey (2011) and Von Bohlen and Halbach (2006) for an extensive discussion of all biochemicals and their link to specific processes and behavior. A particularly interesting biochemical for service research is oxytocin since it is a key driver of empathy, prosocial behavior, and trust during human interaction (e.g., Barraza & Zak, 2009). In addition, biochemical measurement can also serve as ‘manipulation check’ in experimental settings. Cortisol levels, for instance, that spike after being confronted with a stressor could be measured to establish whether an experimental stressor actually worked (Yoon *et al.*, 2012).

Generally, blood samples are the most accurate, but very invasive compared to urine samples and saliva swabs, and therefore often not possible to use in real-life settings. Nevertheless, all of these techniques involve taking samples of body fluid, which are very intrusive. Fortunately, newer technologies, such as smart tattoos, patches, and finger sticks to take small amounts of blood are being developed, and have the potential to change the invasive nature of studying biochemicals (Ramsøy and Skov, 2010; Rohrbaugh, 2016).

THE VALUE OF THE NEUROSCIENTIFIC METHOD

Having introduced the most relevant neuro-tools, we now discuss the added value of adopting these tools. Neuro-data and tools have already proven their worth in consumer behavior (i.e., consumer neuroscience or neuromarketing – Camerer and Yoon, 2015; Harris *et al.*, 2018; Plassmann *et al.*, 2015; Solnais *et al.*, 2013) and organizational behavior (i.e., organizational neuroscience –Becker *et al.*, 2011; Becker and Cropanzano, 2010; Butler *et al.*, 2016; Jack *et al.*, 2019; Murray and Antonakis, 2019). Building on previous work in these domains (Karmarkar and Plassmann, 2019; Plassmann *et al.*, 2015; Senior *et al.*, 2011; Yoon *et al.*, 2012), we identify three key ways in which neuro-data and tools have proven essential for theory development and testing: (1) understanding mechanisms and processes, (2) understanding individual and group differences, (3) improving behavioral predictions. Ultimately, the combination of these three factors leads to better and new theory development and testing.

Understanding Cognitive, Emotional and Physiological Processes and Mechanisms

Previous research demonstrates the value of the neuroscientific method for studying a wide variety of processes, such as affective processes, decision-making, reward and motivational processing, and memory and attention (Plassmann *et al.*, 2011; Puccinelli *et al.*, 2009; Solnais *et al.*, 2013). Neuro-data might be particularly suitable to investigate how internal and external cues impact organizational and behavioral outcomes, acting as moderators/mediators driving cognitive, emotional and physiological processes and mechanisms (Lim, 2018).

Two key reasons can be put forward to why the neuro-toolkit is so well-equipped to study internal processes and mechanisms. First, they allow capturing (implicit) processes and mechanisms that were previously unknown or inaccessible through traditional data capturing (Kumar *et al.*, 2013; Plassmann *et al.*, 2015). Access to neuro-data may push our understanding of specific processes and mechanisms that drive human behavior, such as subconscious responses toward socially undesirable products or cues, levels of neurotransmitters, active brain parts, or visual patterns (e.g., Karmarkar and Plassmann, 2019; Murray and Antonakis, 2019; Waldman *et al.*, 2019). In this sense, the neuro-toolbox is particularly adept to overcome several types of systematic measurement errors that come with more traditional tools, such as social desirability bias, halo effect, and unwillingness to answer (see Table 1; Boshoff, 2012; Fortunato *et al.*, 2014; Poels and Dewitte, 2006).

For example, Boshoff (2012) combined EEG, EMG, galvanic skin response, and self-reports to study the impact of ethnicity and gender of both service provider and customer during a service experience. He showed that, in contrast to what is generally expected (e.g., similarity-attraction theory; Byrne, 1971), high physical similarity between customer and service provider resulted in higher negative emotional responses (measured by neuro-tools) in customers after a service failure. Traditional post-encounter self- report measures did not reveal this difference. Hence, in situations where social desirability might be at play (e.g., impact of gender or ethnicity), neuro-tools may complement insights gained using more traditional approaches.

INSERT TABLE 1 AROUND HERE

Second, unlike most traditional measurement tools the neuro-toolbox allows to capture processes in real-time. Most neuro-tools qualify to measure bodily changes before, during, and after specific target behaviors or processes take place (Plassmann *et al.*, 2015), avoiding issues with timing of evaluation and recall bias (Table 1). Such measurement may offer more fine-grained insights into what customers go through during an experience (Zomerdijk and Voss, 2010). For example, Clark *et al.* (2018) used eye tracking, EEG, galvanic skin response, heart rate, and facial affect to better understand the impact of advertisement placement in mobile applications. By collecting real-time neuro-data, they could pinpoint best practices related to user engagement, attention, and affect.

Understanding Individual and Group Differences

Studying neuroscientific changes can offer deeper insights into individual differences and group differences (e.g., segments, cultures, teams) and how human minds work (Plassmann *et al.*, 2015; Waldman *et al.*, 2019). Variations in brain structure (e.g., gray matter volume), receptors, and genes can be linked to individual differences in personality, behavior, and/or how the brain/body functions (DeYoung *et al.*, 2010; Ebstein *et al.*, 2010). Improving our understanding of why certain customers/employees may react totally different in a given context and understanding whether this is contingent upon situational and/or individual differences holds great value in the service research domain (Chandler and Vargo, 2011; Edvardsson *et al.*, 2018).

The application of neuro-tools may push the boundaries of specific topics since they advance our understanding of how individuals or groups act under certain conditions and provide explanations previously unattainable. For instance, Reimann (2018) show that people who strongly prefer large-sized portions (even if they have a monetary incentive to eat less) have a thicker prefrontal cortex (only specific areas). Similarly, preference for immediate versus delayed rewards can be explained by differences in a particular neurological phenomenon (Meyer-Lindenberg *et al.*, 2006; Ramsøy and Skov, 2010).

One area that is particularly interesting is that of demographic differences. For example, Zhang *et al.* (2009) used a twin study to investigate gender differences in genetic underpinnings of becoming an entrepreneur. Male (female) entrepreneurship is less (more) influenced by genetics, but largely (less) driven by shared-environmental influence. As services are increasingly taking place in a global context and demographic differences are ranked highly on public policy agendas (Ostrom *et al.*, 2015), understanding the importance of demographic differences is important. To date, these variables are too often treated as covariates rather than focal variables of a study.

Also, we may improve our knowledge on the impact of "state-dependent" variability. In other words, how do specific bodily states, such as being nutritionally or sleep-deprived, interplay with the way humans act and feel? Hungry, stressed, and/or tired customers/employees often behave differently than one might expect. For example, hunger can increase unethical behavior at work (Yam *et al.*, 2014), thus managers should think wisely before cutting down on breaks or planning meetings during lunchtime. Further, sleepy people confronted with socially ambiguous situations tend to interpret them in a more negative manner (Budnick and Barber, 2015). Bodily states can shape behaviors, cognition, decisions, and emotion (e.g., Budnick and Barber, 2015; Hoffmann *et al.*, 2019), yet the impact of these bodily states is often overlooked both in service research as in practice. By studying bodily states, research could better understand their working and how companies can use this knowledge to better manage employees and /or satisfy customers.

Improving Behavioral Predictions

Neuro-data can also help improve predictions at both an individual and an aggregate (or population) level (Knutson and Genevsky, 2018; Plassmann *et al.*, 2015; Venkatraman *et al.*, 2012), because these data add other sources of information (i.e., bodily changes and behavior) usable for predictive modeling (Bell *et al.*, 2018). With self-report data, one limits their understanding to, for instance, attitudes or perceptions. Combining this data with neuroscientific input can increase predictive validity and understanding of a situation as a whole (Bell *et al.*, 2018; Boksem and Smidts, 2015; Venkatraman *et al.*, 2012). As behavioral prediction becomes more important, any input to enhance this ability is valuable (Ostrom *et al.*, 2015). Boksem and Smidts (2015), for instance, show that brain changes can successfully predict movie preferences at both the individual level and population level, but also predicts box office revenue. In a similar vein, Genevsky *et al.* (2017) demonstrate that brain activation can successfully predict individual-level and population-level crowdfunding success, whereas survey measures (e.g., choices and affect ratings) could not.

Theory Building and Refinement

By enabling better insights into internal human processes and mechanisms, embracing customer/employee heterogeneity, and informing behavioral predictions, neuro-tools ultimately support theory-building and testing. Several service scholars have suggested that in order to push the boundaries of our domain there is a need to infuse our thinking with novel theories and build more comprehensive conceptual models (e.g., Benoit *et al.*, 2017; Stewart and Zinkhan, 2006). The neuro-toolbox and neuroscientific theory can help to accomplish this in several ways.

First, neuro-tools can help to refine existing theories and uncover their boundary conditions. For instance, Casado-Aranda *et al.* (2018) challenged the traditional notion that different types of perceived online risk (financial, privacy, and performance) lead to similar internal responses and outcomes. Their fMRI-study revealed differences in brain region activation associated with different processes (e.g., distrust, penalty) when experiencing different types of risk (financial, privacy, and performance risk) during an e-shopping assignment, which ultimately led to varying consumer outcomes.

Second, the neuro-toolkit can help shed new light on long-standing discussions between competing theories as they are equipped to dissociate between particular processes that are otherwise hard to distinguish. For example, in the debate on the usefulness of hypothetical scenarios in experimental design, Kang *et al.* (2011) show that real choice versus hypothetical choice settings activate the same neural circuitry, assuring that hypothetical choice experiments can be used as a proxy of real choice. Another example comes from Plassmann *et al.* (2008) who show that price really changes the taste of wine. Tasting expensive wine (vs. cheap, yet identical wine) activates a brain area related to experiencing something pleasant. Before their experiments, it was impossible to conclude whether respondents merely rated the expensive wine better due to social desirability bias or induced expectations, or whether it actually tasted better.

Last, knowledge and findings stemming from the neuroscience field can infuse the service domain to construct novel theories and hypotheses that can be tested with neuro-tools (Littlefield and Johnson, 2011; Yoon *et al.*, 2012). Some interesting examples to consider are new affective theories (e.g., multi-level constructionist approach; Barrett and Satpute, 2017; Breiter *et al.*, 2015), theories about decision-making (e.g., somatic marker hypothesis; Bechara and Damasio, 2005), and novel discoveries on memory, learning, and mirroring processes (e.g., memory engrams; mirror mechanism seems to be a basic principle of brain functioning; Ferrari and Coudé, 2018; Rizzolatti and Sinigaglia, 2016; Roy *et al.*, 2017).

In summary, the neuro-toolkit has the potential to advance the service domain in a variety of ways. Since neuro-tools are well-equipped to study underlying processes over time (including affective processes), understand the impact of context (including individual differences), predict human behavior and enhance theory-building, they hold great promise to push the boundaries of the service field. Combining traditional measures (e.g., surveys) with neuro-tools and theory might be key in advancing our knowledge on customers and employees (Becker and Cropanzano, 2010; Bell *et al.*, 2018; Kenning and Plassmann, 2008).

WORKING WITH NEUROSCIENTIFIC DATA: A ROADMAP

So far, this paper discussed the various types of neuro-tools and highlighted how the neuro-toolbox and theory can bring considerable gain to the service research field. Yet, getting started with new methods might come with significant startup costs and follows a steep learning curve. In this section of the paper, we therefore outline a roadmap for service researchers looking to use neuro-tools and discuss their practical up- and downsides. The goal of this roadmap is to discuss key challenges related to neuro-studies and to give insights to service researchers before embarking on a neuroscientific service journey. Additionally, Table 2 provides a sample checklist to guide future researchers and reviewers in executing, writing, and reviewing neuro-studies.

TABLE 2 AROUND HERE

Assessing the value of neuro-tools for a given project and determining its role

Before planning a neuro-study, it is vital to assess whether the neuro-toolbox can add to the understanding of the topic under study (Plassmann *et al.*, 2015). Not every topic is highly suitable to study by means of neuro-tools (Harris *et al.*, 2018; Waldman *et al.*, 2019). To illustrate, when the goal of a study is to know which option customers choose within a decision-set, looking at sales statistics may be the most efficient answer. However, if the goal is to investigate how a decision set reduces to a consideration set and finally to a choice set, and what products follow the whole process from the first observation until choice, a neuro-tool like an eye tracker may prove to be a very helpful tool above traditional surveys.

When deciding which specific tool(s) to use in a particular study, it is vital to keep in mind that it is not always straightforward to discern what a tool measures (e.g., heart rate analysis can be used both to study affective processes and stress; Bell *et al.*, 2018; Kreibig, 2010; Massaro and Pecchia, 2019). Neuro-tools and our knowledge of the human body are still in progress. This may lead to some uncertainty as to what a tool specifically captures (e.g., Kennedy and Northover, 2016). For example, to comprehend whether a change in arousal, measured by galvanic skin response, is caused by oneself or the servicescape, additional data sources capturing external and/or internal cues should be added, such as observation, video, and surveys.

Various tools can measure exposure to external and internal cues in a more objective way – which are often labeled as objective indicators. Tools to measure external cues include wearable haptics devices (Kurita, 2014), sensors to measure motion and physical activities (Tamura, 2014), microphones to capture sounds or voices, odor sensors, and eye tracking devices to investigate what a subject visually perceived. For example, combining eye tracking with galvanic skin response can help to understand what specific cue evoked physiological arousal by tracking visual attention. Further, socially aware systems and electronic badges can be used to capture social cues. These tools measure how close people stand from each other, how often they talk, track motion, or tone of voice (e.g., 'Sociometer', 'Vibefone'; Choudhury and Pentland, 2003; Gips, 2006; Madan and Pentland, 2006; Olguın *et al.*, 2009). These kinds of applications can inform us whether a certain social cue was present or not (Gips, 2006; Olguın *et al.*, 2009). For example, EEG could be combined with changes in tone of voice during a meeting, to understand if these changes trigger approach or avoidance feelings during the meeting. On a side note, these types of applications can inform whether a certain social cue was present but also help to study the social servicescape in general (Chaffin *et al.*, 2017; Gips, 2006; Olguın *et al.*, 2009).

To objectively measure internal cues (e.g., cortisol change, stable bodily traits), neuro-tools may be used. For example, cortisol measures cannot only serve as an outcome measure but also as a 'manipulation check'. Cortisol spikes after being confronted with a stressor (i.e., a stressful cue). By measuring cortisol levels in participants, one may objectively establish if the stressor manipulation indeed did its job (Yoon *et al.*, 2012).

Trading off the value of neuro-tools with their cost, usability, and intrusiveness

The use of neuro-tools, in general, comes at a cost. Neuro-studies are typically more expensive than their traditional counterparts, sample sizes are often small, and most neuro-tools imply a certain level of invasiveness for participants (e.g., Bell *et al.*, 2018; Fortunato *et al.*, 2014).

The recent development of plug and play devices, including wearables, and even non-contact techniques (e.g., webcams to read heart rate or galvanic skin response; Krzywicki *et al.*, 2014; Lemay *et al.*, 2014; Rohrbaugh, 2016) might overcome these downsides (see Byrom *et al.* (2018) for an overview). These devices typically cost less, are less intrusive allowing for easier use in real-life applications, and can be used with bigger samples. The current criticism that plug and play devices often deliver less accurate data than their medical counterparts is true, yet, recent work argues for the increasing reliability of plug and play data (Akintola *et al.* 2016; Bell *et al.*, 2018; Byrom, *et al.*, 2018).

The obvious trade-offs between the use of medical (i.e., more complex yet more accurate devices) or plug and play tools mandate reflection about the level of complexity and detail needed for a specific study. The more neuro-tools/data are key to answer the research question, the more medical devices are recommended. The more a study seeks to combine various data-sources, plug and play devices may be considered as an extra layer of data. If medical neuro-tools are preferred, a multi-disciplinary team to conduct neuro-studies might be recommended, while a plug and play options may be used by less experienced researchers already (Byrom *et al.*, 2018). Today, it must be noted that multidisciplinary research efforts are increasingly endorsed/encouraged by editors, publishers, and funding institutes (e.g., Gustafsson and Bowen, 2017).

Overcoming neuro-data collection and analysis challenges

To kick-start neuroscientific research in the service domain, straightforward and rather simple designs are recommended (Jack *et al.*, 2019). Yet, even with simple designs, conducting neuro-studies demands involves making careful decisions that will impact study design, sample size, and data analysis. In what follows we highlight some key considerations while designing, conducting, and analyzing neuro-studies oneself. In some cases, interesting datasets may also be available (and bought) from market research companies (e.g., Kantar and Nielsen) specializing in this area.

Study set-up and data collection. Three key challenges while designing a neuro-study and data collection emerge, namely baseline measurement, synchronization, and confounding variables. *First*, measuring baselines or resting state/default bodily activity is standard practice for most types of neuro-data. To illustrate, brain or heart activity is different across individuals even without changes in the environment (e.g., Jackson *et al.*, 2003; Massaro and Pecchia, 2019), hence a baseline measurement allows correcting experimental responses (Kirk, 2003; Pocock *et al.*, 2002; Zhang *et al.*, 2014).

Second, while combining different neuro-tools, accurate synchronization between the tools is vital. To illustrate, a study combining heart rate and eye tracking while studying an e-commerce website normally has to rely on two different devices that both provide different data streams. These two streams of data not only need to be synchronized with each other but also with the events or cues under study.

Third, researchers need to keep track of confounding variables (e.g., Bell *et al.*, 2018; Duncan and Northoff, 2013; Massaro and Pecchia, 2019). Examples are, temperature changes or sudden noise in the study environment, unintended movement of participants, unique participants traits (e.g., sex, age, a beard, glasses, health conditions), or even research assistants traits (e.g., the gender or perfume of the assistant). For example, an author of this paper once lost 7 participants during a study, because the EEG-sensors did not stick due to higher temperatures and the subsequent sweat production. On other occasions, several invited participants had to drop out for an EMG study due to a heavy beard, and female participants wearing too much mascara hindered an eye tracking study.

A less obvious, yet important, confounding variable is tasks or goal instruction (Duncan and Northoff, 2013). Instructions for neuro-studies should be as specific as possible, consistent across participants, and possible variability of reactions toward instructions while designing a study should be taken into account (Duncan and Northoff, 2013). For example, ‘please buy a premium product’ versus ‘please by a product’ or ‘just relax and lie still in the scanner’ versus ‘ignore the scanner noise’ while measuring the baseline can lead to different bodily changes or outcomes (Benjamin *et al.*, 2010; Duncan and Northoff, 2013).

To limit problems related to the previously discussed challenges, it is recommended to extensively pilot test neuro-studies to ensure synchronization, equipment is working properly, avoidable confounding variables are restricted (e.g., check if participants do not make unplanned movements), and instructions before and during the study are clear.

Sample size considerations. As mentioned previously, conducting neuro-studies can be intensive and intrusive for participants, and hence neuro-studies are typically run with relatively small sample sizes. A problem associated with these smaller sample sizes is low statistical power, which refers to the probability to detect a true effect. Button *et al.* (2013) show that the median statistical power of neuro-studies is typically between 8 and 31%, which essentially means that if an effect really exists, it is picked up by only 8 to 31% of the neuroscientific tests designed to detect this effect. Moreover, low-powered studies reduce the likelihood that a statistically significant effect actually reflects a true effect, which generally results in an overestimation of effect sizes and low reproducibility of the results. Researchers planning to conduct a neuro-study should therefore explicitly consider statistical power when determining the number of participants. We gladly refer the reader to Button *et al.* (2013) for more information.

Data-analysis and interpretation. Neuro-data creates new challenges as interpretation is not always straightforward (e.g., reverse inference; Karmarkar and Plassmann,2019; Plassmann *et al.*, 2015), and the data captured by most tools is continuous, large, requires a baseline measurement, and is in need of identification of when the cue under study actually occurred (cf. synchronization and baselines; Bell *et al.*, 2018; Institute of Medicine Washington, 2015; Zhang *et al.*, 2014). Handling and cleaning these data and including baseline corrections typically requires specific statistical analyses (e.g., multi-level or mixed model; Zhang *et al.*, 2014). Yet, both the rise of plug and play devices, which often return immediately usable data, and the growing amount of open source software packages and algorithms to process, clean, and analyze data contribute to optimizing neuroscientific data-analysis (e.g., several packages in Python, PhysioToolkit; Goldberger *et al.*, 2000; Massaro and Pecchia, 2019; Muller *et al.*, 2015).

As a result, the reporting of neuro-studies' procedures, design, and data analysis needs to be as complete and transparent as possible. Researchers need to include detailed information on missing data, data cleaning or filtering, thinkable confounding variables, software and hardware used, and baseline measures, allowing other researchers replicate the study and to assess the validity of the data and interpretations (e.g., Caruelle *et al.*, 2019; Lim, 2018; Stanton *et al.*, 2017). This transparency is particularly necessary as different hardware (i.e., tools), software, and data processing may produce different results (e.g., Caruelle *et al.*, 2019; Kennedy and Northover, 2016).

An important pitfall to avoid while interpreting neuro-data is that of reverse inferences, especially with fMRI data (Karmarkar and Plassmann, 2019; Plassmann *et al*., 2015). To illustrate, stress increases one's heart rate. But finding an increased heart rate in a study does not necessarily mean a participant in actually stressed, as other processes may underlie this change. A theory-driven approach, proper study design, and combination of different types of tools and data can help to deal with this issue. For a detailed discussion on reverse inference, we refer the reader to Plassmann *et al.* (2015) and Karmarkar and Plassmann (2019).

Combining traditional and neuro-data

We explicitly position neuro-data as complementary to traditional data (e.g., surveys, interviews). The combination of both data types might create significant advances in our field (e.g., Bell *et al.*, 2018; Boshoff, 2012; Gountas *et al*., 2019). Both sources of data offer different information, cover for limitations of other data types, and -combined- improve predictions (e.g., Bell *et al.*, 2018; Boksem and Smidts, 2015). For example, Boshoff's (2017) combination of neuro-tools with self-report measures revealed interesting insights when studying the role of service provider attractiveness on customer reactions to service recovery. While the self-reported data did not reveal an effect of frontline employee attractiveness, the neuro-data revealed that male and female customers responded differently toward attractive and less attractive employees. Male customers (compared to female customers) suppressed their negative responses toward failure in self-reports and even more so when an employee was unattractive. The mismatch between self-report and neuro-data, in fact, offered the most valuable information in this case.

Answering ethical concerns

Finally, neuro-studies within the service field deal with human subjects, hence it is vital to keep possible ethical considerations such as privacy concerns and general protection for participants in mind (Lim, 2018; Stanton *et al.*, 2017). Participants need to be briefed about what will be measured, the risks involved, and the option to retract from the study at all times. We strongly recommended to always present a neuro-study to the university ethical board, report followed procedures (e.g., design, data analysis, data storage) as transparent possible, store data anonymously, and meticulously follow international guidelines linked to protection of research participants and their data (e.g., anonymity, informed consent; e.g., Lim, 2018; Stanton *et al.*, 2017; World Medical Association Declaration of Helsinki, 2001). We gladly refer the reader to Stanton *et al.* (2017) and Ulman *et al.* (2015) for additional information on ethical concerns related to conducting neuro-studies.

POTENTIAL APPLICATIONS OF NEUROSCIENTIFIC METHODS IN SERVICE RESEARCH

Few researchers applied neuro-tools to the understanding of service research problems (e.g., Boshoff, 2012, 2017; Huneke *et al.*, 2015). In this section of the paper, we discuss a non-exhaustive list of service research topics where neuro-insights may be particularly useful, building on recent (service) research agendas (e.g., Bolton *et al.*, 2018; De Keyser *et al.*, 2019; Lemon and Verhoef, 2016; Ostrom *et al.*, 2015; Van Vaerenbergh *et al.*, 2019; Voorhees *et al.*, 2017; Wirtz *et al.*, 2018).

Future research opportunities related to external cues

Neuro-tools can bolster our comprehension of how humans experience various physical servicescape elements, such as sounds, taste, touch, smell, and visual aspects, as well as their digital counterparts (Bolton *et al.*, 2018). Servicescapes are multisensory environments in which humans are exposed to various cues. Neuro-tools may help us disentangle which elements have the largest impact on customer perceptions and behavior, and in which context. Also, we are witnessing servicescapes that adapt to customer/employee reactions. For instance, certain types of digital advertising adapt the displayed content based on eye tracking information. More of these applications will emerge in the future. One promising path for future research using is mapping the emotional journey in parallel to visual attention to get insights into how employees and customers both process and feel about the different aspects of the servicescape. Paired up with in-store manipulations such as changing scents, lighting or sound we can further our understanding about how emotions and attention interact in a multisensory experience. Furthermore, EEG equipment can be used in combination to show the effects of emotions, attention, and cognition. One such example relates to how cognitive load can influence the breadth of visual attention in the search process. This has previously been indirectly tested (Wästlund *et al.*, 2015), but the effects can be confirmed by combining tools within the neuro-toolbox.

The use of objective indicators to measure external cues is especially recommended in this area to establish precisely how customers/employees fit within the service environment: Are they moving (i.e., motion tracker)? How close are they to other individuals (i.e., social aware systems)? What noise levels are they experiencing (i.e., microphone)? What are they looking at (i.e., eye trackers)? The use of objective indicators permits to better capture the multitude of stimuli coming at customers/employees. In this sense, integrating neuro-tools and objective indicators allows to investigate the impact of varying combinations of stimuli (e.g., how do scent and touch collectively impact individuals?). Conversely, a tool like fMRI allows investigating specific physical cues in isolation, such as which cues stimulate or not the reward areas in the human brain.

Next, to the physical servicescape elements, the neuro-toolbox may prove valuable in better understanding social interactions between various actors in the service environment. Of particular interest is emotional contagion (i.e., transfer of emotions from one person to others), which represents a key process during social interactions and has been looked at in co-creation, team processes, leadership, and customer attitudes research (Barsade *et al.*, 2018). Moreover, emotional contagion is critical during the formation of trust and empathy (Prochazkova and Kret, 2017). Although emotional contagion is crucial for studying (frontline) employees and customers, it is still not fully understood (Hatfield *et al.*, 2014). So far, emotional contagion and its outcomes have largely been studied with self-report data. Yet, as emotional contagion represents an automatic nonconscious process, self-report measures might not fully capture emotional contagion as it unfolds.

Mimicry or synchronization between humans represents one of emotional contagion's basic mechanisms. This process can be seen in muscles (e.g., facial muscles, eye direction, body posture), but also hormonal synchronization and physiological synchronization (e.g., pupils, heart rate) can surface (Prochazkova and Kret, 2017). Hence, researchers might use neuro-tools to better study this process in a service setting (Barsade *et al.*, 2018). For example, measuring real-time peripheral changes such as galvanic skin response while employees and customers co-create could give us an indication of energy or even anxiety throughout the process (e.g., Knight and Barsade, 2013; West *et al.*, 2017). Another possibility is to use 'hyperscanning', where neuroimaging tools, such as EEG, are simultaneously used on several subjects during social interaction (Babiloni and Astolfi, 2014).

Emotional contagion is not limited to human interaction only but is also relevant to interactions with service robots (Barsade *et al.*, 2018). Research on service robots is still in a nascent stage (De Keyser *et al.*, 2019; Wirtz *et al.*, 2018), hence the service domain is in a privileged position to contribute to the general emotional contagion-technology literature. Research and insights on what specific features exactly create emotional contagion while interacting with robots might help the robotics field to design better hard- and software capable of creating deep interactions with customers and/or employees (Wirtz *et al.*, 2018).

Another interesting research avenue is the impact of both social and physical cues on cognitive (over)load (e.g., Choi *et al*., 2014). Cognitive load relates to the total amount of mental activity imposed on working memory resources (cf. cognitive load theory; e.g., Choi *et al*., 2014; Sweller, 2011), and may, for instance, be considered in service research looking at co-creation and the adoption of new technologies (De Keyser *et al.,* 2019). For example, as customers often have to assemble products themselves, it could be interesting to understand the cognitive load of customers during this self-assembly (e.g., reading instructions, building, working together) and how this translates to satisfaction or even the successful finishing of the customer's task. Such research could help to improve assembly instructions and even the product's design.

When cognitive load increases too much, situations of cognitive overload may occur which can have detrimental effects on customer and employee outcomes like satisfaction, learning, and performance (e.g., De Jong, 2010; Jen-Hwa Hu *et al*., 2017). In research, for instance, EEG and eye tracking could be used to test if workshops for employees and instructions for customers/patients do not result in cognitive overload (e.g., Antonenko *et al.*, 2010; Wästelund *et al*., 2015). Import to note is that cognitive load can be influenced by external cues, but can also go together with internal cues (e.g., Choi *et al*., 2014). For example, previous experiences, individual differences in cognitive capacity, age, and/or anxiety can contribute to cognitive overload (e.g., Choi *et al*., 2014). Disentangling which cues and under what circumstances matter most might prove a valuable research goal for future endeavors (Sweller, 2011).

Future research opportunities related to internal cues

Considering internal cues, researchers call for an increased understanding of employee and customer wellbeing (Anderson *et al.*, 2013; Anderson and Ostrom, 2015; Ostrom *et al.*, 2010). The neuro-toolbox has great potential to contribute to this area. For example, understanding how stress impacts people at work (i.e., employee role) or in the service environment (i.e., customer role) may help devise strategies to improve overall well-being. Stress is a highly complex process (e.g., chronic versus temporary stress) and not captured easily (e.g., McEwen *et al.*, 2015). While previous research has focused on the impact of self-reported stress levels (Singh and Duque, 2012), neurophysiological tools (e.g., galvanic skin response, cardiovascular measures) and biochemical tools (e.g., measure cortisol levels) are well suited to measure different aspects of stress objectively (Föhr *et al.*, 2015; Goyal *et al.*, 2016; Seemann *et al.*, 2016).

Similarly, service research would benefit from a better understanding of how various other internal states, like hunger, fatigue, sexual arousal, and others impact customer/employee behavior and ultimately service evaluations. One particular area of interest might relate to understanding the impact of fatigue and sleep deprivation. In today's society, sleeping patterns are disturbed by a variety of factors including the use of technology (Rosen *et al.*, 2016) and rotating working schedules. Research on the latter, for instance, finds that working in shifts reduces the cognitive performance of employees due to sleep fragmentation, while also causing a degraded mood (Bonnet and Arand, 2003). Obviously, these outcomes may have a significant impact on many service settings such as healthcare and hospitality. Research could try to understand how the lack of sleep and/or fatigue and its associated outcomes (i.e., slower response time, bad mood) impacts service interactions.

Neuro-tools can be used to monitor sleep (disturbance) and sleep quality itself (e.g., EEG; galvanic skin response; Herlan *et al.*, 2019; Krystal and Edinger, 2008). Yet, physical (e.g., Yu *et al.*, 2019) and/or mental fatigue (e.g., Hopstaken *et al.*, 2016) may be more relevant and can be captured as well using eye tracking (e.g., blinking, visual attention) and/or EEG. General changes in physical fatigue (which is a physiological state) can be captured using neuro-tools such as cardiovascular measures, EEG, galvanic skin response, and electromyographic (EMG; e.g., to track specific muscle tiredness) (Dawson *et al.*, 2014).

Furthermore, accelerating technological advancements to measure peripheral changes (e.g., facial muscle activity, galvanic skin response, heart rate) with cameras, sensors, and mobile devices might give rise to new service applications. Indeed, adaptive service systems could be built to instantaneously track and respond to human peripheral changes (Ostrom *et al.*, 2015). For example, camera systems could pick up customer's heightened stress or negative feelings and inform an employee to intervene and turn the negative experience around. Future research could also contribute to a better understanding of how frontline employees/robots may be supported by neuro-tools in real-time.

Future research opportunities related to the service experience and its dynamics

Finally, researchers call for a better understanding of the overall experience across the service journey (Lemon and Verhoef, 2016). Neuro-tools are particularly interesting to look at this topic, since they allow real-time dynamic measurement of employees/customers taking part in the service process and avoid relevant biases (e.g., social desirability or unwillingness to show true feelings). While some researchers have used real-time experience tracking to capture experiences in-the-moment (Baxendale *et al.*, 2015); neuro-tools by their very nature have the potential to provide stronger and more objective real-time measures of what happens within and to employees/customers along the service journey. Particularly, the neurophysiological tools and EEG are well suited for this. Not only could these tools help academics and practitioners better understand the importance of various touchpoints along the service journey, they may also help make decisions on resource allocations across the various journey stages (Voorhees *et al.*, 2017) and design appropriate experience profiles (Ariely and Carmon, 2000).

Recently, McColl-Kennedy *et al.* (2019) argued that more work is desired on touchpoints, such as mapping out and improve (painful) touchpoints throughout services experience. Similarly, Van Vaerenbergh *et al.* (2019) suggest neuro-tools are an interesting complement to study the service recovery journey, including failure and recovery episodes. Specifically, neuro-tools could help uncover unconscious and less biased reactions toward service failure incidents. Understanding both physiological valence, arousal, and their interaction during reported versus unreported failures could improve our understanding considerably. Neuro-tools may also help us improve our understanding of the effectiveness of recovery actions. fMRI, for instance, could be used to investigate responses in reward and decision-making areas of the brain, further pushing our knowledge on the impact of recovery actions (Van Vaerenbergh *et al.* 2019).

CONCLUSION

This paper showcases that neuro-studies and theory are a promising complement to enhance service theory and push the boundaries of the service field. This paper synthesizes literature from a variety of domains (e.g., neuroscience, consumer neuroscience, organizational neuroscience) to provide an in-depth background on the potential value of neuro-tools for the service domain and offers guidelines on how to start applying them. Neuro-tools are particularly valuable to study internal human processes and mechanisms, improve our understanding of the impact of context, and advance predictions of human behavior. While adopting neuro-tools might be challenging in terms of costs and data complexity, plug and play devices may offer a good starting point for a starting project. Further, we hope that this paper can assist editors and reviewers (whom might be unfamiliar with the neuro-method) to judge the rigor of neuro-studies, understand the potential value of this approach, but also give them insides in the challenges of conducting neuro-studies. Requesting an additional study, for instance, with self-reports scales versus neuro-tools has different implications (e.g., time needed, budget, etc.). Altogether, we hope this paper will encourage service researchers to start their own service neuroscience journey and stimulate increased collaboration with the neuro-field.

REFERENCES

Ahlert, D., Kenning, P. and Plassmann, H. (2006), "A window to the consumer's mind: application of functional brain imaging techniques to advertising research", in Diehl S., Terlutter R. (Eds.), *International Advertising and Communication*, DUV, Wiesbaden, pp. 163–178.

Akinola, M. and Mendes, W.B. (2012), "Stress-induced cortisol facilitates threat-related decision making among police officers", *Behavioral Neuroscience*, Vol. 126 No. 1, pp. 167–174.

Akintola, A.A., van de Pol, V., Bimmel, D., Maan, A.C. and van Heemst, D. (2016), "Comparative Analysis of the Equivital EQ02 Lifemonitor with Holter Ambulatory ECG Device for Continuous Measurement of ECG, Heart Rate, and Heart Rate Variability: A Validation Study for Precision and Accuracy", *Frontiers in Physiology*, Vol. 7, 391.

Anderson, L. and Ostrom, A.L. (2015), "Transformative service research: Advancing our knowledge about service and well-being", *Journal of Services Research*, Vol. 18 No. 3, pp. 243-249.

Anderson, L., Ostrom, A.L., Corus, C., Fisk, R.P., Gallan, A.S., Giraldo, M., Mende, M., Mulder, M., Rayburn, S.W., Rosenbaum, M.S. and Shirahada, K. (2013), "Transformative service research: An agenda for the future", *Journal of Business Research*, Vol. 66 No. 8, pp. 1203–1210.

Antonenko, P., Paas, F., Grabner, R. and Van Gog, T. (2010), "Using electroencephalography to measure cognitive load", *Educational Psychology Review*, Vol. 22 No. 4, pp. 425-438.

Ariely, D. and Carmon, Z. (2000), "Gestalt characteristics of experiences: The defining features of summarized events", *Journal of Behavioral Decision Making*, Vol. 13 No. 2, pp. 191-201.

Babiloni, F. and Astolfi, L. (2014), "Social neuroscience and hyperscanning techniques: past, present and future", *Neuroscience and Biobehavioral Reviews*, Vol. 44, pp. 76–93.

Bargh, J.A. (2002), "Losing consciousness: Automatic influences on consumer judgment, behavior, and motivation", *Journal of Consumer Research*, Vol. 29 No. 2, pp. 280–285.

Barraza, J.A. and Zak, P.J. (2009), "Empathy toward strangers triggers oxytocin release and subsequent generosity", *Annals of the New York Academy of Sciences*, Vol. 1167 No. 1, pp. 182–189.

Barrett, L.F. (2006), "Are emotions natural kinds?", *Perspectives on Psychological Science,* Vol. 1 No. 1, pp. 28–58.

Barrett, L.F., Mesquita, B., Ochsner, K.N. and Gross, J.J. (2007), "The experience of emotion", *Annual Review of Psychology,* Vol. 58, pp. 373–403.

Barrett, L.F. and Satpute, A.B. (2017), "Historical pitfalls and new directions in the neuroscience of emotion", *Neuroscience Letters*, Vol. 693, pp. 9-18.

Barsade, S.G., Coutifaris, C.G.V. and Pillemer, J. (2018), "Emotional contagion in organizational life", *Research in Organizational Behavior*, Vol. 38, pp. 137–151.

Baxendale, S., Macdonald, E.K. and Wilson, H.N. (2015), "The impact of different touchpoints on brand consideration", *Journal of Retailing*, Vol. 91 No. 2, pp. 235–253.

Bechara, A. and Damasio, A.R. (2005), "The somatic marker hypothesis: A neural theory of economic decision", *Games and Economic Behavior*, Vol. 52 No. 2, pp. 336–372.

Becker, W.J. and Cropanzano, R. (2010), “Organizational neuroscience: The promise and prospects of an emerging discipline”, *Journal of Organizational Behavior*, Vol. 31 No. 7, pp. 1055–1059.

Becker, W.J., Cropanzano, R. and Sanfey, A.G. (2011), “Organizational neuroscience: Taking organizational theory inside the neural black box”, *Journal of Management*, Vol. 37 No. 4, pp. 933–961.

Bell, L., Vogt, J., Willemse, C., Routledge, T., Butler, L.T. and Sakaki, M. (2018), “Beyond Self-Report: A Review of Physiological and Neuroscientific Methods to Investigate Consumer Behavior”, *Frontiers in Psychology*, Vol. 9, 1655.

Benjamin, C., Lieberman, D.A., Chang, M., Ofen, N., Whitfield-Gabrieli, S., Gabrieli, J.D.E. and Gaab, N. (2010), “The influence of rest period instructions on the default mode network”, *Frontiers in Human Neuroscience*, Vol. 4, 218.

Benoit, S., Scherschel, K., Ates, Z., Nasr, L. and Kandampully, J. (2017), “Showcasing the diversity of service research: Theories, methods, and success of service articles”, *Journal of Service Management*, Vol. 28 No. 5, pp. 810–836.

Berntson, G.G., Quigley, K.S., Norman, G.J. and Tassinary, L.G. (2016), “Cardiovascular Psychophysiology”, in Cacioppo J.T., Tassinary, L. and Berntson, G. (Eds.), *Handbook of Psychophysiology*, Cambridge University Press, Cambridge, pp. 183–216.

Bitner, M.J. (1992), “Servicescapes: The impact of physical surroundings on customers and employees”, *Journal of Marketing*, Vol. 56 No. 2, pp. 57–71.

Boksem, M. a. S. and Smidts, A. (2015), “Brain responses to movie-trailers predict individual preferences for movies and their population-wide commercial success”, *Journal of Marketing Research*, Vol. 52 No. 4, pp. 482-492.

Bolton, R.N., McColl-Kennedy, J.R., Cheung, L., Gallan, A., Orsingher, C., Witell, L. and Zaki, M. (2018), "Customer experience challenges: Bringing together digital, physical and social realms", *Journal of Service Management*, Vol. 29 No. 5, pp. 776–808.

Bonnet, M.H. and Arand, D.L. (2003), "Clinical effects of sleep fragmentation versus sleep deprivation", *Sleep Medicine Reviews*, Vol. 7 No. 4, pp. 297–310.

Boshoff, C. (2012), "A neurophysiological assessment of consumers' emotional responses to service recovery behaviors: The impact of ethnic group and gender similarity", *Journal of Service Research*, Vol. 15 No. 4, pp. 401–413.

Boshoff, C. (2017), "An assessment of consumers' subconscious responses to frontline employees' attractiveness in a service failure and recovery situation", *South African Journal of Economic and Management Sciences*, Vol. 20 No. 1, pp. 1–13.

Bradley, M.M., Miccoli, L., Escrig, M.A. and Lang, P.J. (2008), "The pupil as a measure of emotional arousal and autonomic activation", *Psychophysiology*, Vol. 45 No. 4, pp. 602–607.

Breiter, H.C., Block, M., Blood, A.J., Calder, B., Chamberlain, L., Lee, N., Livengood, S., Mulhern, F.J., Raman, K., Schultz, D. and Stern, D.B. (2015), "Redefining neuromarketing as an integrated science of influence", *Frontiers in Human Neuroscience,* Vol. 8, 1073.

Brookings, J.B., Wilson, G.F. and Swain, C.R. (1996), "Psychophysiological responses to changes in workload during simulated air traffic control", *Biological Psychology,* Vol. 42 No. 3, pp. 361–377.

Buckert, M., Schwieren, C., Kudielka, B.M. and Fiebach, C.J. (2014), "Acute stress affects risk taking but not ambiguity aversion", *Frontiers in Neuroscience,* Vol. 8, 82.

Budnick, C.J. and Barber, L.K. (2015), “Behind sleepy eyes: Implications of sleep loss for organizations and employees.”, *Translational Issues in Psychological Science*, Vol. 1 No. 1, pp. 89-96.

Butler, M.J.R., O’broin, H.L.R., Lee, N. and Senior, C. (2016), “How organizational cognitive neuroscience can deepen understanding of managerial decision-making: a review of the recent literature and future directions”, *International Journal of Management Reviews*, Vol. 18 No. 4, pp. 542–559.

Button, K.S., Ioannidis, J.P.A., Mokrysz, C., Nosek, B.A., Flint, J., Robinson, E.S.J. and Munafò, M.R. (2013), “Power failure: why small sample size undermines the reliability of neuroscience”, *Nature Reviews Neuroscience*, Vol. 14 No. 5, pp. 365–376.

Byrne, D.E. (1971), *The Attraction Paradigm*, Academic Press, New York.

Byrom, B., McCarthy, M., Schueler, P. and Muehlhausen, W. (2018), “Brain Monitoring Devices in Neuroscience Clinical Research: The potential of remote monitoring using sensors, wearables, and mobile devices”, *Clinical Pharmacology & Therapeutics*, Vol. 104 No. 1, pp. 59–71.

Cacioppo, J.T., Berntson, G.G., Larsen, J.T., Poehlmann, K.M., Ito, T.A. (2000), “The psychophysiology of emotion”, In Lewis M. and Haviland-Jones J.M. (Eds.), *Handbook of emotions*, The Guilford Press, New York, pp. 173–191.

Cacioppo, J.T., Tassinary, L.G. and Berntson, G.G. (2016), “Strong inference in psychophysiological science”, in Cacioppo, J.T., Tassinary, L.G. and Berntson, G.G. (Eds.), *Handbook of Psychophysiology*, Cambridge University Press, Cambridge, pp. 3–15.

Camerer, C. and Yoon, C. (2015), “Introduction to the Journal of Marketing Research special interdisciplinary issue on consumer financial decision making”, *Journal of Marketing Research*, Vol. 52 No. 4, pp. 423-426.

Caruelle, D., Gustafsson, A., Shams, P. and Lervik-Olsen, L. (2019), “The use of electrodermal activity (EDA) measurement to understand consumer emotions – a literature review and a call for action”, *Journal of Business Research*, Vol. 104, pp. 146-160.

Casado-Aranda, L.-A., Sánchez-Fernández, J. and Montoro-Ríos, F.J. (2018), “How consumers process online privacy, financial, and performance risks: An fMRI Study”, *Cyberpsychology, Behavior, and Social Networking*, Vol. 21 No. 9, pp. 556–562.

Chaffin, D., Heidl, R., Hollenbeck, J.R., Howe, M., Yu, A., Voorhees, C. and Calantone, R. (2017), “The promise and perils of wearable sensors in organizational research”, *Organizational Research Methods*, Vol. 20 No. 1, pp. 3–31.

Chandler, J.D. and Vargo, S.L. (2011), “Contextualization and value-in-context: How context frames exchange”, *Marketing Theory*, Vol. 11 No. 1, pp. 35–49.

Choi, HH., van Merriënboer, J.J.G. and Paas, F. (2014), “Effects of the physical environment on cognitive load and learning: towards a new model of cognitive load”. *Educational Psychology Review*, Vol. 26 No. 2, pp. 225- 244.

Choudhury, T. and Pentland, A. (2003), “Sensing and modeling human networks using the sociometer”, *Null*, 216.

Christopoulos, G.I., Uy, M.A. and Yap, W.J. (2019), “The body and the brain: measuring skin conductance responses to understand the emotional experience”, *Organizational Research Methods*, Vol. 22 No. 1, pp. 394–420.

Clark, K.R., Leslie, K.R., Garcia-Garcia, M. and Tullman, M.L. (2018), “How advertisers can keep mobile users engaged and reduce video-ad blocking”, *Journal of Advertising Research*, Vol. 58 No. 3, pp. 311–325.

Critchley, H.D. (2009), “Psychophysiology of neural, cognitive and affective integration: fMRI and autonomic indicants”, *International Journal of Psychophysiology*, Vol. 73 No. 2, pp. 88–94.

Critchley, H.D. and Harrison, N.A. (2013), “Visceral influences on brain and behavior”, *Neuron*, Vol. 77 No. 4, pp. 624–638.

Davidson, R.J., Ekman, P., Saron, C.D., Senulis, J.A. and Friesen, W.V. (1990), “Approach-withdrawal and cerebral asymmetry: Emotional expression and brain physiology: I.”, *Journal of Personality and Social Psychology*, Vol. 58 No. 2, pp. 330-341.

Dawson, D., Searle, A.K. and Paterson, J.L. (2014), “Look before you (s)leep: Evaluating the use of fatigue detection technologies within a fatigue risk management system for the road transport industry”, *Sleep Medicine Reviews*, Vol. 18 No. 2, pp. 141–152.

Dawson, M.E., Schell, A.M. and Filion, D.L. (2016), “The electrodermal system”, in Cacioppo, J.T., Tassinary, L.G. and Berntson, G.G. (Eds.), *Handbook of Psychophysiology*, Cambridge University Press, Cambridge, pp. 217–243.

De Jong, T. (2010), “Cognitive load theory, educational research, and instructional design: some food for thought”, *Instructional Science*, Vol. 38 No. 2, pp.105-134.

De Keyser, A., Köcher, S., Alkire (née Nasr), L., Verbeeck, C. and Kandampully, J. (2019), “Frontline Service Technology infusion: conceptual archetypes and future research directions”, *Journal of Service Management*, Vol. 30 No. 1, pp. 156-183.

De Keyser, A., Lemon, K.N., Klaus, P. and Keiningham, T.L. (2015), “A framework for understanding and managing the customer experience”, *Marketing Science Institute Working Paper Series*, pp. 15–121.

De Leeuw, E.D., Hox, J.J. and Huisman, M. (2003), “Prevention and treatment of item nonresponse”, *Journal of Official Statistics*, Vol. 19, pp. 153-176.

DeYoung, C.G., Hirsh, J.B., Shane, M.S., Papademetris, X., Rajeevan, N. and Gray, J.R. (2010), “Testing predictions from personality neuroscience: Brain structure and the big five”, *Psychological Science*, Vol. 21 No. 6, pp. 820–828.

Dimberg, U. and Petterson, M. (2000), “Facial reactions to happy and angry facial expressions: Evidence for right hemisphere dominance”, *Psychophysiology*, Vol. 37 No. 5, pp. 693–696.

Dimoka, A., Davis, F.D., Gupta, A., Pavlou, P.A., Banker, R.D., Dennis, A.R., Ischebeck, A., Müller-Putz, G., Benbasat, I., Gefen, D. and Kenning, P.H. (2012), “On the use of neurophysiological tools in IS research: Developing a research agenda for NeuroIS”, *MIS Quarterly*, Vol. 36 No. 3, pp. 679–702.

Institute of Medicine Washington (2015), “Training neuroscientists in basic research, tool and technology development, and big data”, available at: https://www.ncbi.nlm.nih.gov/books/NBK315963/ (accessed 26 February 2019).

Duncan, N.W. and Northoff, G. (2013), “Overview of potential procedural and participant-related confounds for neuroimaging of the resting state”, *Journal of Psychiatry & Neuroscience,* Vol. 38 No. 2, pp. 84–96.

Ebstein, R.P., Israel, S., Chew, S.H., Zhong, S. and Knafo, A. (2010), “Genetics of human social behavior”, *Neuron*, Vol. 65 No. 6, pp. 831–844.

Edvardsson, B., Frow, P., Jaakkola, E., Keiningham, T.L., Koskela-Huotari, K., Mele, C. and Tombs, A. (2018), “Examining how context change foster service innovation”, *Journal of Service Management*, Vol. 29 No. 5, pp. 932–955.

Ellingsen, D.-M., Wessberg, J., Chelnokova, O., Olausson, H. Akan, Laeng, B. and Leknes, S. (2014), “In touch with your emotions: oxytocin and touch change social impressions while others' facial expressions can alter touch", *Psychoneuroendocrinology*, Vol. 39, pp. 11–20.

Fernandes, S.L., Gurupur, V.P., Sunder, N.R., Arunkumar, N. and Kadry, S. (2017), "A novel nonintrusive decision support approach for heart rate measurement", *Pattern Recognition Letters*.

Ferrari, P.F. and Coudé, G. (2018), "Chapter 6 - Mirror neurons, embodied emotions, and empathy", in Meyza, K.Z. and Knapska, E. (Eds.), *Neuronal correlates of empathy*, Academic Press, pp. 67–77.

Föhr, T., Tolvanen, A., Myllymäki, T., Järvelä-Reijonen, E., Rantala, S., Korpela, R., Peuhkuri, K., Peuhkuri, K., Kolehmainen, M., Puttonen, S., Lappalainen, R. and Rusko, H. (2015), "Subjective stress, objective heart rate variability-based stress, and recovery on workdays among overweight and psychologically distressed individuals: a cross-sectional study", *Journal of Occupational Medicine and Toxicology*, Vol. 10 No. 1, 39.

Fortunato, V.C.R., Giraldi, J. de M.E. and de Oliveira, J.H.C. (2014), "A review of studies on neuromarketing: Practical results, techniques, contributions and limitations", *Journal of Management Research*, Vol. 6 No. 2, pp. 201–220.

Fridlund, A.J. and Cacioppo, J.T. (1986), "Guidelines for human electromyographic research", *Psychophysiology*, Vol. 23 No. 5, pp. 567–589.

Genevsky, A., Yoon, C. and Knutson, B. (2017), "When brain beats behavior: Neuroforecasting crowdfunding outcomes", *Journal of Neuroscience*, Vol. 37 No. 36 pp. 1633–16.

Gips, J.P. (2006), "Social motion: Mobile networking through sensing human behavior", Ph.D. Thesis, Massachusetts Institute of Technology.

Goldberger, A.L., Amaral, L.A.N., Glass, L., Hausdorff, J.M., Ivanov, P.Ch., Mark, R.G., Mietus, J.E., Moody, G.B., Peng, C.K. and Stanley, H.E. (2000), "PhysioBank, PhysioToolkit, and PhysioNet: Components of a new research resource for complex physiologic signals", *Circulation*, Vol. 101 No. 23, pp. 2015-222.

Gountas, J., Gountas, S., Ciorciari, J. and Sharma, P. (2019), "Looking beyond traditional measures of advertising impact: Using neuroscientific methods to evaluate social marketing messages", *Journal of Business Research*, Vol. 105, pp.121-135.

Gustafsson, A. and Bowen, D.E. (2017), "The curious case of interdisciplinary research deficiency: Cause or symptom of what truly ails us?", *Journal of Business Research*, Vol. 79, pp. 212-218.

Goyal, A., Singh, S., Vir, D. and Pershad, D. (2016), "Automation of stress recognition using subjective or objective measures", *Psychological Studies*, Vol. 61 No. 4, pp. 348–364.

Harris, J.M., Ciorciari, J. and Gountas, J. (2018), "Consumer neuroscience for marketing researchers", *Journal of Consumer Behaviour*, Vol. 17 No. 3, pp. 239–252.

Hatfield, E.C., Bensman, L., Thornton, P.D. and Rapson, R.L. (2014), "New perspectives on emotional contagion: A review of classic and recent research on facial mimicry and contagion", *Interpersona: An International Journal on Personal Relationships*, Vol. 8 No. 2, pp. 159–179.

Hays, R.D. and Ware Jr, J.E. (1986), "My medical care is better than yours: social desirability and patient satisfaction ratings", *Medical care*, pp.519-525.

Herlan, A., Ottenbacher, J., Schneider, J., Riemann, D. and Feige, B. (2019), "Electrodermal activity patterns in sleep stages and their utility for sleep versus wake classification", *Journal of Sleep Research*, Vol. 28 No. 2, 12694.

Hoeks, B. and Levelt, W.J.M. (1993), “Pupillary dilation as a measure of attention: a quantitative system analysis”, *Behavior Research Methods, Instruments, & Computers*, Vol. 25 No. 1, pp. 16–26.

Hoffmann, S., Mai, R., Lasarov, W., Krause, J.S. and Schmidt, U. (2019), “Hungry bellies have no ears. How and why hunger inhibits sustainable consumption”, *Ecological Economics*, Vol. 160, pp. 96–104.

Hopstaken, J.F., van der Linden, D., Bakker, A.B., Kompier, M.A. and Leung, Y.K. (2016), “Shifts in attention during mental fatigue: Evidence from subjective, behavioral, physiological, and eye-tracking data”, *Journal of Experimental Psychology: Human Perception and Performance*, Vol. 42 No. 6, pp. 878-889.

Hubbard, J. (Ed.). (1974), *The Peripheral Nervous System*, Springer, US, available at: https://www.springer.com/us/book/9781461587019.

Huneke, T., Benoit, S., Shams, P. and Gustafsson, A. (2015), “Does service employees’ appearance affect the healthiness of food choice?”, *Psychology & Marketing*, Vol. 32 No. 1, pp. 94–106.

iMotions. available at: https://imotions.com/ (accessed 12 March 2019).

Jack, A.I., Rochford, K.C., Friedman, J.P., Passarelli, A.M. and Boyatzis, R.E. (2019), “Pitfalls in organizational neuroscience: a critical review and suggestions for future research”, *Organizational Research Methods*, Vol. 22 No. 1, pp. 421–458.

Jackson, D.C., Mueller, C.J., Dolski, I., Dalton, K.M., Nitschke, J.B., Urry, H.L., Rosenkranz, M.A., et al. (2003), “Now you feel it, now you don’t: Frontal brain electrical asymmetry and individual differences in emotion regulation”, *Psychological Science*, Vol. 14 No. 6, pp. 612–617.

James, W. (1894), “Discussion: The physical basis of emotion.”, *Psychological Review*, Vol. 1 No. 5, pp. 516-529.

Jänig, W. (1989), “Autonomic nervous system”, In Schmidt R.F. and Thews G. (Eds.), *Human Physiology,* Springer, Berlin, Heidelberg, pp. 333–370.

Jen-Hwa Hu, P., Han-Fen, H. and Xiao, F. (2017),“Examining the mediating roles of cognitive load and performance outcomes in user satisfaction with a website: A field quasi-experiment”, *MIS Quarterly*, Vol. 41 No. 3, pp. 975-987.

Kang, M.J., Rangel, A., Camus, M. and Camerer, C.F. (2011), “Hypothetical and real choice differentially activate common valuation areas”, *Journal of Neuroscience,* Vol. 31 No. 2, pp. 461–468.

Karmarkar, U.R. and Plassmann, H. (2019), “Consumer neuroscience: Past, present, and future”, *Organizational Research Methods*, Vol. 22 No. 1, pp. 174–195.

Kennedy, R. and Northover, H. (2016), “How to use neuromeasures to make better advertising decisions: questions practitioners should ask vendors and research priorities for scholars”, *Journal of Advertising Research,* Vol. 56 No. 2, pp. 183–192.

Kenning, P. and Plassmann, H. (2005), “NeuroEconomics: An overview from an economic perspective”, *Brain Research Bulletin,* Vol. 67 No. 5, pp. 343–354.

Kenning, P., Plassmann, H. and Ahlert, D. (2007), “Applications of functional magnetic resonance imaging for market research”, *Qualitative Market Research: An International Journal*, Vol. 10 No. 2, pp. 135–152.

Kenning, P.H. and Plassmann, H. (2008), “How neuroscience can inform consumer research”, *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, Vol. 16 No. 6, pp. 532–538.

Kirk, Roger E. (2003), “Experimental design”, in Weiner, I.B. (Ed.), *Handbook of Psychology,* John Wiley & Sons, inc., Hoboken, New Jersey.

Kiyonaga, A. and Egner, T. (2014), “The working memory Stroop effect: When internal representations clash with external stimuli”, *Psychological Science,* Vol. 25 No. 8, pp. 1619–1629.

Knight, A.P. and Barsade, S.G. (2013), “The dynamics of emotional energy in entrepreneurial teams”, presented at the Academy of Management, Lake Buena Vista.

Knutson, B. and Genevsky, A. (2018), “Neuroforecasting Aggregate Choice”, *Current Directions in Psychological Science,* Vol. 27 No. 2, pp. 110–115.

Krampe, C., Gier, N.R. and Kenning, P. (2018), “The application of mobile fNIRS in marketing research—detecting the ‘first-choice-brand’ effect”, *Frontiers in Human Neuroscience,* Vol. 12, 433.

Krause, F. and Lindemann, O. (2014), “Expyriment: A Python library for cognitive and neuroscientific experiments”, *Behavior Research Methods,* Vol. 46 No. 2, pp. 416–428.

Kreibig, S.D. (2010), “Autonomic nervous system activity in emotion: A review”, *Biological Psychology,* Vol. 84 No. 3, pp. 394–421.

Krystal, A.D. and Edinger, J.D. (2008), “Measuring sleep quality”, *Sleep Medicine*, Vol. 9, pp. S10–S17.

Krzywicki, A.T., Berntson, G.G., and O’Kane, B.L. (2014), “A non-contact technique for measuring eccrine sweat gland activity using passive thermal imaging”, *International Journal of Psychophysiology*, Vol. 94 No. 1, pp. 25–34.

Kumar, V., Chattaraman, V., Neghina, C., Skiera, B., Aksoy, L., Buoye, A. and Henseler, J. (2013), “Data-driven services marketing in a connected world”, *Journal of Service Management*, Vol. 24 No. 3, pp. 330-352

Kurita, Y. (2014), “Wearable haptics”, in Sazonov, E. and Neuman, M.R. (Eds.), *Wearable sensors: Fundamentals, implementation and applications*, Elsevier, Oxford, pp. 45-60.

Laird, J.D. and Lacasse, K. (2014), “Bodily influences on emotional feelings: Accumulating evidence and extensions of William James′s theory of emotion”, *Emotion Review,* Vol. 6 No. 1, pp. 27–34.

Lang, P.J., Greenwald, M.K., Bradley, M.M. and Hamm, A.O. (1993), “Looking at pictures: Affective, facial, visceral, and behavioral reactions”, *Psychophysiology,* Vol. 30 No. 3, pp. 261–273.

Larsen, J.T., Norris, C.J. and Cacioppo, J.T. (2003), “Effects of positive and negative affect on electromyographic activity over zygomaticus major and corrugator supercilii”, *Psychophysiology,* Vol. 40 No. 5, pp. 776–785.

Lemay, M., Bertschi, M., Sola, J., Renevey, P., Parak, J. and Korhonen, I. (2014), “Application of optical heart rate monitoring”, in Sazonov, E. and Neuman, M.R. (Eds.), *Wearable sensors: Fundamentals, implementation and applications,* Elsevier, Oxford, pp. 105–129.

Lemon, K.N. and Verhoef, P.C. (2016), “Understanding Customer experience throughout the customer journey”, *Journal of Marketing*, Vol. 80 No. 6, pp. 69–96.

Lewinski, P., den Uyl, T.M. and Butler, Crystal. (2014), “Automated facial coding: Validation of basic emotions and FACS AUs in FaceReader.”, *Journal of Neuroscience, Psychology, and Economics,* Vol. 7 No. 4, pp. 227–236.

Lichters, M., Brunnlieb, C., Nave, G., Sarstedt, M. and Vogt, B. (2015), “The influence of serotonin deficiency on choice deferral and the compromise effect”, *Journal of Marketing Research*, Vol. 53 No. 2, pp. 183-198.

Lim, W.M. (2018), “Demystifying neuromarketing”, *Journal of Business Research*, Vol. 91, pp. 205–220.

Lin, M.-H., Cross, S.N., Jones, W.J. and Childers, T.L. (2018), “Applying EEG in consumer neuroscience”, *European Journal of Marketing,* Vol. 52 No. 1/2, pp. 66–91.

Littlefield, M.M. and Johnson, J.M. (2011), “Lost and found in translation: Popular neuroscience in the emerging neurodisciplines”, in Pickersgill, M. and Van Keulen I. (eds.), *Sociological Reflections on the Neurosciences*, Emerald Group Publishing Limited, pp.279 – 297.

Lovallo, W.R. and Buchanan, T.W. (2016), “Stress hormones in psychophysiological research: emotional, behavioral, and cognitive implications”, in Cacioppo, J.T., Tassinary, L.G. and Berntson, G.G. (Eds.), *Handbook of Psychophysiology*, Cambridge University Press, Cambridge, pp. 465–494.

McFarland, S.G. (1981), “Effects of question order on survey responses”, *Public Opinion Quarterly*,Vol. 45 No. 2, pp. 208-215.

Madan, A. and Pentland, A. (2006), “Vibefones: Socially aware mobile phones”, *2006 10th IEEE International Symposium on Wearable Computers*, IEEE, pp. 109–112.

Maeng, A., Tanner, R.J. and Soman, D. (2013), “Conservative when crowded: Social crowding and consumer choice”, *Journal of Marketing Research*, Vol. 50 No. 6, pp. 739–752.

Maijers, M.C., Verschuren, O., Stolwijk-Swüste, J.M., van Koppenhagen, C.F., de Groot, S. and Post, M.W.M. (2018), “Is Fitbit Charge 2 a feasible instrument to monitor daily physical activity and handbike training in persons with spinal cord injury? A pilot study”, *Spinal Cord Series and Cases*, Vol. 4 No. 1, p. 84.

Malhotra, N. (2008), “Completion time and response order effects in web surveys”, *Public opinion quarterly*, Vol. 72 No. 5, pp. 914-934.

Massaro, S. and Pecchia, L. (2019), “Heart Rate Variability (HRV) Analysis: A methodology for organizational neuroscience”, *Organizational Research Methods*, Vol. 22 No. 1, pp. 354–393.

Mattila, A.S. and Wirtz, J. (2008), “The role of store environmental stimulation and social factors on impulse purchasing”, *Journal of Services Marketing*, Vol. 22 No. 7, pp. 562–567.

Mauss, I.B. and Robinson, M.D. (2009), “Measures of emotion: A review”, *Cognition & Emotion*, Vol. 23 No. 2, pp. 209–237.

McColl-Kennedy, J.R., Zaki, M., Lemon, K.N., Urmetzer, F. and Neely, A. (2019), “Gaining Customer Experience Insights That Matter”, *Journal of Service Research*, Vol. 22 No. 1, pp. 8–26.

McEwen, B.S., Bowles, N.P., Gray, J.D., Hill, M.N., Hunter, R.G., Karatsoreos, I.N. and Nasca, C. (2015), “Mechanisms of stress in the brain”, *Nature Neuroscience*, Vol. 18 No. 10, pp. 1353–1363.

Meyer-Lindenberg, A., Buckholtz, J.W., Kolachana, B., Hariri, A.R., Pezawas, L., Blasi, G., Wabnitz, A., Honea, R., Verchinski, B., Callicott, J.H. and Egan, M. (2006), “Neural mechanisms of genetic risk for impulsivity and violence in humans”, *Proceedings of the National Academy of Sciences*, Vol. 103 No. 16, pp. 6269–6274.

Millet, K. and Dewitte, S. (2006), “Second to fourth digit ratio and cooperative behavior.”, *Biological Psychology*, Vol. 71 No. 1, pp. 111–5.

Monkaresi, H., Calvo, R.A. and Yan, H. (2014), “A machine learning approach to improve contactless heart rate monitoring using a webcam”, *IEEE Journal of Biomedical and Health Informatics*, Vol. 18 No. 4, pp. 1153–1160.

Morales, A.C., Amir, O. and Lee, L. (2017), “Keeping it real in experimental research—Understanding when, where, and how to enhance realism and measure consumer behavior”, *Journal of Consumer Research*, Vol. 44 No. 2, pp. 465–476.

Morhenn, V., Park, J., Piper, E. and Zak, P. (2008), "Monetary sacrifice among strangers is mediated by endogenous oxytocin release after physical contact", *Evolution and Human Behavior*, Vol. 29 No. 6, pp. 375–383.

Morin, C. (2011), "Neuromarketing: The New Science of Consumer Behavior", *Society*, Vol. 48 No. 2, pp. 131–135.

Mozos, O.M., Sandulescu, V., Andrews, S., Ellis, D., Bellotto, N., Dobrescu, R. and Ferrandez, J.M. (2017), "Stress detection using wearable physiological and sociometric sensors", *International Journal of Neural Systems*, Vol. 27 No. 2, 1650041.

Muller, E., Bednar, J.A., Diesmann, M., Gewaltig, M.-O., Hines, M. and Davison, A.P. (2015), "Python in neuroscience", *Frontiers in Neuroinformatics*, Vol. 9, 11.

Murray, M.M. and Antonakis, J. (2019), "An introductory guide to organizational neuroscience", *Organizational Research Methods*, Vol. 22 No. 1, pp. 6–16.

Ohme, R., Matukin, M. and Pacula-Lesniak, B. (2011), "Biometric measures for interactive advertising research", *Journal of Interactive Advertising*, Vol. 11 No. 2, pp. 60–72.

Ohme, R., Reykowska, D., Wiener, D. and Choromanska, A. (2009), "Analysis of neurophysiological reactions to advertising stimuli by means of EEG and galvanic skin response measures", *Journal of Neuroscience, Psychology, and Economics*, Vol. 2 No. 1, pp. 21–31.

Ohme, R., Reykowska, D., Wiener, D. and Choromanska, A. (2010), "Application of frontal EEG asymmetry to advertising research", *Journal of Economic Psychology*, Vol. 31 No. 5, pp. 785–793.

Olguın, D.O., Gloor, P.A. and Pentland, A.S. (2009), "Capturing individual and group behavior with wearable sensors", in *Proceedings of the 2009 Aaai Spring Symposium on Human Behavior Modeling, SSS*, Stanford, California.

Ostrom, A.L., Bitner, M.J., Brown, S.W., Burkhard, K.A., Goul, M., Smith-Daniels, V., Demirkan, H., et al. (2010), “Moving forward and making a difference: research priorities for the science of service”, *Journal of Service Research*, Vol. 13 No. 1, pp. 4–36.

Ostrom, A.L., Parasuraman, A., Bowen, D.E., Patricio, L. and Voss, C.A. (2015), “Service research priorities in a rapidly changing context”, *Journal of Service Research*, Vol. 18 No. 2, pp. 127–159.

Pizzi, G., Marzocchi, G.L., Orsingher, C. and Zammit, A. (2015), “The temporal construal of customer satisfaction”, *Journal of Service Research*, Vol. 18 No. 4, pp.484-497.

Plassmann, H., O’Doherty, J., Shiv, B. and Rangel, A. (2008), “Marketing actions can modulate neural representations of experienced pleasantness”, *Proceedings of the National Academy of Sciences*, Vol. 105 No. 3, pp. 1050–1054.

Plassmann, H., Ramsøy, T.Z. and Milosavljevic, M. (2011), “Branding the brain: A critical review and outlook”, Vol 22, pp 18-36.

Plassmann, H., Venkatraman, V., Huettel, S. and Yoon, C. (2015), “Consumer neuroscience: applications, challenges, and possible solutions”, *Journal of Marketing Research*, Vol. 52 No. 4, pp. 427–435.

Pocock, S.J., Assmann, S.E., Enos, L.E. and Kasten, L.E. (2002), “Subgroup analysis, covariate adjustment and baseline comparisons in clinical trial reporting: current practice and problems”, *Statistics in Medicine*, Vol. 21 No. 19, pp. 2917–2930.

Podsakoff, P.M., MacKenzie, S.B., Lee, J.Y. and Podsakoff, N.P. (2003), “Common method biases in behavioral research: A critical review of the literature and recommended remedies”, *Journal of applied psychology*, Vol. 88 No. 5, pp. 879-903.

Poels, K. and Dewitte, S. (2006), “How to capture the heart? Reviewing 20 years of emotion measurement in advertising”, *Journal of Advertising Research*, Vol. 46 No. 1, pp. 18–37.

Poh, M.-Z., McDuff, D.J. and Picard, R.W. (2011), “Advancements in noncontact, multiparameter physiological measurements using a webcam”, *IEEE Transactions on Biomedical Engineering*, Vol. 58 No. 1, pp. 7–11.

Poldrack, R.A. (2008), “The role of fMRI in cognitive neuroscience: where do we stand?”, *Current Opinion in Neurobiology*, Vol. 18 No. 2, pp. 223–227.

Prochazkova, E. and Kret, M.E. (2017), “Connecting minds and sharing emotions through mimicry: A neurocognitive model of emotional contagion”, *Neuroscience & Biobehavioral Reviews*, Vol. 80, pp. 99–114.

Puccinelli, N.M., Goodstein, R.C., Grewal, D., Price, R., Raghubir, P. and Stewart, D. (2009), “Customer experience management in retailing: understanding the buying process”, *Journal of Retailing*, Vol. 85 No. 1, pp. 15–30.

Ramsøy, T.Z. and Skov, M. (2010), “How genes make up your mind: Individual biological differences and value-based decisions”, *Journal of Economic Psychology*, Vol. 31 No. 5, pp. 818–831.

Empatica. available at: https://www.empatica.com/research/e4 (accessed 12 March 2019).

Reimann, M. (2018), “Decision muscles? How choosing more food (despite incentives to eat less) is associated with the brain’s cortical thickness”, *Journal of Neuroscience, Psychology, and Economics*, Vol. 11 No. 1, p. 45.

Ridder, D. de, Kroese, F., Adriaanse, M. and Evers, C. (2014), “Always gamble on an empty stomach: Hunger is associated with advantageous decision making”, *PLOS ONE*, Vol. 9 No. 10, 111081.

Rilling, J.K. and Sanfey, A.G. (2011), “The neuroscience of social decision-making”, *Annual Review of Psychology*, Vol. 62 No. 1, pp. 23–48.

Rizzolatti, G. and Sinigaglia, C. (2016), “The mirror mechanism: a basic principle of brain function”, *Nature Reviews Neuroscience*, Vol. 17 No. 12, p. 757.

Rohrbaugh, J.W. (2016), “Ambulatory and non-contact recording methods”, in Cacioppo, J.T., Tassinary, L.G. and Berntson, G.G. (Eds.), *Handbook of Psychophysiology*, Cambridge University Press, Cambridge, pp. 300–338.

Rosen, L., Carrier, L.M., Miller, A., Rokkum, J. and Ruiz, A. (2016), “Sleeping with technology: cognitive, affective, and technology usage predictors of sleep problems among college students”, *Sleep Health*, Vol. 2 No. 1, pp. 49–56.

Rosenbaum, M.S. and Massiah, C. (2011), “An expanded servicescape perspective”, *Journal of Service Management*, Vol. 22 No. 4, pp. 471–490.

Rosenbaum, M.S. and Montoya, D.Y. (2007), “Am I welcome here? Exploring how ethnic consumers assess their place identity”, *Journal of Business Research*, Vol. 60 No. 3, pp. 206–214.

Roy, D.S., Muralidhar, S., Smith, L.M. and Tonegawa, S. (2017), “Silent memory engrams as the basis for retrograde amnesia”, *Proceedings of the National Academy of Sciences*, Vol. 114 No. 46, pp. 9972–9979.

Sazonov, E. and Neuman, M.R. (2014), *Wearable sensors: Fundamentals, implementation and applications*, Elsevier, Oxford.

Schultz, W. (2017), “Electrophysiological correlates of reward processing in dopamine neurons”, in Dreher J.-C. and Tremblay, L. (Eds.), *Decision Neuroscience: An integrative perspective*, Elsevier, San Diego, pp. 21–31.

Seemann, N.M., Gimon, T.I., Mutabdzic, D., LeBlanc, V.R. and Moulton, C.-A.E. (2016), “Capturing the complexity of acute stress in the health professions: a review of methods for measuring stress and considerations for moving forward", *Academic Medicine,* Vol. 91 No. 11, pp. S11–S12.

Senior, C., Lee, N. and Butler, M. (2011), "Perspective—organizational cognitive neuroscience", *Organization Science,* Vol. 22 No. 3, pp. 804–815.

Shaw, S.D. and Bagozzi, R.P. (2018), "The neuropsychology of consumer behavior and marketing", *Consumer Psychology Review*, Vol. 1 No. 1, pp. 22–40.

Shimmer. available at: http://www.shimmersensing.com/ (accessed 12 March 2019).

Singh, S. and Duque, L.C. (2012), "Moderating role of stress in evaluating negative services: encounters with the police", *Journal of Service Research,* Vol 15 No. 2, pp. 231-241.

Society of Neuroscience. (1969), "The Creation of Neuroscience from the Society for Neuroscience", available at: https://www.sfn.org/about/history-of-sfn/the-creation-of-neuroscience/introduction. (accessed 5 May 2019).

Solnais, C., Andreu-Perez, J., Sánchez-Fernández, J. and Andréu-Abela, J. (2013), "The contribution of neuroscience to consumer research: A conceptual framework and empirical review", *Journal of Economic Psychology*, Vol. 36, pp. 68–81.

Stanton, S.J., Sinnott-Armstrong, W. and Huettel, S.A. (2017), "Neuromarketing: Ethical implications of its use and potential misuse", *Journal of Business Ethics*, Vol. 144 No. 4, pp. 799–811.

Stewart, D.W. and Zinkhan, G.M. (2006), "Enhancing marketing theory in academic research", *Journal of the Academy of Marketing Science*, Vol. 34 No. 4, pp. 477–480.

Sweller, J. (2011). "Cognitive load theory", In Mestre J.P. and Ross B.H. (Eds.), *The psychology of learning and motivation: Vol. 55,* Elsevier Academic Press, San Diego, CA, US, pp. 37-76).

Tamura, T. (2014), “Wearable inertial sensors and their applications”, in Sazonov, E. and Neuman, M.R. (Eds.), *Wearable sensors: Fundamentals, implementation and applications*, Elsevier, Oxford, pp. 85-104.

Tombs, A. and McColl-Kennedy, J.R. (2003), “Social-servicescape conceptual model”, *Marketing Theory*, Vol. 3 No. 4, pp. 447–475.

Ulman, Y.I., Cakar, T. and Yildiz, G. (2015), “Ethical issues in neuromarketing: ‘I consume, therefore I am!’”, *Science and Engineering Ethics,* Vol. 21 No. 5, pp. 1271–1284.

Unnewehr, S., Schneider, S., Margraf, J., Jenkins, M. and Florin, I. (1996), “Exposure to internal and external stimuli: Reactions in children of patients with panic disorder or animal phobia”, *Journal of Anxiety Disorders,* Vol. 10 No. 6, pp. 489–508.

Van Vaerenbergh, Y. and Thomas, T.D. (2012), “Response styles in survey research: A literature review of antecedents, consequences, and remedies”, *International Journal of Public Opinion Research*, Vol 25 No. 2, pp.195-217.

Van Vaerenbergh, Y., Varga, D., De Keyser, A. and Orsingher, C. (2019), “The service recovery journey: conceptualization, integration, and directions for future research”, *Journal of Service Research*, Vol. 22 No. 2, pp. 103-119.

Venkatraman, V., Clithero, J.A., Fitzsimons, G.J. and Huettel, S.A. (2012), “New scanner data for brand marketers: How neuroscience can help better understand differences in brand preferences”, *Journal of Consumer Psychology,* Vol. 22 No. 1, pp. 143–153.

Von Bohlen, O. and Halbach, D. (2006), *Neurotransmitters and Neuromodulators: Handbook of Receptors and Biological Effects*, Wiley-VCH Verlag GmbH & Co., Weinheim, Germany.

Voorhees, C.M., Fombelle, P.W., Gregoire, Y., Bone, S., Gustafsson, A., Sousa, R. and Walkowiak, T. (2017), “Service encounters, experiences and the customer journey:

Defining the field and a call to expand our lens", *Journal of Business Research*, Vol. 79, pp. 269–280.

Waldman, D.A., Wang, D. and Fenters, V. (2019), "The added value of neuroscience methods in organizational research", *Organizational Research Methods*, Vol. 22 No. 1, pp. 223–249.

Wästlund, E., Otterbring, T., Gustafsson, A. and Shams, P. (2015), "Heuristics and resource depletion: eye-tracking customers' in situ gaze behavior in the field", *Journal of Business Research*, Vol. 68 No. 1, pp. 95–101.

Wedel, M. and Pieters, R. (2008), "A review of eye-tracking research in marketing", in Malhotra (Ed.), *Review of Marketing Research*, M.E. Sharpe, Armonk, New York, pp. 123–147.

West, T.V., Koslov, K., Page-Gould, E., Major, B. and Mendes, W.B. (2017), "Contagious anxiety: Anxious European Americans can transmit their physiological reactivity to African Americans", *Psychological Science*, Vol. 28 No. 12, pp. 1796–1806.

Widmaier, E.P., Raff, H., Strang, K.T. and Vander, A.J. (2018), *Vander's human physiology: the mechanisms of body function*, McGraw-Hill Higher Education, Boston.

Wirtz, J. (2003), "Halo in customer satisfaction measures: The role of purpose of rating, number of attributes and customer involvement", *International Journal of Service Industry Management*, Vol. 14 No. 1, pp. 96-119.

Wirtz, J., Patterson, P.G., Kunz, W.H., Gruber, T., Lu, V.N., Paluch, S. and Martins, A. (2018), "Brave new world: service robots in the frontline", *Journal of Service Management*, Vol. 29 No. 5, pp. 907–931.

World Medical Association Declaration of Helsinki (2001), "Ethical principles for medical research involving human subjects", *Bulletin of the World Health Organisation*, Vol 79 No. 4, pp. 373.

Yam, K.C., Reynolds, S.J. and Hirsh, J.B. (2014), “The hungry thief: Physiological deprivation and its effects on unethical behavior”, *Organizational Behavior and Human Decision Processes*, Vol. 125 No. 2, pp. 123–133.

Yitzhak, N., Giladi, N., Gurevich, T. and Messinger, D. (2017), “Gently does it: Humans outperform a software classifier in recognizing subtle, nonstereotypical facial expressions”, *Emotion*, Vol. 17 No. 8, pp. 1187-1198.

Yoon, C., Gonzalez, R., Bechara, A., Berns, G.S., Dagher, A.A., Dubé, L., Huettel, S.A., Kable, J.W., Liberzon, I., Plassmann, H. and Smidts, A. (2012), “Decision neuroscience and consumer decision making”, *Marketing Letters*, Vol. 23 No. 2, pp. 473–485.

Yu, Y., Li, H., Yang, X., Kong, L., Luo, X. and Wong, A.Y.L. (2019), “An automatic and non-invasive physical fatigue assessment method for construction workers”, *Automation in Construction*, Vol. 103, pp. 1–12.

Zhang, S., Paul, J., Nantha-Aree, M., Buckley, N., Shahzad, U., Cheng, J., DeBeer, J., Winemaker, M., Wismer, D., Punthakee, D. and Avram, V. (2014), “Empirical comparison of four baseline covariate adjustment methods in analysis of continuous outcomes in randomized controlled trials”, *Clinical Epidemiology*, Vol 6, 227.

Zhang, Z., Zyphur, M.J., Narayanan, J., Arvey, R.D., Chaturvedi, S., Avolio, B.J., Lichtenstein, P., et al. (2009), “The genetic basis of entrepreneurship: Effects of gender and personality”, *Organizational Behavior and Human Decision Processes*, Vol. 110 No. 2, pp. 93–107.

Zomerdijk, L.G. and Voss, C.A. (2010), “Service design for experience-centric services”, *Journal of Service Research*, Vol. 13 No. 1, pp. 67–82.

Figure 1: Summary Framework

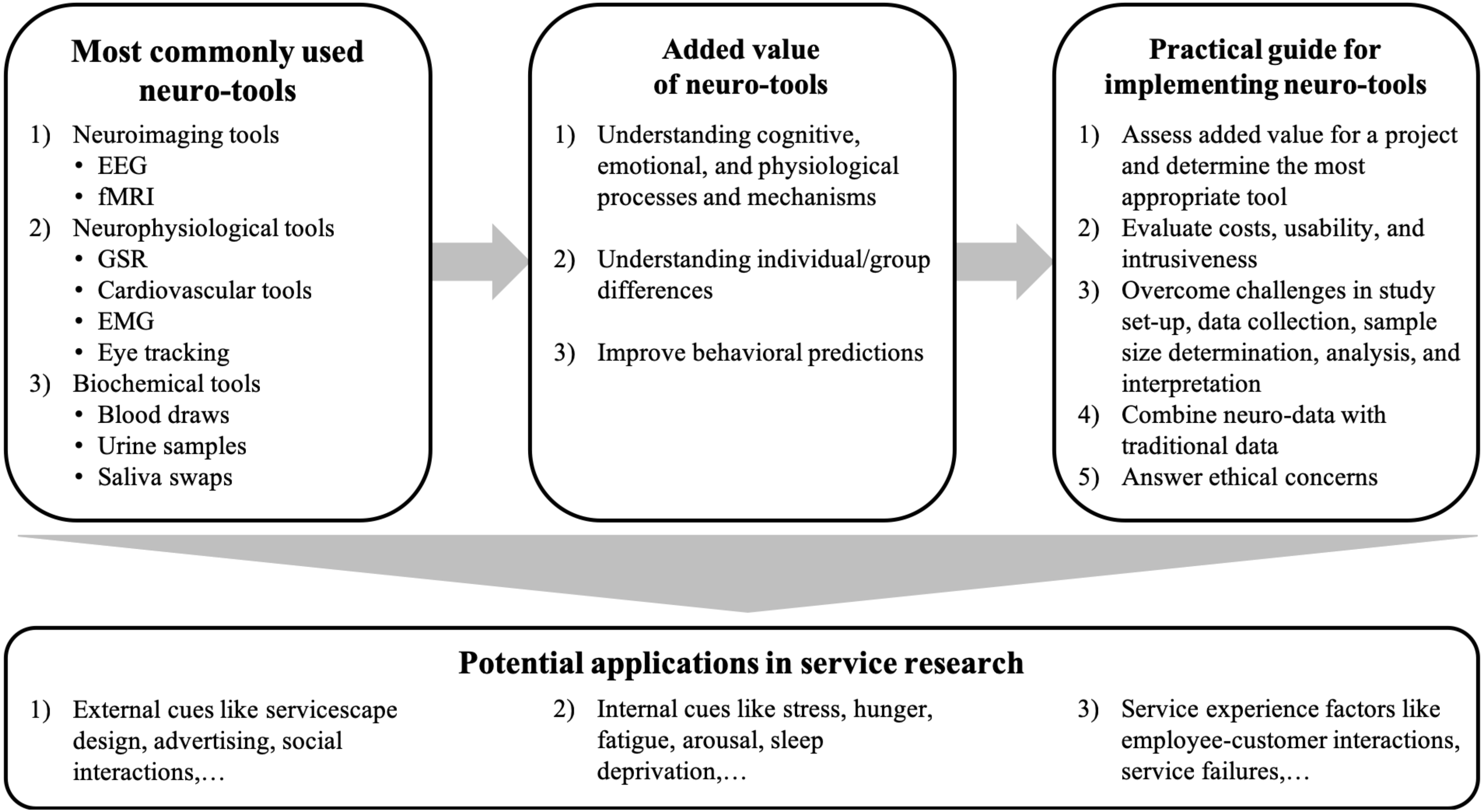

Figure 2: The Neuroscientific Method

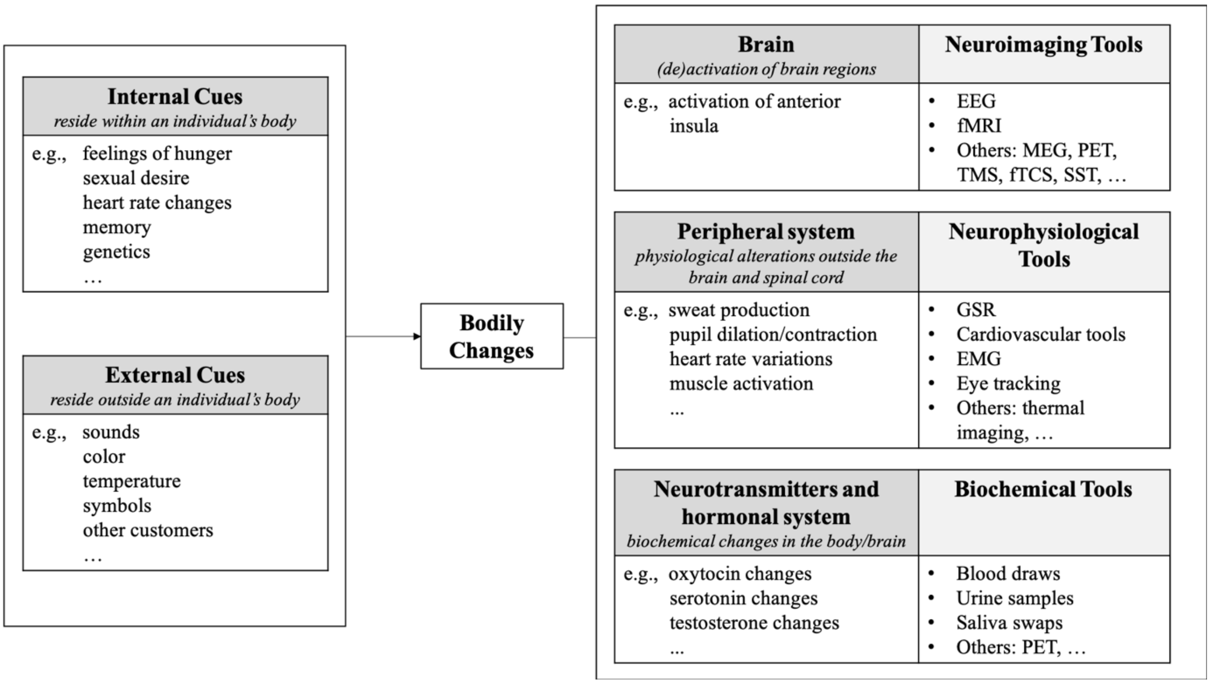

Table 1. Sources of measurement error in surveys and how neuro-tools deal with these issues

Type of bias	Definition	Consequence for results	Representative study	Neuro-tools
Item nonresponse	An eligible sample member responds to the survey, but does not provide an answer to all questions	Respondents might have deliberate reasons not to respond to the particular item. Findings might be an underestimation or overestimation of the population parameter	De Leeuw et al., (2003)	Not present. The participants do not have to answer questions
Response style	Tendency to answer survey questions without reading the question	Means and standard deviations might be inflated depending on respondent characteristics or surveys procedures. Response styles inflate correlations among survey items.	Van Vaerenbergh & Thomas (2013)	Not present. The participants do not have to answer questions -
Common method	Variance and covariance in a survey that is attributable to the measurement method rather than to the constructs the measures represent	Correlations among survey items might be inflated.	Podsakoff et al. (2003)	Complementing surveys with neuro-tools can help overcoming common method bias
Timing of evaluation and recall bias	Response to a survey might differ depending on whether the survey is administered immediately after an event or a longer time after an event	Participants' memories of past experiences might be inaccurate or incomplete, leading them to base their evaluations on concrete (abstract) attributes when the survey is administered immediately (a longer time) after the event	Pizzi et al. (2015)	Not a problem, since most neuro-tools measure in real-time + participants do not have to answer questions
Social desirability	Tendency to answer survey questions in a manner that is perceived favorably by others	Means might be inflated because people do not want to reveal their true perceptions	Hays and Ware (1986)	Not a problem, since neuro-tools mostly measure automatic bodily changes + participants do not have to answer questions
Order effect	Change in covariances among survey items depending on whether the dependent variable was measured before or after the independent variable(s)	Means, standard deviations, and correlations among survey items might be based on the questions that were asked previously in the survey (e.g. the dimensions of the experience that were made salient) rather than the customer’s real experience.	Malhotra (2008), McFarland (1981)	Irrelevant, participants do not have to answer questions
Halo effect	Excess correlation over and above the true correlation between attributes cause by tendencies to think of something as good or bad *in general* or use the evaluation of a salient dimension to evaluate less salient dimensions.	Means and standard deviations on individual measurement items may be underestimated or overestimated	Wirtz (2003)	Not a problem, since neuro-tools mostly measure automatic bodily changes + participants do not have to answer questions

Table 2: Potential criteria that should be reported

Tool selection
• Make explicit how the neuro-tool(s) used, measure the construct(s) under study.
• Is the relevance of the neuro-tool discussed?
• *(when relevant)* Is the complementarity with other data/tools discussed?
Study execution
• Are the hardware and software used to collect the data specified?
• Is the design explained in detail? Is it replicable?
• Are the participant instructions discussed?
• Is the sample size sufficient?
• *(when necessary)* Are baseline measures included?
• Is the synchronization of data assured and discussed in detail?
• Are details provided on the environmental conditions in which the data is collected?
• If the data is collected by and/or bought from an external partner, is the collecting research firm mentioned?
Data analysis
• Is the software that is being used for analysis specified?
• Are data-cleaning and filtering procedures reported?
• Is the data analysis explained in detail? How are baseline corrections executed and reported?
• How clear and detailed is the data interpretation?
• Are possible confounding variables discussed?
Study ethics
• Is the paper ethically sound?
• Is an ethical approval by a university and/or external board mentioned?
• Did study participants sign an informed consent document?

AUTHOR BIOGRAPHIES

Nanouk Verhulst is working as a doctor assistant in the Business department at the Vrije Universiteit Brussels (VUB). She obtained a Ph.D. in Applied Business Economics (Ghent University). Further, she holds a Master's in organizational and occupational psychology (Ghent University) and a Master's in Management (KU Leuven). Her publications appeared and/or are forthcoming in the *Journal of Services Marketing* and *Journal of Service Management.*

Arne De Keyser is Assistant Professor of Marketing at EDHEC Business School (France). His research focuses on customer experience, service recovery, and frontline service technology. Arne has published articles in the *Journal of Service Research, International Journal of Research in Marketing, Journal of Business Research, Journal of Service Management* and the *Journal of Service Theory and Practice*. He has won numerous research and teaching awards, including the SERVSIG Best Dissertation Award in 2015. Arne serves on the editorial boards of the *Journal of Service Research, Journal of Business Research, Journal of Service Management* and the *Journal of Service Theory and Practice*.

Anders Gustafsson is a professor of marketing at the Norwegian Business School. Dr. Gustafsson is conducting research on customer satisfaction and loyalty, management of customer relationships, and consumer behavior. He is the current editor in chief for Journal of Business Research and an area editor of Journal of Service Research. Dr. Gustafsson is also Distinguished Professorial Fellow at the University of Manchester's Alliance Manchester Business School (AMBS). He is also the upcoming president for AMA's academic council and will be responsible for some of AMA's major academic events in 2019/2020. Recently he received the Christopher Lovelock Career Contributions to the Services Discipline Award.

Poja Shams is an assistant Professor at Karlstad Business School in Sweden. His research has primarily been focused on consumer decision making and visual attention in the retail environment. His research has been awarded by the Gunnar Sundblad Research Foundation and published in several distinguished journals such as *Journal of Business & Retail Management Research*, *Journal of Business Research* and *Psychology & Marketing*.

Yves Van Vaerenbergh is Associate professor of marketing at KU Leuven (Belgium). His research focuses on service failures, service recovery, access-based services, and meta-analysis. His publications have appeared in *Journal of Service Research, Journal of Retailing,* and *Academy of Management Perspectives*, among others. He has received several best reviewer awards and best paper awards from service journals and serves on the editorial boards of the *Journal of Service Research*, *Journal of Business Research*, *Journal of Service Management*, and the *Journal of Service Theory and Practice*.