Potential and challenges for using neuroscientific tools in strategic management studies

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Abstract

Purpose – The purpose of this study is to understand how neuroscientific tools are used and discussed in ongoing research on strategy in organizations.

Design/methodology/approach – The authors used a bibliometric study of bibliographic pairing to answer the research question. They collected data from the Web of Science and Scopus databases using the keywords "neuroscience*," "neurostrategy*" and "neuroscientific*."

Findings – This study presents a framework that relates fundamental aspects discussed in current research using neuroscientific tools: Neuroscience and its research tools in organizations; emotions and information processing; interdisciplinary application of neuroscientific tools; and moral and ethical influences in the leaders' decision-making process.

Research limitations/implications – The inclusion of neuroscientific tools in Strategic Management research is still under development. There are criticisms and challenges related to the limitations and potential to support future research.

Practical implications – Despite recognizing the potential of neuroscientific tools in the mind and brain relationship, this study suggests that at this stage, because of criticisms and challenges, they should be used as support and in addition to other traditional research techniques to assess constructs and mechanisms related to strategic decisions and choices in organizations.

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Social implications – Neuroscientific methods in organizational studies can provide insights into individual reactions to ethical issues and raise challenging normative questions about the nature of moral responsibility, autonomy, intention and free will, offering multiple perspectives in the field of business ethics.

Originality/value – In addition to presenting the potential and challenges of using scientific tools in strategic management studies, this study helps create methodological paths for studies in strategic management.

Keywords Neuroscientific tools, Strategic management studies, Potential, Challenges

Paper type Literature review

1. Introduction

Neuroscientific tools have the potential to help researchers understand executives' behavior and strategic decision-making. Implicit attitudes and emotions, automatic bodily responses and unconscious brain processes shape how individuals think, feel and act at work (Becker and Menges, 2013). These tools are applied in different areas of knowledge, such as Economics, Law and Marketing, and can advance knowledge in strategic management (Powell, 2011).

One of the most frequent of studies in strategic management is testing the relationships without testing the explanatory mechanisms (Miller and Tsang, 2011). Powell (2011) argues that using neuroscientific tools can be adequate to progress in this direction and contribute to advancing knowledge and practice. This argument is important because strategic management is inherently behavioral (Augier, Fang and Rindova, 2018). The support of neuroscience makes it possible to understand behavior based on brain mechanisms (Becker and Cropanzano, 2010; Nofal, Nicolaou, Symeonidou and Shane, 2018).

Neuroscientific tools allow researchers to measure biological data that, complemented by other traditional collection methods, can be related to the behavior and emotions of individuals (Becker and Cropanzano, 2010; Laureiro-Martínez, Venkatraman, Cappa, Zollo and Brusoni, 2015). These signals, which represent the human body's physiological reactions to stimuli, make it possible to capture the subconscious events that underlie cognition and behavior. Neuroscientific tools provide a complementary lens for strategic management studies by allowing researchers to assess human behavior at the neurophysiological level (Vom Brocke and Liang, 2014).

However, despite this potential, there are challenges to be overcome and a limited number of empirical studies. Among the challenges is the limitation of techniques, especially neuroimaging, because of the response time, the expenses involved and the number of the participants, and ethical problems related to the research (Spence, 2019). In addition, Lindebaum (2016) has criticized the use of neuroscience in organizational studies, reinforcing the low validity of the data and vague statements about the results.

The first limitation is related to the neuroscientific tool used. There is a predominance of studies that seek to link mind and brain with the predominant use of neuroimaging. However, other possibilities of scientific tools also have limitations and advantages (Karmarkar and Plassmann, 2019), although they are little explored in strategic management studies, in which neuroimaging studies have been highlighted (Laureiro-Martínez, Venkatraman, Cappa, Zollo and Brusoni, 2015). A second limitation is related to the number of participants and statistical validity. Lindebaum (2016) argues that although there is the argument of trust of hard data (Lindebaum and Jordan, 2014a, 2014b) and e-attenuation of problems related to self-report (Becker, Cropanzano and Sanfey, 2011), there are indications of the low statistical value of neuroimaging studies, which, because of limitations, are performed with a reduced sample size (Button *et al.*, 2013).

An additional concern to studies that use neuroscientific tools is related to what has been called *Neuroethics*. It involves the implications of neuroscientific techniques that are increasingly accessible, both for research and practice. As a result, there is a need to maintain the privacy and confidentiality of data and responses necessary to protect the storage of neurological data (Waldman, Wang and Fenters, 2019).

In particular, studies related to behavioral strategy seek to understand decision-makers, especially business leaders, and the effects of decisions and actions that can influence the various forms of performance (Augier, Fang and Rindova, 2018). The use of neuroscientific tools in studies related to leadership, for example, presents challenges; with all the limitations explained above, Lindebaum and Zundel (2013) suggest a *body-brain pattern*, in which the brain is not the "ultimate cause of human behavior, but merely one part of more complexly unfolding processes" (p. 66).

The inclusion of neuroscientific tools in research on strategic management is still under development; there are criticisms and challenges related to the limitations and the potential to support future research. Still, a growing number of publications use neuroscientific tools in Applied Social Sciences. For example, the interest of the Academy of Management to create a group to study Organizational Neuroscience. For these opportunities and challenges, to shed light on research using scientific tools in strategic management, we seek in this study to understand how neuroscientific tools are used and discussed.

We used a bibliometric study of bibliographic pairing to answer this research question. We collected data from the Web of Science and Scopus databases using the keywords "neuroscience*," "neurostrategy*" and "neuroscientific*." We refined the search using the business and management categories. We also selected the relevant periodicals in the strategic management area. The final sample resulted in 120 articles supported by exploratory factor analysis (EFA) and networks, of which 46 served as the basis for the literature review.

The results of our study enabled the presentation of a framework that relates fundamental aspects discussed in current research with the use of neuroscientific tools: neuroscience and its tools for research in organizations; emotions and information processing; interdisciplinary application of neuroscientific tools; and moral and ethical influences in the decision-making process of leaders. In addition to presenting the potentials and challenges for using scientific tools in strategic management studies, our study assists in the methodological paths for studies in strategic management. However, despite recognizing the potential of using neuroscientific tools in the mind and brain relationship, we suggest that at this stage, because of criticisms and challenges, they should be used as support and in addition to other traditional research techniques to assess constructs and mechanisms related to decisions and strategic choices in organizations.

2. Neuroscientific tools and their use

Neuroscience uses different tools based on noncognitive human brain responses. To understand the results, potentials and challenges for using these tools in strategic management research, we will summarize their specifications and characteristics. Then, we offer the tools used in research, classified according to the metabolic or electrical activity in the brain that allows recording (Table 1). These records may indicate the research questions these tools may most likely answer. In a way, the possible records also show the limitations and the possibilities for use in conjunction with other neuroscientific tools or research techniques (Jack *et al.*, 2019).

The tools presented in Table 1 can be classified in several ways. One possibility is the portability and cost. In this case, tools such as electroencephalography (EEG), eye-tracking and facial action coding system (FACS), for example, would present the possibility of being used in natural environments and give access to larger samples that would influence the statistical power (Button *et al.*, 2013). It is one of the challenges when using tools like

Table 1.
Presentation of neuroscientific tools

Tool	Form of analysis	Description	Strengths	Limitations	Most appropriate for research	Studies that used the tool
Anatomical imaging*	Brain images	MRI scanner measures static differences in brain anatomy	Good spatial resolution Identify differences in the volume of basic tissue types in the brain Assess structural connectivity of the brain	The significance of differences in white matter volume is not well understood Reliable individual difference studies require large N (>50)	Tests hypotheses about individual differences between brain anatomy/volume/connectivity/microstructure and cognition/behavior	
Electroencephalography (EEG)*	Brain electrical activity	Electrodes placed on the scalp to measure electrical changes that result from neural activity	Longest established method Strongest temporal resolution (with MEG) Less expensive than fMRI or MEG Portable – not constrained to scanner Allows realistic interaction between subjects	Sensitive to other sources of electrical current (e.g. muscular activity) Detects signals that are not wholly spatially independent, creating an inverse problem	Requires face-to-face interaction between subjects Tests hypotheses about the timing of cognitive processes Tests hypotheses related to known and reliable ERP signatures (e.g. N400, mismatch negativity) Tests hypotheses relating to high-frequency neuronal oscillations (e.g. alpha and gamma)	Balthazard *et al.* (2012) Deitz *et al.* (2016) Geske and Bellur (2008) Hannah *et al.* (2013) Daugherty, Hoffman and Kennedy (2016) Telpaz *et al.* (2015) Pozharliev *et al.* (2015) Gountas *et al.* (2019)
Eye-tracking	Eye movement	Assistive technology allows one to assess and research an individual's eye movements revealing where to visual attention is directed	Identifies in which areas the person fixes their attention, for how long and in what order they follow their visual exploration It can be done either in closed or open environments, dynamically or statically, for activities carried out in a natural or controlled	The equipment and software, as most commercial products still have a high average price Although this technology is becoming cheaper and even though there are free solutions for conducting and analyzing experiments, the technical reliability of low-cost solutions can be challenging	It can be used in product and service interaction activities, sports, occupational or leisure activities, contributing to knowledge about eye movement and its relationship with cognitive processes	Gerpott *et al.* (2018) Meißner, Oppewal and Huber (2020) Maran *et al.* (2019) Federico and Brandimonte (2019)

(*continued*)

Tool	Form of analysis	Description	Strengths	Limitations	Most appropriate for research	Studies that used the tool
			environment, allowing various applications			Federico *et al.* (2021) Ceravolo *et al.* (2019) Venkatraman *et al.* (2012) Meißner *et al.* (2020)
Facial action coding system (FACS)	Facial expressions	It is a scientific measurement system of facial actions/movements in human beings	Researchers can manually label almost any anatomically possible facial expression	Labeling expressions require trained experts	Used to analyze the emotions displayed on the face, differentiating them through the movement of the facial muscles	
Facial electromyography	Muscles electrical impulses	It is a tool that measures muscle activity by detecting and amplifying the small electrical impulses generated by muscle fibers when they contract	It is the most reliable tool to assess reactions with emotional valence by placing bipolar electrodes on two facial muscles It is not language-dependent and does not require cognitive effort or memory It can measure the activities of facial muscles to weakly evocative emotional stimuli It is less intrusive than other physiological measures It is often the only helpful approach when movement is not visible	Although commonly used as an index of emotional responses, facial muscle activity is also influenced by the social context in which it is measured	Used to verify emotional valence (positive or negative), measure social cognition (empathic states) and situational awareness It has been used to distinguish and track positive and negative emotional reactions to a stimulus as they occur	Minas *et al.* (2014) Zellars *et al.* (2008)
Functional magnetic resonance imaging (fMRI)*	Brain metabolical activities and images	Indirectly measures neural activity via changes in oxygenation level in blood Depends on the function of endogenous biological	Captures entire brain Offering rich spatial information, provides a good foundation for inferences about function	Limited to tasks that can be performed in a scanner Cannot easily distinguish top-down from bottom-up signals Measurements are not strictly	Uses localization of function, forward inference or reverse inference (see discussion) Assesses functional connectivity of regions during	Molenberghs *et al.* (2017) Boyatzis *et al.* (2012)

(*continued*)

Table 1.

Table 1.

Tool	Form of analysis	Description	Strengths	Limitations	Most appropriate for research	Studies that used the tool
		mechanism by which neuronal activity leads to changes in blood flow ("neurovascular coupling")		quantitative (units are not biologically meaningful)	tasks or rest Assesses changes in brain function before/after intervention Assesses neural basis of individual differences	Laureiro-Martínez *et al.* (2014) Plassmann *et al.* (2008) Berns and Moore (2012)
Functional near-infrared spectroscopy (fNIRS)*	Brain metabolical activities	Indirectly measures neural activity by detecting changes in near-infrared light, which reflect changes in the amount of (de) oxygenated hemoglobin in the blood Depends on neurovascular coupling, similar to fMRI	Has better temporal resolution and is cheaper than fMRI No cost after initial purchase (e.g. maintenance) Portable Participant does not need to remain stationary, as with other imaging techniques Similar to EEG, allows realistic interaction between subjects	Lower spatial resolution and lower signal-to-noise ratio, compared to fMRI Can only detect metabolic activity on the cortical surface (approximately only 4 cm underneath the skull)	Tests hypotheses for tasks that are not optimally suited for fMRI paradigms (e.g. those requiring movement or face-to-face social interaction) Involves longitudinal studies, given the relatively low cost	Lee and Yun (2017) Meyerding and Mehlhose (2020)
Galvanic skin response (GSR)	Glands electric activity	It measures the electrical activity of glands that produce sweat in the palms of the hands and fingertips, which are more sensitive to emotions and thoughts	The more stimulated the central nervous system, the more sweat the glands will produce and the less resistance will be measured on the electrodes, thus increasing the amplitude of the circuit's output signal Although this response is not always visible (sweat), there is a change in skin resistance because of psychological changes such as increased arousal and anxiety	Individuals may experience a gradual loss of motor faculties	It is widely used in learning relaxation in general and to help identify situations that cause stress and anxiety	Christopoulos, Uy and Yap (2019) Kouchaki and Wareham (2015) Reimann *et al.* (2012)
Magnetoencephalography (MEG)*	Records electrical	Magnetometers near the scalp measure magnetic	More reliable and accurate than EEG because magnetic permeability of head is more	More expensive than EEG Not portable Very sensitive to external noise	Tests hypotheses about the timing of cognitive processes, neuronal oscillations and	

(*continued*)

Tool	Form of analysis	Description	Strengths	Limitations	Most appropriate for research	Studies that used the tool
	activity in the brain	fields generated by neural activity	uniform than electrical conductivity, which simplifies inverse solution calculations	Signal falls off with a cube of distance – deeper brain structures very hard to detect Most sensitive to activity in regions that are perpendicular to the skull surface	connectivity between regions Combined with EEG, it allows more signals to be detected and improved solutions to the inverse problem	
Positron emission tomography (PET)*	Records metabolic activity in the brain	A radioactive tracer is inserted into the bloodstream	O15 tracer measures blood flow in absolute terms Can measure other biological markers (e.g. glucose isotope provides an absolute measure of metabolic activity)	A small number of measurements per subject Low spatial and temporal resolution compared to fMRI Ethical issues arise from the fact that this is an invasive technique involving intravenous administration of radioactive isotopes Limit to a number of scanning sessions per individual to reduce radiation exposure Requires nearby cyclotron to produce isotopes Accurate anatomical localization requires a separate MRI scan	As for fMRI has limited application to functional connectivity Superior to fMRI for assessing the neural basis of individual differences (absolute measure not confounded by irrelevant factors)	
Steady state topography	Records electrical activity in the brain	It is a methodology for observing and measuring human brain activity	High temporal resolution: SST methodology is able to continuously track rapid changes in brain activity over a long period of time The SST methodology is able to tolerate high levels of noise or interference because of head movements, muscle tension, blinking and eye movements Suitable for cognitive studies	It needs to be used in conjunction with other tools	Used with audiovisual materials and/or during a psychological task to record the brain's electrical activity	

(*continued*)

Table 1.

Table 1.

Tool	Form of analysis	Description	Strengths	Limitations	Most appropriate for research	Studies that used the tool
			where eye, head and body movements occur naturally			
Transcranial direct current stimulation (tDCS)*	Records electrical activity in the brain	Coil is used to suppress (occasionally to enhance) neural activity using an electrical current Single-pulse (very brief effect) and repetitive pulse methods (*15 min effect) can be used	Allows for within-participant comparisons that sidestep endogeneity concerns Good temporal specificity is possible with a single pulse Portable – not confined to the scanner With specialized equipment, virtual lesion location can be pinpointed to regions were shown to be activated by fMRI	Generally, it can only affect the dorsal, lateral and occipital cortical surfaces (but see deep brain TMS) Directly affects only isolated regions, but the impact on networks/other regions is not fully known Impact of machine noise and skeletal muscle enervation on task performance requires careful control	Tests hypotheses related to the necessity a particular brain region might have for cognition and behavior; tests and resolves concerns about reverse inference	
Transcranial magnetic stimulation (TMS)*	Records electrical activity in the brain	Similar to TMS but uses a constant current applied through patch electrodes	Enable brain to causal cognition with more confidence because of direct stimulation of neural activity Portable Well tolerated by participants It can both increase and decrease neuronal excitability Effects last longer than TMS The technique is developing rapidly with numerous technical innovations	Anatomical location of effects is hard to assess Less spatial and temporal control than TMS Recent meta-analysis suggests no statistically reliable effects, although ongoing advances may overcome shortcomings	Tests hypotheses related to the necessity cortical areas might have for cognition, behavior and learning	Camus *et al.* (2009)

Notes: Prepared from different sources in this work; the items marked *are from the work by Jack *et al.* (2019, pp. 425–427) functional magnetic resonance imaging (fMRI), magnetic resonance imaging (MRI) and positron emission tomography (PET) (Waldman, Wang and Fenters, 2019). These tools can also be classified according to their measurements. For instance, EEG, magnetoencephalography (MEG) and eye-tracking are accurate concerning time resolution, while fMRI is accurate to the location of the activated brain region (Murray and Antonakis, 2018). Another possible difference concerns the ethical use of tools that could indicate physical limitations and the need to have a health specialist for interpretation (Waldman, Wang and Fenters, 2016), which would be the case of EEG and fMRI, among others. Also, according to Table 2, we can see the predominance of some tools in organizational studies. Primarily, studies use EEG, eye-tracking and fMRI, whereas some use Facial Electromyography, fNIRS and GSR.

EEG studies were mainly dedicated to consumers (Deitz *et al.*, 2016; Geske and Bellur, 2008; Daugherty, Hoffman and Kennedy, 2016; Telpaz *et al.*, 2015; Pozharliev *et al.*, 2015; Gountas *et al.*, 2019) and leadership (Balthazard *et al.*, 2012; Hannah *et al.*, 2013). The extension of the use of this tool for strategy studies poses some challenges. Despite its potential, it is a reductionist perspective, considering the behavioral strategy approach proposed by Powell (2011). Although behavioral strategy helps understand decisions and behavior, it works with simple alternatives for decision-making about strategic problems (Hambrick and Crossland, 2018). Concerning the leadership works of Balthazard *et al.* (2012) and Hannah *et al.* (2013), there is a criticism of reductionism of a complex situation presented by the works of Lindebaum (2016), Lindebaum and Zundel (2013) and Lindebaum and Jordan (2014a, 2014b). However, the study of Hannah *et al.* (2013) is considered a fine example of using neuroscientific tools (Waldman *et al.*, 2019) by combining EEG measurements with a psychometric scale. The use of the EEG, because of its portability and cost, is very attractive (Tivadar and Murray, 2019).

Another widely used tool is eye-tracking. In addition to being portable, it has time resolution and is suitable for assessing attention (Ceravolo *et al.*, 2019). It has been used in studies to evaluate choices in decision-making (Meißner, Oppewal and Huber, 2020; Ceravolo *et al.*, 2019), consumer segmentation (Venkatraman *et al.*, 2012), attention to objects (Federico and Brandimonte, 2019; Federico *et al.*, 2021) and recognition of leadership (Gerpott *et al.*, 2018; Meißner, Oppewal and Huber, 2020). An important aspect is that eye-tracking does not measure brain function, and therefore, it is not used to infer a relationship between brain and behavior. However, it can assess attention when in conjunction with other tools such as EEG. In addition, recent developments increased the flexibility of eye-tracking, such as the possibility of online use. One such example is the RealEye software (Federico *et al.*, 2021).fMRI has been used in research that assesses consumption experiences

Journal	No. of articles	ISSN	H index
Organizational Research Methods	14	10944281 and 15527425	111
Journal of Business Research	12	1482963	195
Journal of Business Ethics	11	01674544 and 15730697	187
Journal of Management Information Systems	9	07421222 and 1557928X	144
Harvard Business Review	8	178012	179
Journal of Management Inquiry	8	10564926 and 15526542	62
Leadership Quarterly	7	1E + 07	151
Journal of Management	5	01492063 and 15571211	224
Human Relations	5	00187267 and 1741282X	134
Journal of Organizational Behavior	4	08943796 and 10991379	177

Table 2. Journals with more publications in the sample

(Plassmann *et al.*, 2008; Berns and Moore, 2012), studies of leadership (Molenberghs *et al.*, 2017; Boyatzis *et al.*, 2012) and executive decision (Laureiro-Martínez *et al.*, 2014). The fMRI can accurately indicate the areas of the brain that are activated. Despite these possibilities, it has received several criticisms because of the low statistical power of the studies, the imprecision of the statements and the ethical challenges (Lindebaum, 2016). It was accused of research reductionism by Lindebaum and Zundel (2013), who presented the "body-brain pattern," with the argument that "the brain level is not always the ultimate cause of human behavior, but merely one part of more complexly unfolding processes" (p. 859).

3. Research method and techniques

This study used a bibliometric analysis of bibliographic coupling (Zupic and Čater, 2015), supported by EFA and relationship networks techniques. Using this method, because of its empirical nature, we could avoid part of the subjectivity of traditional qualitative reviews.

3.1 Data collection and sampling

The data were collected from a secondary source. The databases used were Web of Science and Scopus. These two databases are considered the most complete and serve as a reference for assessing the relevance of published research (CAPES, 2019).

We selected the sample by searching all articles available in the "business or management" subarea. There was a total overlap of Web of Science journals by the Scopus database. Only articles from periodicals with an H Index above 50 were selected (Table 2) and which had "neuroscience*," "neurostrategy*" and "neuroscientific*" in their titles, abstracts or keywords. We found 120 articles from 1990 to 2020.

3.2 Analysis procedure

To elaborate the bibliographic coupling analyses, we structured a cooccurrence matrix of the sample references (Bernard and Ryan, 2010). This matrix contains only documents with at least two samples' shares, generating 105 articles. This cut was not arbitrary. The 105 articles correspond to 87.5% of the total of 120 articles. The 105 articles had a total of 10,984 shares of 12,450 of the total articles, which corresponds to 88.2% of the total.

The cooccurrence matrix of the 105 most cited documents was prepared using the Bibexcel software. As a selection criterion for the number of components to be retained for analysis, we analyzed information from eigenvalues (Kaiser, 1960), percentage of explained variance (Fabrigar and Wegener, 2011), screen plot graph (Cattell, 1978) and parallel analysis (Velicer, Eaton and Fava, 2000).

These methods converged to an ideal number of four factors with 46 articles in total. The four factors explain 69% of the total variance of the matching matrix. We use an orthogonal rotation. Therefore, the possibility of correlation between the oblique rotations' components is irrelevant in the analysis. We chose Varimax with Kaiser normalization among the orthogonal rotations because it maximizes the sum of the load variances, allowing a better analysis of the relationship between the components and the documents that compose them.

The load criterion to justify the presence of certain documents in a component was that the component had a factorial load ≥ 0.5 (Comrey and Lee, 2013). The degree of reliability of the EFA factors was measured using Cronbach's alpha (α). It indicates scales' confidence, accuracy or internal consistency (Cortina, 1993). Values found for Cronbach's alpha above 0.70 are established as reliable, while those above 0.80 are very reliable (Nunnally and Bernstein, 1994).

In the final result, we identified the correlation matrix analysis referring to the Kaiser–Meyer–Olkin (KMO) sample adequacy index to verify the feasibility of using factor analysis.

For this sample, the KMO value was 0.825. More proximity to the value 1 for the KMO means higher commonality and better factorability of the sets of items (Kerlinger and Lee, 2008).

We use an additional method to gauge robustness to the pairing analysis (Vogel and Güttel, 2013). We build a network diagram using Ucinet (Borgatti, Everett and Johnson, 2013), with the same matrix used in EFA. Factors were plotted over the network to allow visualization between them. We defined the names of the factors based on the detailed analysis of the joint content of the articles that comprise them.

4. Results

Figure 1 presents the bibliographic coupling network of the 46 articles. We conducted a factor analysis (Table 3) and superimposed the results on the network. With this procedure, we improved the definition of the clusters. We identified four factors. The blue cluster, Factor 1, on the left of Figure 2, is the one with the most articles and is the predominant one. On the right side of Figure 1, the other factors are separated from Factor 1. The results of factor loadings, negative for the other factors about Factor 1 and vice versa, confirm that they follow an opposite direction.

Density and cohesion results (Table 4) indicate that the factors are dense (conceptual coherence exists) but deal with different issues (cohesion). The article with the highest centrality is Ashkanasy, Becker and Waldman (2014). It means that this article is the most critical node, considering the links and clusters around it.

The articles that compose Factor 1 are linked to the general theme of this article: *Factor 1 – Potential and challenges of neuroscientific tools*. We start the analysis from this factor representing the discussion that unfolds in the other factors. There are 26 articles in this factor that together present two aspects: they show the potential and encourage the use of neuroscientific tools in organizational studies; they pose critics and are reticent to the use of neuroscientific tools in such studies.

This factor incorporates the most central article, authored by Ashkanasy, Becker and Waldman (2014), who argue that despite the potential of using neuroscientific tools for organizational studies, *four issues* need to be discussed: (i) neuroscientific research and reductionism; (ii) the need to address methodological and technological challenges in conducting this type of research; (iii) how neuroscientific research is meaningful in organizations; and finally, (iv) neuroscience as just another management fad (p. 909).

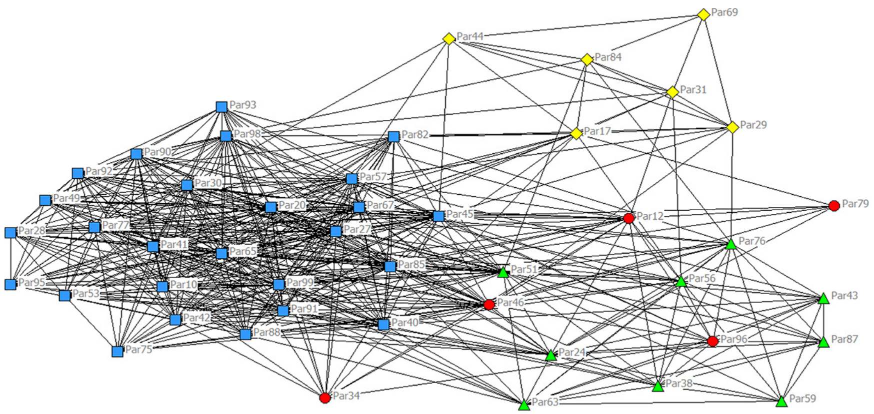

Figure 1. Bibliographic coupling network

References	Code	Factor 1	Factor 2	Factor 3	Factor 4	Communalities	Cronbach's alpha
Jebb and Tay (2017)	Par53	0.913	−0.018	0.066	−0.028	0.840	0.964
Molenberghs *et al.* (2017)	Par67	0.908	0.030	0.119	−0.008	0.839	
Tivadar and Murray (2019)	Par77	0.905	−0.008	0.107	−0.043	0.833	
Lindebaum and Jordan (2014)	Par41	0.904	−0.032	−0.001	−0.022	0.819	
Lindebaum (2016)	Par65	0.895	−0.046	0.084	−0.034	0.811	
Butler, Lee and Senior (2017)	Par91	0.885	0.040	0.124	−0.064	0.804	
Braeutigam, Lee and Senior (2019)	Par99	0.876	−0.006	0.253	−0.031	0.833	
Lindebaum and Zundel (2013)	Par27	0.860	−0.003	−0.087	−0.083	0.754	
Massaro and Pecchia (2019)	Par88	0.859	0.000	0.182	−0.062	0.775	
Ashkanasy, Becker and Waldman (2014)	Par30	0.858	−0.058	0.140	−0.054	0.763	
Bagozzi and Lee (2019)	Par85	0.845	−0.023	0.208	−0.011	0.759	
Lindebaum and Jordan (2014)	Par28	0.836	−0.043	−0.104	−0.058	0.714	
Lindebaum and Raftopoulou (2017)	Par92	0.824	−0.038	−0.143	−0.075	0.707	
Lindebaum (2013)	Par42	0.807	−0.043	−0.073	−0.078	0.664	
Cropanzano and Becker (2013)	Par49	0.798	−0.018	0.097	−0.039	0.649	
Waldman, Wang and Fenters (2019)	Par57	0.790	−0.075	0.294	−0.048	0.719	
Nicolaou and Shane (2014)	Par40	0.783	0.142	0.068	−0.050	0.641	
Healey and Hodgkinson (2014)	Par20	0.778	−0.049	0.188	−0.003	0.643	
Van Vugt and Von Rueden (2020)	Par98	0.733	−0.103	−0.037	−0.039	0.550	
Schoeneborn, Blaschke and Kaufmann (2013)	Par75	0.731	−0.077	0.151	−0.044	0.566	
Houdek (2017)	Par93	0.722	−0.054	0.157	−0.021	0.549	
Waldman *et al.* (2017)	Par45	0.703	−0.069	0.333	−0.027	0.610	
Powell and Puccinelli (2012)	Par82	0.700	0.109	0.049	0.115	0.517	
Becker, Volk and Ward (2015)	Par90	0.685	−0.125	0.145	−0.078	0.512	
Lindebaum (2013)	Par95	0.685	−0.031	−0.200	−0.074	0.516	
Bagozzi *et al.* (2013)	Par10	0.674	−0.077	0.308	−0.001	0.556	
Meyerding and Mehlhose (2020)	Par63	−0.038	0.937	−0.039	−0.023	0.881	0.909
Hsu (2017)	Par43	−0.097	0.922	0.032	−0.039	0.862	
Stanton, Sinnott-Armstrong and Huettel (2017)	Par38	−0.069	0.916	0.048	−0.009	0.846	
Daugherty, Hoffman and Kennedy (2016)	Par59	−0.061	0.903	−0.015	−0.03	0.819	
Spence (2019)	Par51	0.201	0.862	−0.008	−0.032	0.785	
Zuschke (2020)	Par76	−0.075	0.800	−0.015	0.036	0.646	
Gountas *et al.* (2019)	Par87	−0.081	0.794	0.080	−0.083	0.651	
Lim (2018)	Par24	−0.028	0.791	0.034	−0.033	0.629	
Karmarkar and Plassmann (2019)	Par56	−0.043	0.775	0.019	0.018	0.604	
Lee and Yun (2019)	Par96	0.098	0.308	0.822	−0.027	0.781	0.842
Moore and Gino (2015)	Par12	0.136	−0.013	0.817	−0.023	0.686	
Pohling *et al.* (2016)	Par34	0.189	−0.061	0.797	−0.002	0.674	
Cropanzano, Massaro and Becker (2017)	Par46	0.354	−0.050	0.774	−0.009	0.728	
Ryan (2017)	Par79	0.034	0.042	0.739	0.158	0.575	
Anderson *et al.* (2016)	Par44	0.030	−0.059	0.095	0.852	0.740	0.833
Hu, West and Smarandescu (2015)	Par29	−0.039	−0.037	0.017	0.841	0.711	
Ahn *et al.* (2018)	Par84	−0.117	0.092	−0.143	0.757	0.615	
Moody and Galletta (2015)	Par69	−0.121	−0.082	−0.114	0.746	0.591	
Gregor *et al.* (2014)	Par31	−0.100	−0.044	0.037	0.711	0.519	
Riedl *et al.* (2014)	Par17	−0.001	−0.026	0.216	0.701	0.539	

Table 3.
Bibliographic coupling factor analysis

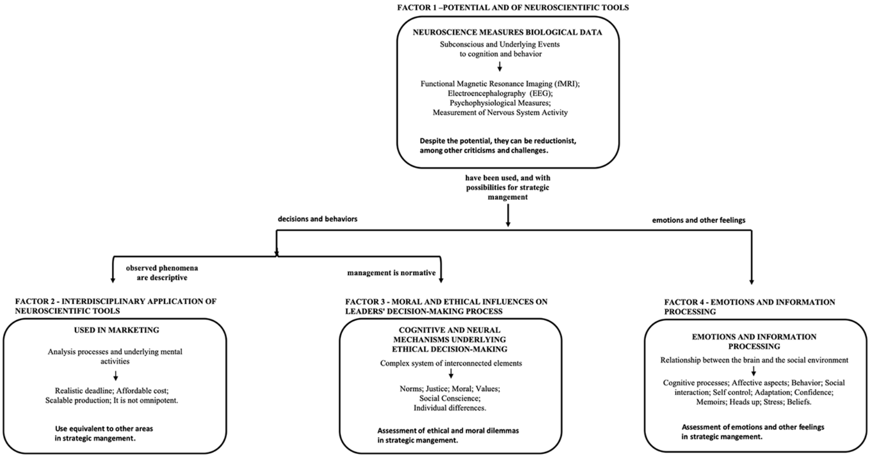

Figure 2. Neuroscientific tools' potential use and challenges in Strategic Management research

Factor	Article quantity	Explained variance	Density	Cohesion
1. Square	26	37.740	1.81	2.22
2. Triangle	9	14.892	2	2.22
3. Circle	5	8.562	1.6	1.83
4. Losangle	6	7.987	1.86	2.15
Total	46	69.181	Centrality Par 30	Ashkanasy, Becker and Waldman (2014)

Table 4. Factor analysis and network metrics for the bibliographic coupling

Ashkanasy, Becker and Waldman (2014) address each issue in favor of neuroscientific tools but parsimoniously. The article seems to be built as a counterpoint to the article by Lindebaum and Zundel (2013) that points out the reductionist aspects of using neuroscientific tools in leadership studies. Moreover, the authors address the other aspects in Lindebaum (2016).

The dominant view in neuroscience is that the human brain is a reactive system where sensory inputs cause different neural activities, which result in responses, such as some affective processes, cognitive or motor activity (Braeutigam, Lee and Senior, 2019). Therefore, by using neuroscientific concepts and tools in studies in the area of Strategy, there is an opportunity to elucidate the role of mental phenomena, including conscious ones (Bagozzi and Lee, 2019). Furthermore, a group of authors considers that neuroscientific tools have the potential to explain behavior from biological aspects. For example, the authors explain leadership in terms of personality traits (Van Vugt and Von Rueden, 2020).

The identification of brain activity alone may not be sufficient to infer the requirement for such activity to perform particular behaviors or patterns of behavior (Balthazard *et al.*, 2012). However, the evolution of organizational theories requires new and more sophisticated techniques, tools and analytics for accurate data inferences. The testing of theories is constrained by the practical aspects of research design and analysis, and therefore, methodology and theory tend to be intertwined in a relationship of mutual influence (Jebb and Tay, 2017).

The use of neuroscientific tools in studies on management indicates continuous scientific progress, technological advances and the reducibility of higher-order social systems to more fundamental theories of brain processes. There are various concepts and forms of inquiry at different levels of analysis, and the divergence between them, rather than their unification, indicates a prosperous and thriving community of inquiry (Lindebaum and Zundel, 2013).

By conducting empirical research using neuroscientific tools, researchers will identify neurological mechanisms that underscore effects on particular situations (Molenberghs *et al.*, 2017). Neuroscientific tools help researchers perceive and understand the relationship between organizational behavior and the brain. It enables the analysis of specific social processes at the neurobiological level (Lindebaum and Raftopoulou, 2017).

The domain of neuroscience and its tools may be applied to strategic management studies to help researchers overcome some limitations, allowing a broader conceptualization and measurement of phenomena and encouraging new research directions. Among the benefits of applying these tools in research are the explorations of the brain and behavior of individuals that tend to emphasize the role of unconscious processing. In contrast, most current theories of organizational behavior focus on conscious choices and resolution of existing conceptual divergences; for instance, issues that are difficult to differentiate at one level of analysis may become more distinctive at the neural processing level (Braeutigam, Lee and Senior, 2019).

These tools highlight the individual's behavioral aspects and prove that emotions and affection are of great interest to science. However, so far, these emotions have only been assessed by psychometric instruments that have limitations, as they do not adequately capture the emotional moment and the underlying experiences of individuals (Braeutigam, Lee and Senior, 2019). Another factor to be considered is that personality traits can influence the brain's response, so the tools and the complete interpretation of their results can pave the way to new microfoundations that promote the understanding of organizational behavior (Healey and Hodgkinson, 2014).

The application of neuroscientific tools has generated significant interest and converged in the emerging field of neuroscience in organizations. This new way of collecting data in research provides strategic management research promise to advance organizational research and practice (Ashkanasy, Becker and Waldman, 2014). Furthermore, neuroscience in organizations offers the opportunity to inform a variety of constructs relevant to management inquiries and advance the comprehensive research agenda in organizational neuroscience and its ecological validity (Massaro and Pecchia, 2019).

Neuroscientific tools may allow strategic management researchers to understand which neural processes support the individual's state during research or how influential factors, such as stress, can impact them. They can complement the subjectivity of self-reports and other behavioral measures, improve our understanding of constructs and their relationships and new ways to refine theories (Tivadar and Murray, 2019) and improve understanding of the relationship between organizational behavior and our brains (Lindebaum and Zundel, 2013). However, we cannot reduce complex processes and behaviors to electrochemical activity in the brain only; we need to complement and not replace traditional research methods (Becker and Cropanzano, 2010), understanding not only the physiological foundations of signals measured with a given neuroscience technique but also the analytical and interpretive assumptions and constraints of such a technique.

Using neuroscientific tools in strategic management research, we may strengthen the ability to predict critical organizational phenomena, understand the ontological basis of constructs of interest and create a more accurate or reinforced measurement (Waldman, Wang and Fenters, 2019). When analyzing the data that neuroscientific tools generate, researchers must develop skills to transfer neuroscientific insights from the human mind to the role of individual actors in organizational contexts. For this reason, it is relevant to use, in addition to tools, other methods that can complement each other (Schoeneborn, Blaschke and Kaufmann, 2013).

Despite the many positive aspects of fMRI, some authors present some drawbacks, such as the validity of neuroimaging data, the use of imprecise statements and the provision of nonethical theoretical and empirical advances (Lindebaum, 2016; Lindebaum and Jordan, 2014a, 2014b). Butler, Lee and Senior (2017) rebut such critics. They recognize that management, and strategic management, need firm foundations that incorporate a neuroscience perspective as a significant potential, both in terms of knowledge development and managerial and organizational effectiveness.

Neuroscientific tools assess the dimension and level of a specific mental capacity or executive function needed to complete particular tasks. Nevertheless, implementing these tools in research can generate a high financial cost and force researchers to deal with new ethical considerations and dilemmas (Becker, Volk and Ward, 2015). Neuroscience and its tools hold promise for advancing organizational theories and practices, with not only rapid advances and new challenges, but also moral risks and ethical dilemmas, which researchers must anticipate and respond to (Cropanzano and Becker, 2013). Interventions derived from this research in the future will create ethical risks and concerns (Lindebaum, 2013a, 2013b).

The lack of availability and the prohibitive costs of brain imaging technology have historically limited the application of this method in organizational settings. In the past decade, perceiving the need for new ways to measure many of the constructions of organizational phenomena and behaviors, neuroscience has come into evidence in management not to replace traditional approaches but rather to promote an understanding that such methods do not encourage (Waldman, Wang and Fenters, 2019).

As a field under construction, neuroscience and its tools applied in studies on strategic management need more research on its results and methods so that organizations can encourage or endorse proven interventions, as it is an approach with the potential to address important questions and unanswered questions in the field (Nicolaou and Shane, 2014).

However, research using these tools is developing rapidly and becoming the subject of technological and methodological challenges that must be considered when conducting or interpreting research in neuroscience applied to organizations (Ashkanasy, Becker and Waldman, 2014). Some phenomena that happen within organizations have already been researched with neuroscientific methods, for example, the practice of leadership. The dominant view is that neuroscientific tools offer better and refined predictions.

Controlling individual behavior is something organizations already do, and the question is whether neuroscience can help them do better, considering that structures have a substantial financial and human impact. However, they are not necessarily "more human" than the brain technologies that allow people to control their behavior (Powell and Puccinelli, 2012).

Factor 2 was named *Interdisciplinary application of neuroscientific tools*. The nine articles that make up this factor present neuroscientific tools in marketing, and we argue about the possibilities for their use in strategic management studies. A significant amount of work uses neuroscientific tools in various disciplines such as Neuroergonomy, Neuromarketing, Neurogastronomy, Neurostrategy and Neuroeconomics, among many others (Daugherty, Hoffman and Kennedy, 2016). The strategic management area is still starting to use these tools, but the Marketing area has been publishing for a few decades, mainly studies on consumer behavior (Gountas *et al.*, 2019; Meyerding and Mehlhose, 2020; Zuschke, 2020). Companies want to understand, predict and change the behavior of those they interact with, advise or provide services to, using recent advances in neuroscience, as this method allows more understanding of the mind, being the most effective intervention designed to date (Spence, 2019).

However, some issues limit the companies' broader adoption of neuroscientific tools, such as the time needed to get an answer, the expenses involved and the large number of participants required to answer the questions' objectives, legality and ethics. In addition, the lack of access to the latest neuroimaging techniques in many emerging economies is also a significant constraint for companies worldwide (Spence, 2019).

Neuroscience domains are being used in different areas within organizations, as traditional internal and external analysis methods suffer from well-known limitations. They have remained virtually unchanged since their introduction decades ago (Hsu, 2017). They facilitate a more direct understanding of how brain states and other physiological mechanisms relate to phenomena, behaviors and decision-making (Stanton, Sinnott-Armstrong and Huettel, 2017). Thus, neuroscience offers researchers and professionals from different areas a new view into the analysis processes and underlying mental activities experienced by their target markets when exposed to specific types of stimuli. This practice has great potential for advancing theory and practice (Lim, 2018).

Although the use of neuroscientific tools has made significant advances in recent years, the interface with business and the concerns of large companies remains challenging. The domain of neuroscience is one of the most fruitful approaches, as it adapts the tools, techniques, methods and understandings from the academic research that can help solve the world's business problems real people-related behavior, in a realistic timeframe, at an affordable cost and in a scalable manner (Spence, 2019).

In research, whether to assess theories or practices, it can be helpful for the researcher to choose a single method that best answers the issue of interest. However, engaging multiple complementary methods offer significant benefits as well as tangible evidence for results. Regarding neuroscientific tools, combining methods can allow researchers to measure the correlation and establish the causality of neural mechanisms hypotheses. That is, one can apply these techniques in different areas of knowledge. However, they are not omnipotent; they complement existing investigations, offering data, models, theories and analyses integrated into current social science research (Karmarkar and Plassmann, 2019).

Five articles make up *Factor 3 – Moral and ethical influences on leaders*' *decision-making process*. These articles use neuroscientific tools to investigate ethically controversial behaviors and situations.

Both affective reactions and cognitive reasoning contribute to moral judgments, although automatic affective processes dominate (Pohling *et al.*, 2016). In organizations, decision-makers face moral issues that challenge them because of the rapidly changing environment, pressures from different stakeholders and different observed practices from local or international businesses. Incorporating dynamic aspects into moral decision-making could open new avenues for understanding ethical behavior in a changing world.

Neuroscientific tools can provide insights into individual reactions to ethical issues and raise challenging normative questions about the nature of moral responsibility, autonomy, intention and free will, showing considerable promise in the field of business ethics. In empirical research, these tools demonstrate how individuals make ethical decisions below the level of consciousness, by physiological analysis and, therefore, beyond what individuals themselves can tell us.

Dominant workplace models, unethical behavior and failure help to explain what we learn from moral psychology and cognitive neuroscience on how and why people make decisions. These decisions can be explained by intuition, affection and physiological factors that support the more deliberative reasoning process in the construction and representation of moral behavior (Moore and Gino, 2015).

Another noteworthy phenomenon is *time constraints*, which can increase mental efforts and alter the outcome of moral judgments when decision-makers face ethical dilemmas. Time constraints can overwhelm brain activities and increase decision stress, possibly leading to moral incompetence (Lee and Yun, 2019).

Rationalist and moral-realist assumptions still describe most theories that address business ethics. Thus, studies using neuroscientific tools point to the importance of morals, emotions and intuition in forming a moral judgment. Ryan (2017) used neuroscience related to male and female brain structures and brain chemistry. The results of recent neuroeconomic research conclude that male and female brains are structured differently. However, different portions of both genders' brains are used for the same tasks, often leading to identical conclusions. This study suggests that these results can benefit six areas of business ethics research: trust, moral decision-making, organizational justice, moral development, service ethics and female management styles.

Another study that sought to understand the underlying neural mechanisms and the psychological mechanisms of deontic justice used rules to assess events, affective empathy and cognitive empathy. As a result, the authors identified that deontic justice is important, even when it does not directly serve our self-interest. This conclusion involves psychological mechanisms, cognitive and affective empathy and our ability to assess and apply moral rules; that is, these mechanisms are associated with neural systems that work together to form and direct an internalized sense (Cropanzano, Massaro and Becker, 2017).

Finally, six articles make up *Factor 4 – Emotions and information processing*. Automatic or unconscious mental processes underlie much human cognition and decision-making; they likely play an essential role in several other behaviors. However, neurophysiological measures alone are generally insufficient; it is advisable to use data sources to triangulate between measures (Anderson, 2016).

When we observe the role of human emotions in information systems (ISs) phenomena in organizations, we need to understand the interaction of language, physiology and individuals' behavior. Furthermore, to study these ISs using neuroscientific tools in strategic management research, we need to distinguish between different emotional systems of language and physiology, choose emotion measures carefully and recognize the intertwining of emotion and cognitive processing systems (Gregor *et al.*, 2014).

The different emotional systems link to other human systems, including the cognitive processing system. For example, emotional experiences can be directly triggered by emotion-inducing stimuli present in ISs; in turn, emotional experiences can influence resulting behaviors, such as acceptance and use of ISs and human decision-making (Gregor *et al.*, 2014).

Emotion is a critical component of people's lives and experiences and their interactions. It plays a critical role in high cognition and can be assessed through neuroscientific tools. Emotions are related to several other processes experienced by individuals within organizations, such as attention, memory, adaptation, self-control, stress, confidence, cognitive processes, affective aspects, social interaction, behavior, beliefs and a series of results (Gregor *et al.*, 2014; Riedl *et al.*, 2014; Moody and Galletta, 2015; Ahn *et al.*, 2018).

Emotions can also influence how individuals get used to the information received in organizations, and neuroscientific tools can also be used to analyze this adaptation. They allow us to see how the brain processes familiar visual stimuli. In addition to the results provided by the tools, it is relevant to consider the biological characteristics of individuals and offer proper neurophysiological data/measures to guide the design of adaptation-resistant warnings (Anderson *et al.*, 2016).

In addition to understanding how individuals adapt to information, *self-control* is another factor considered worth observing. It influences individual behavior, and within an organization, individuals can be just as dangerous as, and potentially more dangerous than, those outside it, because of their intimate knowledge of systems and the access they are given to their routine activities (Hu, West and Smarandescu, 2015).

Self-control is generally defined as one's control over oneself; it is an individual ability to refrain from committing deviance or criminal acts under certain circumstances. Neuroscientific tools can be used to investigate the neural correlates of human decisions and self-control in organizations. Therefore, their application to screening employees' self-control is practical and recommended for organizations to protect themselves (Hu, West and Smarandescu, 2015).

5. Discussion

In this article, we used bibliometrics to access the potential and challenges of adopting neuroscientific tools for research in strategic management. We used the bibliographic coupling analysis to verify publications on neuroscientific tools in organizational studies to verify the possibilities for studies in strategic management. The study made it possible to empirically present the current discussion on the use of neuroscientific tools in the field and indicate ways to add value to their use in the current stage of development.

Interest in using neuroscientific tools in strategic management research has grown, especially since the conceptual article by Powell (2011), entitled *Neurostrategy*. These tools can enable the advancement of knowledge and approximation with real-life (Powell, 2011), considering that decisions and other aspects of strategic management are inherently behavioral (Augier, Fang and Rindova, 2018). However, despite this potential, there are some divergence and challenges considering their application in the current stage of development. This divergence between the potential and challenges of neuroscientific tools has been the central debate among researchers (Factor 1 of Figure 2). We summarize this divergence manifested by *the enthusiasm* and *the preoccupation* of researchers (Table 5).

The framework presented in Figure 2 represents the result of our bibliometric research on neuroscientific tools' potential use and challenges in strategic management research. As mentioned before, the main ongoing discussion is the one that indicates the divergence in the use of these tools (Factor 1), especially the points presented by Lindebaum and his coauthors (Lindebaum, 2016; Lindebaum and Zundel, 2013; Lindebaum and Jordan, 2014a, 2014b). The main problem is the reductionism of a complex condition, leading to results and indications that can harm the practice instead of helping it. The concerns raised by Lindebaum were debated in favor of the use of neuroscientific tools by the most central article in the sample, namely, Ashkanasy, Becker and Waldman (2014). We agree with Lindebaum's concern, but together with Ashkanasy, Becker and Waldman (2014), we see great potential in the use of neuroscientific tools in strategy studies.

To a great extent, the criticism concerns the use of neuroscientific tools that indicate areas of brain activation and seek to relate them to behavior (Ashkanasy, Becker and Waldman, 2014; Lindebaum, 2016; Lindebaum and Zundel, 2013; Lindebaum and Jordan, 2014a, 2014b), such as fMRI (Laureiro-Martínez *et al.*, 2014). However, using neuroscientific tools with other tools can help develop new insights and contributions. In Figure 2, two sets of works have used neuroscientific tools, those that seek to investigate decisions and behaviors (Factors 2 and 3) and those that investigate emotions and other feelings (Factor 4).

Table 5. Enthusiasm and preoccupation about the use of neuroscientific tools

Enthusiasm	Neuroscience may provide a new source of data for advancing theory in organizations	Ashkanasy, Becker and Waldman (2014); Becker, Cropanzano and Sanfey (2011); Healey and Hodgkinson (2014); Lee, Senior and Butler (2012); Senior, Lee and Butler (2011); Waldman, Balthazard and Peterson (2011a); Molenberghs *et al.* (2017), Macoveanu *et al.* (2016); and Jack *et al.* (2019)
	Neuroscience can complement Psychology, allowing researchers to understand the underlying mechanisms responsible for an individual's emotional and behavioral interactions and experiences in the workplace	Reina, Peterson and Waldman (2015); Niven and Boorman (2016), Pinazo *et al.* (2016); Bischoff *et al.* (2013), Waegeman *et al.* (2014); Hinvest *et al.* (2014); and Wong, Xue and Bechara (2011)
	Neuroscience can be useful in analyzing processes related to morals, justice and values for decision-making, understanding that there is a biological substrate for human morals	Braeutigam, Lee and Senior (2019); Cropanzano, Massaro and Becker (2017); Salvador and Folger (2009), Emonds *et al.* (2011); and Mason, Dyer and Norton (2009)
	Research in organizations needs cognitive neuroscience to benefit from the theories and discoveries of this field and add its techniques to the set of existing scientific management methods	McDonald (2018); Balthazard *et al.* (2012); Laureiro-Martínez *et al.* (2015); Laureiro-Martínez and Brusoni (2018); and Waldman, Balthazard and Peterson (2011b)
Preoccupation	Research results using neuroscience methods can be accepted simplistically, falling short of the methodological standards of investigation methods established in organizational research	Lindebaum and Jordan (2014); Lindebaum and Zundel (2013), Healey and Hodgkinson (2014); Lindebaum (2016); and Jack *et al.* (2019)
	Debates on the challenges of Neuroscience in different areas: Neuroeconomics, Neuromarketing and information systems	Konovalov and Krajbich (2019), Fugate (2007); Lee and Yun (2019); Dulleck *et al.* (2011); and Carter, Meyer and Huettel (2010)
	Ethical, logical and empirical reasons for using neuroscientific methods in organizational research	Lindebaum and Jordan (2014); and Lindebaum and Zundel (2013)
	Sociological inquiries about what kind of questions arise as neuroscientific data is produced	Pickersgill (2013)

On the left side of Figure 2 are Factors 2 and 3, composed of articles on decisions and behaviors. Factor 2 considers the use of neuroscientific tools in marketing and its possible extension to strategic management, whereas the articles in Factor 3 assess the moral and ethical influences in the decision-making process, also likely to be applied to strategic management.

The articles in Factor 2 have focused on consumer decisions and choices, using mobile neuroscientific tools (EEG and fNIRS). We can highlight two aspects of using the scientific tools presented in this Factor for application in strategic management. The first is the risk of the isolated use of neuroscientific tools. The second is some reductionism, as Hambrick and Crossland (2018) commented on. However, we see the possibility of using all these tools, but mainly eye-tracking, to assess choice and attention in specific contexts, for example, the use of new methods to investigate attention from the perspective of the attention-based view (Ocasio and Joseph, 2018) that also eliminates sample size problems.

Factor 3 articles present the discussion on the possibility of studying ethical and moral aspects in decision-making. These articles, more than empirically evaluating with neuroscientific tools, are concerned with exploring the constructs and the possibility of associating moral behavior with specific brain locations and functions. Although we agree that it is interesting to evaluate the ethical and moral aspects of one decision (e.g. in studies that assess managerial hubris, narcissism and others linked to the upper echelon), these studies seem to meet the criticisms of Lindebaum's articles (Lindebaum, 2016; Lindebaum and Jordan, 2014a, 2014b) of reductionism and the body-brain pattern (Lindebaum and Zundel, 2013). However, we see the potential of using neuroscientific tools in conjunction with other instruments and tools to assess the presence of ethical and moral behaviors in different contexts in strategic management. In this case, portable devices, such as EEG and eye-tracking, are also promising. Unfortunately, we did not identify any studies in our sample that used FACS, which now have a more automated interpretation technology.

Finally, at the right side of Figure 2, we present Factor 4, entitled Emotions and information processing. Most studies use EEG and fMRI to assess the activation of specific brain zones. Similar to what was presented for Factor 3, we consider it an opportunity for studies in strategic management to set emotions and other feelings, especially in situations of choice and decision-making. We also consider the use of portable equipment (EEG and eye-tracking) and FACS.

Our reluctance regarding the use of instruments and their relationship with the activation of specific brain regions, as mentioned, is because of the criticisms presented by Lindebaum, especially the body-brain pattern, as the brain is not the "ultimate cause of human behavior, but merely one part of more complexly unfolding processes" (Lindebaum and Zundel, 2013, p. 66). Furthermore, although technology has progressed significantly, scientific tools, depending on their type and how they are used, present the problem of *reverse inference*, in which it is not possible to infer that the activation of a particular area of the brain during a task corresponds to a specific thought (Hutzler, 2014).

Human behavior is influenced by social context, but the mechanisms underlying these effects remain poorly understood. For this reason, we believe that, even though there is a long way to go, the contribution we seek to bring with this article is related to the possibility of developing and implementing neuroscientific tools in studies in the area of Strategy. We note that different theoretical gaps and study opportunities are to be created.

These tools are considered interdisciplinary applications in strategic management and make it possible to verify the analysis processes and underlying mental activities with a realistic deadline, an accessible cost and a scalable production, but without considering the method omnipotent compared to others. It is also necessary to understand that the phenomena observed will be descriptive and may affect ethical decision-making, thus interfacing with business.

By using neuroscientific tools, we have the potential to analyze the microfoundations of individuals, understood as a complex system of interconnected elements that involve the judgment of norms, justice, morals, values, social conscience and individual differences. These analyses of the microfoundations of individuals by measuring biological data can be carried out on emotional aspects. They influence information processing through the relationship between the brain and the social environment considering cognitive processes, affective and behavioral elements, social interaction, self-control, adaptation, trust, memoraies, attention, stress and individual beliefs.

Research using neuroscientific tools in the area of Strategy advances because of technological innovations. Nevertheless, we understand that these innovations ignore the importance of emotions in the evaluated processes, even considering that the issue of social status dominates decision-making processes within the human brain (Wong, Xue and Bechara, 2011; McDonald, 2018).

Using neuroscientific tools, we can analyze patterns of neural activity in different situations. In the area of Strategy, we can develop research to assess the understanding of social cognition in organizations, considering a deeper analysis of the phenomena occurring in specific processes. In companies, neuroscientific tools can be used for more effective selection and placement of leaders in decision-making processes. It will be possible to gain more knowledge about how choices are made.

We believe that studies in strategic management are receptive to the neurokinetic domains and tools and are being used to deepen behavioral issues that challenge management knowledge, such as employee training, leadership, learning and organizational behavior (McDonald, 2018). For example, the identification of emotional influences on decision-making (Dulleck *et al.*, 2011) and the existence of biased beliefs to the phenomena (Bischoff *et al.*, 2013) are some conclusions of studies that have used these tools in research.

Emotions play an essential role in evaluating research results in the field of Strategy. Neuroethics is yet another emerging field; it studies ethical decision-making's cognitive and neural mechanisms. In addition to being associated with emotions, this process also needs to be evaluated and related to structures and mechanisms in the human brain (Salvador and Folger, 2009). In different situations, strategies reflect compliance with the norm, routine moral judgment and social conscience; that is, people with different social value orientations are affected by different extrinsic incentives (Emonds *et al.*, 2011).

The decision-making process that takes place through structured strategies is usually carried out under the responsibility of leaders, and ethical decision-making by leaders is distinguished from other types of decision-making processes. It implies an analysis beyond the conscious reasoning process, considering that emotions play a critical role and that normative approaches to morality have distinct underlying neural mechanisms. Conscious and unconscious emotions influence decision-making and ethical behavior, and only through their understanding is it possible to deepen research on leadership and business ethics (Salvador and Folger, 2009).

It is understood, then, that the ethical process of leaders is related to individual differences in the processing of emotions, which are the result of similar stimuli that promote different neural responses in people with different personalities (Canli *et al.*, 2000). Furthermore, similar behavioral responses may also be associated with distinct neural responses depending on personality (Emonds *et al.*, 2011).

In this context, the choice of the leaders of an organization, those who have the decision-making power, can be carried out using neurokinetic tools that will facilitate the selection and placement of individuals. This is justified because neurological assessments, the result of scientific research, can provide an insight into the biological sources of the behavior of those assessed. Even considering this opportunity, it is necessary to understand that identifying brain activity alone may not be enough to infer the requirement of such activity for the performance of particular behaviors or behavior patterns such as leadership (Balthazard *et al.*, 2012).

Therefore, preferences for certain decision-making norms are associated with particular structures and mechanisms in the human brain involved in emotional processing, moral judgment and behavior on the part of individuals (Salvador and Folger, 2009). This movement demonstrates how research and practice can use resources such as MRI to provide managers with the ability to explain their neuronal processes that influence decision-making (Emonds *et al.*, 2011).

6. Conclusions

We conclude that research using neuroscientific methods in organizational studies seeks to analyze complex social phenomena through neurological processes. However, this is a lower-level boundary condition for studying the microfoundations of organizations. They must be contextualized in an integrated way. They should incorporate the cognitive system that expresses the relationship between our brain and the specific and shared social environment. All artifacts constitute the organizational system, considering that psychological mechanisms are as emotional as they are cognitive (Hodgkinson and Healey, 2011; Healey and Hodgkinson, 2014).

Using neuroscientific tools in research on Strategy indicates continuous scientific progress and technological advances (Lindebaum and Zundel, 2013). As an interpretive framework, the tools can be understood as a paradigm that can clarify existing problems, but on the other hand, raise issues that should be carefully considered. Researchers can view mastering neuroscience as a tool that complements current methods and is mutually informative and enriching (Becker and Cropanzano, 2010).

In addition to the research fronts already presented, we consider it a suggestion for future work to analyze the criticism that strategy studies often do not test their constructs or unobservable mechanisms (Miller and Tsang, 2011). We suggest using experiments that can address decision-making and the psychological foundations of the strategic practice to identify problems related to the ability to learn and develop interpersonal relationships in the context of organizations. Many emotional and implicit factors shape behavior in organizations; neuroscience methods can help these processes and, based on this understanding, create strategies that favor the brain to work in the best way according to the objective.

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