On the (brain) Map

A Framework for Structuring Neuroscientific Results in the Field of Leadership

Robert Rybnicek, Sabine Bergner, Alfred Gutschelhofer

Department of Corporate Leadership and Entrepreneurship, University of Graz, Graz, Austria
e-mail: robert.rybnicek@uni-graz.at

Abstract

Measuring brain activity during the completion of cognitive tasks allows for conclusions about the perception, thinking and feeling of individuals. For many sciences, neuroscientific methods provide new opportunities to empirically consolidate theoretical constructs. In leadership research, neuroscience contributes to the clarification of whether and how successful leaders differ from less successful ones, how a leader's social influence impacts subordinates, and what the neurophysiological basis of leadership competences is. The present paper summarises, organizes, and discusses current findings of neuroscientific-oriented leadership research. Based on this research we derived a framework that helps to develop this vital field from a patchwork approach to a more structured picture.

Introduction

Amongst other things, human brain activity during the solution of exercises is measured in neuroscientific studies. With the use of contemporary instruments and methods, temporal and spatial neuronal processes can be localised so that it can be determined which brain areas contribute to the solution of an exercise. By linking this knowledge, networks and structures in the brain can be identified whose activation allows us to make conclusions about the thinking and feeling of a person. This aspect is probably the reason for the huge public interest and the "neuro" boom of recent years that led not only to a multitude of academic and popular scientific papers but also to the foundation of numerous new subdisciplines that often adorn themselves with the prefix "neuro".

The neuroscientific approach opens up the possibility to empirically test theoretical constructs and relations important for the social sciences. In leadership research, this approach has become very popular too although the results gained from neurosocial experiments are so far rarely of practical importance and are mainly conducted to impress a scholarly audience. Moreover, neuroscientific results in the field of leadership appear very fragmented and are poorly connected to one another. Therefore, these findings seem to represent a confusing jigsaw puzzle with only very small pieces of valuable results. What still remains, is to find corner and edge pieces or similar larger blocks giving neuroleadership research a framework to align to.

The main scope of this article is to answer the question of what neuroscience contributes to leadership research and if there are any common trends and topics in neuroleadership research. Therefore, we establish a framework that can be used to structure empirical results of neuroscientific studies in the field of leadership. Furthermore, we integrate empirical results and provide an overview of those brain areas that have been proven to impact leaders and leadership behaviour.

A framework for structuring neuroscientific results in the field of leadership

For this purpose, we conducted an explorative literature-survey on neuroscientific experiments relevant for the field of leadership. Studies were only included in the survey 1) if they were published in peer reviewed journals, 2) if the reported effect sizes on brain areas are relevant for leadership tasks and 3) if they had work-related study designs. Given our goal of presenting an overview of MR and EEG studies on leadership, the PsycINFO database (from 2000 to 2013) was searched using the keywords *neuroleadership, neuromanagement, neuronal activation in leaders respectively managers, neuroscience and leadership respectively management,* and *brain activation and leadership respectively management*. This search produced 58 articles. Theoretical articles and reviews as well as articles not published in peer reviewed journals were excluded. Studies were further excluded if they did not report effect sizes on relevant brain areas and if their study design was not work-related. These exclusion criteria lead to a final set of 31 studies that are reviewed in our literature-survey.

In leadership research we can primarily distinguish between the leaders on the one hand and their subordinates on the other. This insight is not very surprising at all but it is a useful detail to start with as it gives us the outline of our model when structuring neuroscientific results. Taking this as a basis we investigated which questions are mainly addressed by neuroleadership studies and thereby focus either on leaders or on subordinates.

Our in-depth literature survey reveals that studies focusing directly on leaders are very rare but those that do so focus mainly on the following question: What are the neuroscientific correlates of skills and competences relevant to leaders? Referring to our framework we will add “skills and competences” as a main field for structuring neuroleadership research.

In reference to the studies which focus on co-workers, employees or subordinates we identified another very interesting question for recent and future leadership research. This question refers to the neurophysiological activity that occurs in the brain of the subordinates when they experience social influence from their leaders. Hence another main field of our model is determined by “social influence”.

However, when analysing the existing studies we came across another important aspect that is not covered by the previous two questions. In this last aspect the focus is on the brains of both the leaders and their subordinates. It is about whether successful leaders can be neurophysiologically distinguished from less successful ones. Even though there are no results for leaders themselves available at the moment, this question is just for this purpose of great interest.

If we combine these aspects into a model, the two opposite sides – leaders and subordinates – provide the outline. On this outline we can determine three layers that structure recent neuroscientific literature and provide a pattern for future research: 1. Findings that contribute to the clarification of what the neurophysiological correlates of competences and skills relevant for leaders are. 2. Findings that contribute to the question of if and how successful leaders neurophysiologically differ from less successful ones. 3. Findings that contribute to answer the question of which neurophysiological processes are activated in subordinates when they experience social influence from their leader.

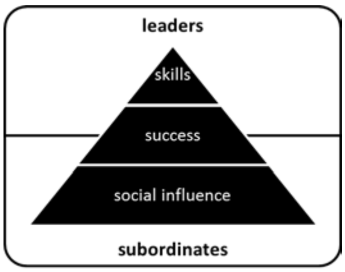

Figure 1. A framework for structuring neuroscientific results in the field of leadership

Figure 1 illustrates the proposed model. The top of the pyramid is the competences and skills of leaders. As the pyramid also indicates, there are only a small number of studies that investigate these on a neurophysiological basis. The level beneath is about the question of whether it is possible to distinguish successful and less successful leaders on a neurophysiological level. This question can be analysed with respect to the leaders or the subordinates, for which reason it is located at the intersection of the two sides of the framework. The third level merges all studies that investigate the social influence of the leaders on their subordinates. Most neuroleadership studies can be assigned to this level. This may be caused by the fact that subordinates are often easier than leaders to recruit for research. The pyramidal form does not only reflect the number of studies that can be summarised for the purpose of this article. The form also suggests that these three levels cannot be seen as independent categories. They strongly relate to each other and are somehow constitutive and sometimes even overlapping.

Literature review of empirical findings

Referring to our model and in regard to our literature review we are able to provide a well-structured overview of empirical results on neuroscientific research in the field of leadership and thus can answer the question what neuroscience contributes to leadership research. However, it needs to be mentioned that within our review we focus purely on studies using neuroimaging methods (e.g. EEG, MRI). Although there is certainly a merit in the use of neuroimaging methods, there are also potential problems to consider. First, most studies rely on very small and selected (student) samples. Thus, the statistical significance of the results needs to be interpreted with caution. Until now, only a small number of studies exist in which actual leaders have been examined. Second, so far hardly any studies have been replicated, which might be a threat to the validity of their results. Finally, neuroimaging methods are often combined with high costs and are thus only available for certain researchers, which might reduce the study results' generality.

Neuroscientific studies in leadership research do not only include neuroimaging studies but also comprise studies focusing on hormones and genes. As already stated earlier in the current review we solely focus on neuroimaging studies. The reason for that is simple. Studies inspecting the relevance of hormones in leadership setting are rather rare and mainly present inconsistent findings on the relationship between testosterone and dominant leadership [1]. The same holds true for genetic studies. The few existing studies state that taking charge of leading positions has a heritability factor [2] and that the covariance of transformational behaviour and taking charge of leading positions has common genetic factors [3]. To this end, there are simply too few studies on the relevance of genetic or hormonal influences in the leadership to provide a summary. This is the main reason why these will not be mentioned within the current paper.

How do successful leaders differ from less successful ones

Two different approaches can be taken when it is discussed how successful leaders differ from less successful ones on a neuroscientific level. On the one hand, it is possible to compare the brain activity of successful leaders to less successful ones. So far no research findings exist on this first approach. On the other hand, neurophysiological *reactions* of subordinates *to* successful versus less successful leaders can be compared. Various research findings are based on this second approach.

For instance, Rule et al. [4] studied the brain activity of subordinates that had to look at faces of very successful and less successful managers (classified according to the Fortune 1000 ranking). Subordinates were not informed about the fact that the faces belonged to leaders with varying levels of success. As a distraction task, they had to judge the presented faces according to their facial symmetry. At the end of the experiment, study participants rated the leadership competences of the managers whose faces were presented. At the sight of the manager's faces a strong activity in the amygdala was mostly observed; successful managers and successfully perceived managers provoked more brain activity in general and lead to higher activation in the left amygdala in particular. It has to be emphasized that this distinct activation pattern was maintained even if the facial attractiveness was controlled.

The amygdala plays a crucial role in emotional judgments and is activated during the perception of affect-accented stimulation such as social and emotional stimuli [e.g., 5]. Based on these findings Rule et al. [4] summarised that successful managers evoke higher brain activity, which is possibly induced by their dominant and powerful facial expression. For instance Rule et al. [4] found that when looking at the face of a successful leader the superior temporal gyrus is activated. The superior temporal gyrus plays an important role in the inspection of dominant facial expressions. Accordingly, Chiao et al. [6] showed that when looking at dominant faces a particular neuronal pattern of cerebral excitation is activated, including the right lingual gyrus and the above-mentioned (right) superior temporal gyrus. Both brain structures are strongly linked to the amygdala and play an important role when handling specific aspects of human faces (e.g. viewing direction) or when expecting intended movements [e.g., 7]. Furthermore, looking at dominant faces activates the right insula which, as a part of the paralimbic structure, is involved when adapting to affective processes and when avoiding risky situations [6]. Based on the findings above, it can be summarised that when looking at successful leaders neuronal structures are involved that play a crucial role in decoding dominant facial expressions. Moreover, experienced dominance activates neurophysiological processes which are associated with risk avoidance.

Leaders are attributed a position-related dominance which gives them the opportunity to guide and lead others through behaviour, ideas, and beliefs. Dominance is seen as an indicator of hierarchical status, which is higher for leaders than for subordinates [8]. Individual dominance orientation and hierarchical status are commonly intercorrelated. Thus, neuroanatomic structures which are activated during the perception of dominance – like the ventromedial prefrontal cortex (VMPFC; [9]) – should also be sensitive to the perception of a person's hierarchical status. Recently, this assumption was examined by Cloutier et al. [10] who confronted study participants in an fMRI experiment with individuals who differed regarding their *financial* and *moral* status. High financial status was operationalised by an annual income of more than 125,000 dollars whereas low status was operationalised by an annual income of maximum 40,000 dollars. Moral status was operationalised by occupational fields: Jobs like paparazzi or managers of hedge funds were considered as examples for low moral status, whereas neurologists or inventors of alternative energies were regarded as morally high-rated jobs.

Cloutier et al.'s [10] findings show that while rating the financial status the intraparietal sulcus (IPS) reacted in a sensitive way whereas while rating the moral status the VMPFC reacted sensitively: High financial status led to lower activation in the right IPS, whereas high moral status led to stronger activity in the VMPFC. If the neuroscientific findings on financial and moral status are combined with the above-described findings on dominant facial expressions, it can be concluded that processing information on facial expression-induced dominance and social status lead to neuronal activation in similar areas – namely in the VMPFC. However, the activation in the VMPFC seems to be moderated by the type of social status: Activation in the VMPFC only occurs when the moral status of a person is observed.

The fact that different forms of social status generate different neuronal activation is perhaps down to the fact that they are based on different processes. For instance Chiao et al.

[11] showed that the parietal cortex in general and the IPS in particular are activated if the status of two individuals is compared. Consequently, the IPS seems to be involved in the cognitive processing of status information and in creating a hierarchy. This is consistent with findings which show that the IPS is involved in the processing of symbolic information as well as in the interpretation of other's intentions [e.g., 12].

In contrast, the VMPFC seems to play an important role when hierarchical positions are judged affectively [9]. Thus, Marsh et al. [13] allude that stronger activity in the VMPFC occurs if individuals with higher status are judged. This is consistent with findings showing that the VMPFC is among other things relevant for processing emotional and motivational information of the personal surrounding [14]. If the *own* social status is compared to that of another person and the own status is perceived as similarly high then an activation in the ventral striatum can be found [15]. Since the ventral striatum is primarily involved in the processing, initiation and implementation of reward-related behaviour [16] the perception of a comparatively high status could be regarded as a form of reward.

In summary, current findings show that successful and less successful leaders and individuals with higher and respectively lower status provoke differential neurophysiological patterns. Differences in activation patterns are primarily seen in the amygdala, the VMPFC and the IPS. These different activation patterns come along with a more dominant effect of successful managers and with individuals having a higher social status. Success and social status might be communicated by means of facial expression.

Leaders and their social influence on subordinates

Commonly, leaders use their social influence to lead their subordinates which in consequence leads to certain neuronal processes in the subordinates' brain. In leadership research probably one of the most researched approaches of social influence is the concept of charismatic and transformational leadership. Charismatic leaders use values and motives important to their subordinates to influence them and to achieve outstanding performance [17]. Leaders do not only influence the behaviour of others but also impact their brain activity. This has been demonstrated by Schjoedt et al. [18] who provided their study participants with spoken messages. These were read out loud by religious leaders that differed regarding their charisma (high, middle and low charisma). In fact, the speakers were neither religious leaders nor did they differ in any other features relevant for the study. Before the voices of the speakers could be heard, the study participants were informed that they were going to listen to a highly, medium or respectively to a little charismatic leader. The behavioural plausibility check confirmed that the study participants attributed the expected level of charisma to the particular leader. Additionally, the sample was classified into more religious and less religious subordinates, based on their frequency of praying.

The neurophysiological findings by Schjoedt et al. [18] showed that in the group of religious subordinates a specific neuronal pattern was deactivated which was activated in less religious subordinates. Especially in brain areas, which are involved in attentional processes (e.g. superior parietal lobe), in working memory (e.g. central executive; dorsolateral prefrontal cortex) as well as in processing social interactions (e.g. temporoparietal junction), enormous deactivation occurred when listening to highly charismatic versus less charismatic leaders. From these findings, two conclusions can be drawn: First, it seems as if leaders who are perceived to be charismatic deactivate neuronal structures in their subordinates that are important for attentional processes and working memory. Second, the specific neuronal effect of charismatic leader occurs only if subordinates trust and believe their leaders.

The interaction between leaders and employees is not only affected by charisma but also by the interpersonal relationship. In the leader-member-exchange approach the trade-off between employees and leaders comes to the forefront [19]. Boyatzis et al. [20] proved evidence that the perceived quality of the leader-subordinate-relationship can be depicted neurophysiologically. Subordinates had to remember situations in which their boss acted positively, supportively and when their boss acted negatively, obstructively towards them. Study participants verbalised and recorded the statements of their boss they remembered. As part of the fMRI study the participants had to listen to the recorded statements that reflected positive (i.e. resonant) and negative (i.e. dissonant) relationships. Neurophysiologically it could be observed that in negative and dissonant employee-leader-relationships neural patterns were activated that are important for cognitive avoidance (e.g. left superior temporal gyrus), negative emotions (e.g. anterior cingulate cortex) and reduced attention as well as low empathy (e.g. posterior cingulate cortex). If employees described their relationship to the boss in a positive way, neural patterns were activated which are relevant in interacting with other persons (e.g. the social cognitive network) and in perceiving positive affects (parts of the limbic system). Summing up, the quality of the employee-leader-relationship activates neuronal processes and patterns in employees that can take on social cognitively but also emotionally supportive (in positive relationships) or obstructive (in negative relationships) effects.

Leaders can influence their subordinates in various ways. Providing reward for good behaviour or performance is probably one of the most common ways to do so. A study conducted by Lin et al. [21] shows that financial reward and social reward (the smile of a person who says supporting words) has a similar neurophysiological basis. Both activate the medial orbitofrontal cortex, a structure primarily involved in processing reward stimuli [22]. Neurophysiologically speaking, financial and social rewards are compatible to a certain extent. However, it has to be added that in anticipating financial and social reward gender differences appear. Spreckelmeyer et al. [23] alluded that in men a broader neuronal network is activated if financial instead of social reward is anticipated, whereas in women both brain areas are similarly activated.

Related to the question which neurophysiological processes are activated if subordinates experience social influence it can be summarised that religious charismatic leaders provoke a deactivation of brain areas that are primarily involved in attentional processes and goal-directed information processes. Furthermore, negative leader-subordinate-relationships lead to neurophysiological stimulation in employees, which comes along with cognitive avoidance, negative emotion, reduced attention and less empathy. In turn, financial and social reward should positively affect the brain activity of employees.

Neuroscientific correlates of leadership skills and competences

There is no doubt about the importance of successful interpersonal communication in leadership settings. Research offers numerous findings on the neurophysiological correlates of interpersonal communication relevant for leadership settings. In the following section findings are only discussed if they describe the brain activity of individuals that actively influence others (*acting* individuals) whereas in the previous section neuronal processes of individuals *reacting* to leaders (e.g. employees) were discussed. Due to the low number of neurophysiological studies including samples of leaders, studies based on non-leader samples were also included.

The ability to take another person’s perspective is certainly very important in any subordinate-leader-relationship. Neurophysiologically this ability is often linked to the *Theory of Mind.* The Theory of Mind refers to the ability of perceiving another person’s feeling [24], in other words to perceive and understand another person’s wishes, intentions, emotions, states of consciousness or thoughts and to differentiate these feelings from one’s own feeling. According to Carrington and Bailey [24] when empathically taking another person’s perspective regions of the medial prefrontal cortex, orbitofrontal cortex, temporoparietal gyrus and anterior as well as paracingulate cortex are involved. Empirical findings show that the specific Theory of Mind network is activated if a person imagines to live through the feelings of another person [25], if individuals rate the cooperative intentions of their counterparts [e.g., 26], or if they weigh up strategies to overpower their counterpart by arguing [27].

The specific build-up of trustful relationships can also be very important for the long-term success of leaders. The conscious decision to trust another person is strongly influenced by the other person's facial expression [28] and mostly entails activation of the amygdala and the VMPFC [29]. A lower stimulation of the amygdala indicates less intensive perception of affects, i.e. less fear of betrayal, and is associated with a higher attribution of trust. In contrast, the VMPFC, especially its frontal pole, seems to play an important role if future advantages of a trustful relationship are considered [e.g., 30]. Neurophysiologically, the perception of interpersonal trust activates structures that are linked to the Theory of Mind network (especially dorsomedial prefrontal cortex and temporoparietal gyrus; [31, 32]). This is seen as evidence that the ability to trust another person and taking another person's perspective are neurophysiologically built on common ground (further findings are offered by Rilling & Sanfey [33]).

Mutual trust is also a guideline of transformational leadership. Transformational leaders are able to motivate employees through, inter alia, attractive visions, common goals, individual support, or role model function [17]. First findings show that low and high transformational leaders can be differentiated neurophysiologically. In an EEG study using resting EEG (eyes closed) Balthazard et al. [34] showed that strong and weak transformational leaders differ especially in the prefrontal and frontal cortex, but also in the temporal, central, parietal and occipital areas of the cortex. The authors interpret the stronger activation of the (pre-)frontal cortex in transformational leaders as evidence for their better planning competencies, emotion regulation and strategic competences. This interpretation is based on findings which show that frontal brain areas are strongly involved in processes of the central executive respectively the working memory [35]. Furthermore, the activation of the frontal brain lobe corresponds with the effective handling of one's own emotions and others' emotions [e.g., 36]. Strong and weak transformational leaders do not only show different stimulation intensity in specific brain areas but also show diverging quality of neurophysiological signals. Thus, Balthazard et al. [34] suggest that strong and weak transformational leaders differ in their amplitude asymmetry, coherence, and phase lock duration. The above-mentioned findings as well as findings showing that vision-oriented communication activates neuronal patterns [37] offer first evidence that even complex and multilayer constructs like transformational leadership can be depicted in very specific brain areas.

Decision making is another one of the central tasks of leaders. With respect to the neurophysiological basis of decision making processes, a number of findings can be quoted (for a more detailed description see Rilling & Sanfey [33]). Decision making in social situations involves neuronal structures. On the one hand, the VMPFC (especially the frontal pole), which is involved in rating long-term decision advantages [38], regulating decision-complicating emotions (e.g. uncertainty and ambiguity), and perceiving as well as abstracting rewards through charitable decisions [39], plays an important role. As a function of certain situational conditions other areas of the prefrontal cortex are also involved in the process of decision making. It seems that the activation of the dorsolateral prefrontal cortex comes along with efforts to ignore egoistical decision impulses (e.g. to oppress unfair behaviour; [40]), whereas the ventrolateral prefrontal cortex is activated if unfair behaviour of the counterpart is altered [41]. In contrast, the dorsomedia prefrontal cortex seems to primarily play a role if it has to be decided whether the counterpart is given trust [30]. Moreover, three further structures have special meaning in social decision making: First, the dorsal anterior cingulate cortex functions as social alarm system that reacts to norm violations [42]. Second, the amygdala seems to play a role in the context of decisions especially in experiencing injustice [43] and last, the anterior insula is important when considering altruistic and reconciliatory decisions [44].

When reviewing neurophysiological correlates of leader behaviour, it must be noted that the Theory of Mind network as well as the VMPFC play an important role. Both correspond with empathy, trust building actions and with social decision making. Referring to the prefrontal cortex it can be summarised that strong and weak transformational leaders differ regarding their brain activation.

Conclusion and outlook

The use of neuroscientific methods in leadership research is, without doubt, a recent trend. However, it has already shown that central aspects of leadership can be depicted in neuroanatomical structures and networks. Current findings give evidence that successful and less successful leaders as well as persons high and low in status can be distinguished using neurophysiological methods. Secondly, recent findings show that leaders can activate neurophysiological networks in their subordinates through influence (e.g. by a charismatic appearance). Furthermore, they show that the skills and competences relevant for leadership – like taking an empathetic perspective or the ability to make decisions – are based on distinct neurophysiological processes.

Although these findings give interesting insights, they are fragmented and uncoordinated. They are tiny pieces of a larger jigsaw puzzle for which, so far, neither the frame pieces nor the corner pieces, which define the overall picture, are known. Therefore, it was necessary to build a framework for structuring neuroleadership research that helps to present a comprehensive overview about recent empirical neuroleadership research and develop this interesting field from patchwork into a more structured approach. This will enable significant contributions to leadership research to be made.

Nevertheless, neuroscience seems to be irresistibly entering leadership research – as well as other non-specialist branches of science. Some people are already talking about “neuromania“ and, without doubt, sceptical questions need to be proposed. What is the actual added-value of a study in which activated brain areas are colourfully dyed except for the sometimes surprising finding that everyone actually has a brain? Isn’t it way too easy and uncritical to break down social actions into more or less primitive neurophysiological processes respectively to reduce the human being to synapses and neurons? Are simple experiments appropriate to depict the complex phenomena of leadership and can serious scientific findings actually be derived from such a small sample? In order to obtain an added-value for leadership research on the basis of neuroscientific methods, it is necessary to discuss these and address further ethical questions in depth, before jumping to conclusions.

References

1. Gray, P.B. & Campbell, B.C. (2009). Human male testosterone, pair-bonding, and fatherhood. In P. Gray & P. Ellison (Eds.), *Endocrinology of Social Relationships*. Cambridge: Harvard University Press.
2. De Neve, J. E., Mikhaylov, S., Dawes, C. T., Christakis, N. A. & Fowler, J. H. (2013). Born to lead? A twin design and genetic association study of leadership role occupancy. *The Leadership Quarterly*, *24*, 45–60.

3. Li, W. D., Arvey, R. D., Zhang, Z. & Song, Z. (2012). Do leadership role occupancy and transformational leadership share the same genetic and environmental influences? *The Leadership Quarterly*, *23*, 233–243.
4. Rule, N. O., Moran, J. M., Freeman, J. B., Whitfield-Gabrieli, S., Gabrieli, J. D. & Ambady, N. (2011). Face value: Amygdala response reflects the validity of first impressions. *NeuroImage, 54* (1), 734–741.
5. Adolphs, R., Tranel, D. & Damasio, A. R. (1998). The human amygdala in social judgment. *Nature*, *393* (6684), 470–474.
6. Chiao, J. Y., Adams, R. B., Tse, P. U., Lowenthal, W. T., Richeson, J. A. & Ambady, N. (2008). Knowing Who's Boss: fMRI and ERP Investigations of Social Dominance Perception. *Group Processes & Intergroup Relations*, *11* (2), 201–214.
7. Puce, A., Syngeniotis, A., Thompson, J. C., Abbott, D. F., Wheaton, K. J. & Castiello, U. (2003). The human temporal lobe integrates facial form and motion: evidence from fMRI and ERP studies. *NeuroImage, 19* (3), 861–869.
8. Hogg, M. A. (2001). A social identity theory of leadership. Personality and social psychology review, 5 (3), 184-200.
9. Karafin, M. S., Tranel, D. & Adolphs, R. (2004). Dominance Attributions Following Damage to the Ventromedial Prefrontal Cortex. *Journal of Cognitive Neuroscience, 16* (10), 1796–1804.
10. Cloutier, J., Ambady, N., Meagher, T. & Gabrieli, J. D. E. (2012). The neural substrates of person perception: Spontaneous use of financial and moral status knowledge. *Neuropsychologia, 50* (9), 2371–2376.
11. Chiao, J. Y., Harada, T., Oby, E. R., Li, Z., Parrish, T. & Bridge, D. J. (2009). Neural representations of social status hierarchy in human inferior parietal cortex. *Neuropsychologia, 47* (2), 354–363.
12. Vrtička, P., Andersson, F., Grandjean, D., Sander, D., & Vuilleumier, P. (2008). Individual attachment style modulates human amygdala and striatum activation during social appraisal. *PLoS One, 3* (8), e2868.
13. Marsh, A., Blair, K., Jones, M., Soliman, N. (2009). Dominance and Submission : the ventrolateral prefrontal cortex and responses to status cues. *Journal of Cognitive Neuroscience, 21* (4). 713–724.
14. Miller, E. K. & Cohen, J. D. (2001). An integrative theory of prefrontal cortex function. *Annual Review of Neuroscience, 24* (1), 167–185.
15. Ly, M., Haynes, M. R., Barter, J. W., Weinberger, D. R. & Zink, C. F. (2011). Subjective Socioeconomic Status Predicts Human Ventral Striatal Responses to Social Status Information. *Current Biology, 21* (9), 794–797.
16. Wrase, J., Schlagenhauf, F., Kienast, T., Wustenberg, T., Bermpohl, F., Kahnt, T. et al. (2007). Dysfunction of reward processing correlates with alcohol craving in detoxified alcoholics. *Neuroimage*, *35* (2), 787–794.
17. Felfe, J. (2006). Validierung einer deutschen Version des "Multifactor Leadership Questionnaire" (MLQ Form 5 x Short) von. *Zeitschrift für Arbeits- und Organisationspsychologie, 50* (2), 61–78.
18. Schjoedt, U., Stødkilde-Jørgensen, H., Geertz, A. W., Lund, T. E. & Roepstorff, A. (2011). The power of charisma—perceived charisma inhibits the frontal executive network of believers in intercessory prayer. *Social Cognitive and Affective Neuroscience, 6* (1), 119–127.
19. Ilies, R., Nahrgang, J. D. & Morgeson, F. P. (2007). Leader-member exchange and citizenship behaviors: a meta-analysis. *Journal of Applied Psychology, 92*, 269–282.

20. Boyatzis, R. E., Passarelli, A. M., Koenig, K., Lowe, M., Mathew, B., Stoller, J. K. et al. (2012). Examination of the neural substrates activated in memories of experiences with resonant and dissonant leaders. *The Leadership Quarterly, 23* (2), 259–272.
21. Lin, A., Adolphs, R. & Rangel, A. (2012). Social and monetary reward learning engage overlapping neural substrates. *Social Cognitive and Affective Neuroscience, 7* (3), 274–281.
22. Roesch, M. R., & Olson, C. R. (2004). Neuronal activity related to reward value and motivation in primate frontal cortex. *Science*, *304* (5668), 307-310.
23. Spreckelmeyer, K. N., Krach, S., Kohls, G., Rademacher, L., Irmak, A., Konrad, K. et al. (2009). Anticipation of monetary and social reward differently activates mesolimbic brain structures in men and women. *Social Cognitive and Affective Neuroscience, 4* (2), 158–165.
24. Carrington, S. J. & Bailey, A. J. (2009). Are there theory of mind regions in the brain? A review of the neuroimaging literature. *Human Brain Mapping, 30* (8), 2313–2335.
25. Ruby, P. & Decety, J. (2004). How Would You Feel versus How Do You Think She Would Feel? A Neuroimaging Study of Perspective-Taking with Social Emotions. *Journal of Cognitive Neuroscience, 16* (6), 988–999.
26. McCabe, K., Houser, D., Ryan, L., Smith, V. & Trouard, T. (2001). A functional imaging study of cooperation in two-person reciprocal exchange. *Proceedings of the National Academy of Science U.S.A., 98* (20), 11832–11835.
27. Gallagher, H. L., Jack, A. I., Roepstorff, A. & Frith, C. D. (2002). Imaging the Intentional Stance in a Competitive Game. *NeuroImage, 16* (3), 814–821.
28. Van't Wout, M., & Sanfey, A. G. (2008). Friend or foe: The effect of implicit trustworthiness judgments in social decision-making. *Cognition*, *108* (3), 796–803.
29. Winston, J. S., Strange, B. A., O'Doherty, J. & Dolan, R. J. (2002). Automatic and intentional brain responses during evaluation of trustworthiness of faces. *Nature Neuroscience, 5* (3), 277.
30. Krueger, F., Grafman, J. & McCabe, K. (2008). Neural correlates of economic game playing. *Biological Sciences, 363* (1511), 3859–3874.
31. Krueger, F., McCabe, K., Moll, J., Kriegeskorte, N., Zahn, R., Strenziok, M. et al. (2007). Neural correlates of trust. *Proceedings of the National Academy of Science U.S.A., 104* (50), 20084–20089.
32. Sripada, C. S., Angstadt, M., Banks, S., Nathan, P. J., Liberzon, I. & Phan, K. L. (2009). Functional neuroimaging of mentalizing during the trust game in social anxiety disorder. *NeuroReport, 20* (11), 984–989.
33. Rilling, J. K. & Sanfey, A. G. (2011). The Neuroscience of Social Decision-Making. *Annual Review of Psychology, 62* (1), 23–48.
34. Balthazard, P. A., Waldman, D. A., Thatcher, R. W. & Hannah, S. T. (2012). Differentiating transformational and non-transformational leaders on the basis of neurological imaging. *The Leadership Quarterly, 23* (2), 244–258.
35. Kounios, J., Fleck, J. I., Green, D. L., Payne, L., Stevenson, J. L., Bowden, E. M., & Jung-Beeman, M. (2008). The origins of insight in resting-state brain activity. *Neuropsychologia*, *46* (1), 281–291.
36. Naqvi, N., Shiv, B., & Bechara, A. (2006). The role of emotion in decision making a cognitive neuroscience perspective. *Current Directions in Psychological Science*, *15* (5), 260–264.
37. Waldman, D. A., Balthazard, P. A. & Peterson, S. J. (2011). Leadership and Neuroscience: Can We Revolutionize the Way That Inspirational Leaders Are Identified and Developed? *Academy of Management Perspectives, 25* (1), 60–74.

38. Koechlin, E. & Hyafil, A. (2007). Anterior Prefrontal Function and the Limits of Human Decision-Making. *Science, 318* (5850), 594–598.
39. Krajbich, I., Adolphs, R., Tranel, D., Denburg, N. L. & Camerer, C. F. (2009). Economic Games Quantify Diminished Sense of Guilt in Patients with Damage to the Prefrontal Cortex. *Journal of Neuroscience, 29* (7), 2188–2192.
40. Spitzer, M., Fischbacher, U., Herrnberger, B., Grön, G. & Fehr, E. (2007). The Neural Signature of Social Norm Compliance. *Neuron, 56* (1), 185–196.
41. Tabibnia, G., Satpute, A. B. & Lieberman, M. D. (2008). The Sunny Side of Fairness: Preference for Fairness Activates Reward Circuitry (and Disregarding Unfairness Activates Self-Control Circuitry). *Psychological Science, 19* (4), 339–347.
42. Baumgartner, T., Fischbacher, U., Feierabend, A., Lutz, K. & Fehr, E. (2009). The Neural Circuitry of a Broken Promise. *Neuron, 64* (5), 756–770.
43. Haruno, M. & Frith, C. D. (2009). Activity in the amygdala elicited by unfair divisions predicts social value orientation. *Nature Neuroscience, 13* (2), 160–161.
44. Hsu, M., Anen, C. & Quartz, S. R. (2008). The Right and the Good: Distributive Justice and Neural Encoding of Equity and Efficiency. *Science, 320* (5879), 1092–1095.

Acknowledgment

Parts of this manuscript have been published in Bergner, S. & Rybnicek, R. (in press). Neurophysiologische Ansätze in der Führungsforschung [Neurophysiological approaches in leadership research]. In J. Felfe (Ed.), Aktuelle Ansätze in der Führungsforschung [Current approaches in leadership research]. Göttingen: Hogrefe.