Understanding Neurological Processes in the Leadership Context: A Two Study Investigation on Personality Traits, Transformational Leadership and Subjective Leader Effectiveness

Dissertation

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"The challenge is to stay cool enough to handle the pressure in the moment so that you can succeed in the future."

– *Jürgen Klopp*

A very exciting time for me is coming to an end. A time in which I have learnt a lot, also about myself, and in which I met many great people who supported me during this time. As in this quote above, the dissertation was indeed a challenge for me. It wasn't always easy to keep my nerves. But he is right with the statement that one has to withstand the pressure in order to achieve success.

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Summary

This dissertation examines the neurological perspective in the context of leadership. Recently, there has been an increasing interest in research concerning the relationship between brain processes and leadership behavior. However, a number of key questions remain unanswered in this respect. Therefore, this dissertation considers neurological processes as antecedents of leadership behaviors (transformational leadership) and subjective leadership effectiveness (satisfaction with the leader) on the one hand, and as mediators in the relationship between personality (dark triad) and leadership on the other. Doing so, this dissertation contributes to the previous model of leader traits, emergence and effectiveness. For this purpose, I have conducted two empirical studies providing more insights in regard to personality traits and leadership research. In the first study, all three facets of the dark triad traits (narcissism, machiavellianism and psychopathy) are examined in relation to neurological processes with the method of electroencephalography, to find out whether there are different intrinsic networks of brain regions. Furthermore, I also explore if there is a neurological basis of transformational leadership and if the mechanisms linking leaders' personality and leadership can be explained by intrinsic brain processes. In the second study, I highlight reflexive brain processes which are apparent during mental activities while leading. Moreover, I analyze how these processes can influence the subjective leadership effectiveness via displayed leadership behaviors (transformational leadership).

Study one aims to advance knowledge of the antecedents of transformational leadership by analyzing the psychometric measured dark triad traits but also neurologically measured processes in the form of intrinsic connection (coherence) of brain areas. In addition, a contribution to trait literature is made as neurological insights into individual differences, namely

the personality, are gathered. For this study, 64 dyads of leaders and followers have been acquired. At the first measurement point, leaders provided information on their personality traits. At the second measurement point, their intrinsic brain capacity was recorded and the perceived transformational leadership was assessed by their followers, time-lagged, after a simulated role play. Results show that (1) narcissistic leaders have low intrinsic coherence in the right frontal lobe and psychopathic leaders have low intrinsic coherence in the left frontal lobe. However, no significant results were found on neurological patterns of machiavellian leaders. Furthermore, the findings reveal that (2) leaders with high intrinsic right frontal coherence display more transformational leadership, and that (3) machiavellian leaders are perceived as less transformational, whereas psychopathic leaders are perceived as more transformational. No significant effect was found for the relationship between narcissism and transformational leadership. Finally, I demonstrated that (4) the relationship between dark triad traits and transformational leadership is mediated by intrinsic brain coherence. These results provide first evidence that dark triad traits can be reflected on different decreased intrinsic brain networks and that there is a mediating mechanism of personality trait on leadership via these brain networks. Furthermore, the findings regarding the neuronal basis for transformational leadership are consistent with the first study that dealt with this relationship.

Study two dealt with the analysis of the sub-dimensions of transformational leadership and whether these are reflected in the reflexive brain processes (coherence) with regard to individual-focused and group-focused behaviors. Thus, I contribute to transformational leadership literature at a more detailed level. A mediating framework is presented to clarify how transformational leadership and its impact on subjective leadership effectiveness can be influenced by reflexive brain processes. 64 dyads of leaders and followers participated in this

study, in which the brain processes of leaders were recorded during a role play and the followers assessed the perceived transformational leadership as well as the satisfaction with the leader afterwards. Results show that (1) leaders' reflexive right frontal coherence increases the group-focused sub-dimension team spirit and that their reflexive left frontal coherence increases the individual-focused sub-dimension performance orientation. This means that different psychological processes with regard to leadership behavior can also be reflected at the neuronal level. Moreover, it was found that (2) transformational leadership sub-dimensions have a positive effect on the satisfaction with the leader, and (3) that this neurological difference also shows up in mediating processes, so that reflexive right frontal coherence via group-focused behavior leads to satisfaction with the leader and reflexive left frontal coherence via individual-focused behavior. These findings contribute to transformational leadership research because, for the first time, a mediating mechanism with regard to reflexive brain processes is shown.

In summary, this dissertation represents an important step into a new field of research, namely the interdisciplinary composition of neuroscience and leadership. A contribution to leadership literature can be made by adding neurological processes to the leader trait emergence effectiveness model and thus identifying new mediation mechanisms. This strengthens the understanding of transformational leadership in terms of its emergence and underlying processes. The main result of the dissertation is that on the one hand intrinsic neuronal processes are related to individual differences and leadership processes and on the other hand reflexive neuronal processes are related to leadership behavior and effectiveness. Thus, key questions regarding transformational leadership are clarified taking into account neurological backgrounds.

Zusammenfassung

Die vorliegende Dissertation befasst sich mit der Untersuchung neurologischer Prozesse im Kontext der Führung. In den letzten Jahren ist ein zunehmendes Interesse an der Forschung hinsichtlich des Zusammenhangs zwischen Hirnprozessen und Führungsverhalten zu beobachten. Es konnte gezeigt werden, dass z.B. ethische oder destruktive Führungsverhaltensweisen auf intrinsische Hirnprozesse zurückgeführt werden können. Allerdings ist dieses Forschungsfeld noch sehr jung, weswegen eine Reihe von Schlüsselfragen zu klären ist. Auf Basis zwei empirischer Studien dieser Dissertation werden neurologische Prozesse einerseits als Antezedenzien von Führungsverhalten (transformationale Führung) und subjektiver Führungseffektivität (Zufriedenheit mit der Führungskraft) und andererseits als Mediatoren in der Beziehung zwischen Persönlichkeit (dunkle Triade) und Führung betrachtet. Dadurch trägt die Dissertation zur bisherigen Persönlichkeits- und Führungsforschung bei und erweitert das bisherige Modell der Führungseigenschaften, Führungsentstehung sowie Führungseffektivität um neurologische Aspekte. In der ersten empirischen Studie werden alle drei Facetten der dunklen Triade (Narzissmus, Machiavellismus und Psychopathie) in Bezug auf neurologische Prozesse mit der Methode der Elektroenzephalographie untersucht, um herauszufinden, ob es unterschiedliche intrinsische Vernetzungen von Hirnbereichen gibt. Darüber hinaus wird überprüft, ob es eine neuronale Basis für die transformationale Führung gibt und ob die Mechanismen, die den Zusammenhang zwischen Persönlichkeit und dem Führungsstil vermitteln durch intrinsische Gehirnprozesse erklärt werden können. In der zweiten Studie liegt der Fokus auf den reflexiven Hirnprozessen, die bei mentaler Aktivität z.B. während einem Führungsverhalten, sichtbar werden. Dabei wird analysiert, ob diese Prozesse die

subjektive Führungseffektivität über das Führungsverhalten (transformationale Führung) vermitteln können.

Die erste Studie zielt darauf ab, das Wissen über die Antezedenzien von transformationaler Führung zu erweitern, indem die psychometrisch gemessenen Eigenschaften der dunklen Triade analysiert werden, aber auch neurologisch gemessene Prozesse in Form einer intrinsischen Vernetzung von Hirnbereichen. Darüber hinaus wird ein Beitrag zur Persönlichkeitsforschung geleistet, indem neurologische Erkenntnisse über individuelle Unterschiede gesammelt werden. Für diese Studie wurden insgesamt 64 Dyaden aus Führungskräften und Mitarbeitern rekrutiert. Zum ersten Messzeitpunkt füllten die Führungskräfte einen Fragebogen zur Persönlichkeit aus. Zum zweiten Messzeitpunkt wurde zunächst die intrinsische Hirnkapazität der Führungskräfte erfasst und nach einem simulierten Rollenspiel die wahrgenommene transformationale Führung von den Mitarbeitern eingeschätzt. Die Ergebnisse zeigen, dass (1) narzisstische Führungskräfte eine geringe intrinsische Vernetzung im rechten Frontallappen aufweisen und psychopathische Führungskräfte eine geringe intrinsische Vernetzung im linken Frontallappen. Es konnten jedoch keine signifikanten Ergebnisse hinsichtlich eines neurologischen Musters bei Machiavellisten ermittelt werden. Weiterhin konnte festgestellt werden, dass (2) Führungskräfte mit hoher intrinsischer Vernetzung im rechten Frontallappen eher transformational führen, und dass (3) machiavellistische Führungskräfte als weniger transformational und psychopathische Führungskräfte als mehr transformational wahrgenommen werden. Es wurde kein signifikanter Effekt für den Zusammenhang zwischen Narzissmus und transformationaler Führung ermittelt. Schließlich zeigte sich, dass (4) der Zusammenhang zwischen den Eigenschaften der dunklen Triade und der transformationalen Führung durch intrinsische Vernetzungen von Hirnbereichen vermittelt wird.

Diese Ergebnisse liefern erste Hinweise darauf, dass sich die dunkle Triade in verschiedenen verminderten intrinsischen Hirnvernetzungen widerspiegeln lässt und dass diese Hirnprozesse den Mechanismus von Persönlichkeitseigenschaften auf das Führungsverhalten mediieren. Des Weiteren stimmen die Ergebnisse hinsichtlich der neuronalen Basis für transformationale Führung mit der bisher einzigen Studie überein, die sich mit diesem Zusammenhang beschäftigte.

In der zweiten Studie wird der Fokus auf die Betrachtung der transformationalen Führung auf Facettenebene gelegt, wobei untersucht wird, ob sich diese hinsichtlich der Aufteilung in individualbezogene und gruppenbezogene Verhaltensweisen in den reflexiven Hirnprozessen der Führungskraft widerspiegeln. Somit wird ein Beitrag zur detaillierteren Berücksichtigung dieses Führungsstils auf neuronaler Ebene geleistet. Diesbezüglich wird ein Mediationsmodell überprüft, um zu klären, wie transformationale Führung sowie ihr Einfluss auf die subjektive Führungseffektivität durch reflexive Hirnprozesse beeinflusst werden können. Es nahmen insgesamt 64 Dyaden aus Führungskräften und Mitarbeitern an dieser Studie teil, bei der die reflexiven Hirnprozesse während eines Rollenspiels aufgezeichnet wurden und die Mitarbeiter nachfolgend die wahrgenommene transformationale Führung sowie die Zufriedenheit mit der Führungskraft einschätzten. Die Ergebnisse zeigen, dass (1) die reflexive Vernetzung im rechten Frontallappen die gruppenbezogene Facette, Team Spirit, erhöht und dass die reflexive Vernetzung im linken Frontallappen die individualbezogene Facette, Leistungsentwicklung, erhöht. Das Bedeutet, dass die unterschiedlichen psychologischen Prozesse der transformationalen Führung auch auf neuronaler Ebene abgebildet werden können. Darüber hinaus wurde festgestellt, dass (2) die Facetten transformationaler Führung einen positiven Einfluss auf die Zufriedenheit mit der Führungskraft haben und (3) dass sich dieser

neurologische Unterschied auch im Mediationsprozess zeigt, was bedeutet, dass die reflexive Vernetzung im rechten Frontallappen über gruppenbezogenes Verhalten zur Zufriedenheit mit der Führungskraft führt und die reflexive Vernetzung im linken Frontallappen über individualbezogenes Verhalten. Diese Ergebnisse tragen zur Forschung der transformationalen Führung bei, da erstmals eine Mediation in Bezug auf Hirnprozesse bestätigt wird.

Zusammenfassend lässt sich sagen, dass diese Dissertation einen wichtigen Schritt in einem neuen Forschungsfeld darstellt, nämlich der interdisziplinären Zusammensetzung von Neurowissenschaften und Führung. Es wird ein Beitrag zur Führungsliteratur geleistet, indem neurologische Prozesse in das Modell der Führungseigenschaften, Führungsentstehung sowie Führungseffektivität aufgenommen und dadurch neue Vermittlungsmechanismen identifiziert werden. Dies verbessert das Verständnis von transformationaler Führung in Bezug auf ihre Entstehung und die zugrundeliegenden Prozesse. Das Hauptergebnis der Dissertation ist, dass einerseits intrinsische neuronale Prozesse mit individuellen Unterschieden und Führungsprozessen zusammenhängen sowie andererseits reflexive neuronale Prozesse mit Führungsverhaltensweisen und Führungseffektivität. Somit werden Schlüsselfragen zur transformationalen Führung unter Berücksichtigung neurologischer Hintergründe aufgeklärt.

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List of Abbreviations

CI	Confidence Interval
cf.	from Latin *confer* ‚compare' or ‚consult'
EEG	Electroencephalography
fMRI	Functional Magnetic Reasoning
e.g.	from Latin *exempli gratia* 'for example'
et al.	from Latin *et alia* 'and others'
FIF	Integrative Leadership Survey
Hz	Hertz
ICA	Independent Component Analysis
i.e.	from Latin *id est* 'that is'
M	Mean
MLQ	Multifactor Leadership Questionnaire
MEG	Magnetelectroencephalography
MRI	Magnetresonanceimaging
N	Sample Size
ns	Nonsignificant
r	Correlation Coefficient
R^2	Determination Coefficient
RQ	Research Question
SD	Standard Deviation
SD3	Short Dark Triad

1. Introduction

For many decades the construct of transformational leadership has aroused the attention of researchers. Regarding the numerous positive consequences that have already been fathomed, this leadership style is considered to be one of the most effective. According to meta-analytical studies, transformational leadership has a positive influence on subjective factors such as followers satisfaction or their loyalty to the organization (Banks, McCauley, Gardner, & Guler, 2016; Dumdum, Lowe, & Avolio, 2002; Jackson, Meyer, & Wang, 2013), but also on objective factors such as task performance, sales figures and innovativeness of an organization (Judge & Piccolo, 2004; G. Wang, Oh, Courtright, & Colbert, 2011).

Obviously, research on the emergence of this leadership style is of great interest not only to scholars, but also to human resource professionals in the organizational context for the selection of potential leaders and the development of already recruited leaders. Previous studies on antecedents of transformational leadership have focused on personality traits, mainly examining positive and desirable characteristics of the big five framework (McCrae & Costa, 1994), with the result that extraversion is the strongest and most consistent predictor (Bono & Judge, 2004; Deinert, Homan, Boer, Voelpel, & Gutermann, 2015). However, negative personality traits such as the dark triad – narcissism, machiavellianism and psychopathy – (Paulhus & Williams, 2002), have received less attention in leadership research so far, although they have detrimental effects on organizational outcomes, e.g. counterproductive work behavior and diminished quality of job performance (O'Boyle, Forsyth, Banks, & McDaniel, 2012). Since the majority of the above studies are based on personality self-assessments, the results may be subject to the bias effect of social desirability (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003).

As already mentioned in an introductory editorial in a special issue of The Leadership Quarterly “the field of leadership and individual differences is on the cusp of a renaissance” (Antonakis, Day, & Schyns, 2012, p. 648). Interdisciplinary research and the application of new methods are necessary to extend existing models (Antonakis, 2011; Colarelli & Arvey, 2015). A promising field of research is neuroscience, because it gives us the opportunity to “look” into the human brain, analyze processes and identify possible insights in the context of leadership. Furthermore, this approach goes beyond previous psychometric methods. The human brain consists of about 86 billion nerve cells, so-called neurons, which are connected by synapses. These neuronal interactions form the basis of our everyday functions such as cognition and behavior (Park & Friston, 2013). Regardless of whether we sleep, work, exercise or rest, the brain is always active (Cacioppo et al., 2003) so that brain processes can be recorded at any time, providing many opportunities for leadership research.

In recent years there has already been an increasing interest in research on brain phenomena in the field of management and organization (Waldman, Ward, & Becker, 2017). By using interdisciplinary methods, a mixture of neurological methods and traditional psychometric surveys, first promising results provide insights into neuronal bases of leaders (Balthazard, Waldman, Thatcher, & Hannah, 2012; Hannah, Balthazard, Waldman, Jennings, & Thatcher, 2013; Waldman, Wang, Hannah, & Balthazard, 2017; Waldman, Wang, Hannah, Owens, & Balthazard, 2018). With regard to the dark personality traits, studies have also been conducted, but not the entire dark triad in a joint study (Bagozzi et al., 2013; Fan, Wonneberger et al., 2011; Kim & Jung, 2014). Although neuronal processes seem to influence leadership characteristics and behaviors, which in turn predict leadership effectiveness to some extent (Ng, Ang, & Chan, 2008), there is no study that has examined a model that reflects all perspectives. Based on the

statement of Antonakis et al. (2012), that “leadership research must make serious inroads in this area, […] by providing objective measures…” (p. 646), my dissertation aims to build a bridge between personality traits, leadership, effectiveness and neurological processes by using an electrophysiological method. Three main contributions can be made by this dissertation. First, I extend the current research on transformational leadership antecedents by looking at the neuronal level. Second, my studies are based on hypotheses and thus extend existing neurological research, which often follows an explorative approach. Third, the aforementioned bridge between psychometric and neurometric constructs is explored by mediation analysis.

1.1 Goals and Research Questions of the Dissertation

The overall purpose of this dissertation is to examine the neurological perspective in the context of leadership. In doing so, the networking of the brain areas of leaders is considered and investigated on the one hand as an antecedent of leaders’ behavior and on the other hand as a linkage to leaders’ personality. A potential extension of the leader trait emergence effectiveness model (Judge, Piccolo, & Kosalka, 2009) by neuronal processes is to be attained. Aiming at this, two empirical studies were conducted in order to obtain answers to the following four research questions.

Initially, entering a new research landscape, this dissertation examines a possible neurological predictor of transformational leadership, which is measured non-psychometrically in contrast to the usual antecedents. While previous studies focused on individual dispositional constructs, such as leaders’ personality (Bono & Judge, 2004), leaders’ intelligence (Cavazotte, Moreno, & Hickmann, 2012) or leaders’ gender (Eagly, Johannesen-Schmidt, & van Engen, 2003), there is scarce research on biologically related antecedents. Merely genetic predispositions could be found for transformational leadership (Li, Arvey, Zhang, & Song,

2012). Although a first important step in neurological research on transformational leadership was made by an exploratory study of Balthazard et al. (2012), in which neuronal differences between transformational and non-transformational leaders were observed, it is not yet clear whether there is a theoretical explanation for this. Referring to Antonakis (2011), who encourages the exploration of new fields of research for predicting leadership, e.g. through the application of multi-method approaches, I contribute to existing research through a hypothesis-driven procedure, combining neuronal measurement with survey-based measurement. Since complex cognitive processes cannot be linked to a specific brain location (Cacioppo et al., 2003), I consider the interaction of different brain areas. Thereby, the intrinsic brain capacity is analyzed because it seems to be relevant for predicting behavior (Northoff, Qin, & Nakao, 2010). Consequently, the first goal of this dissertation is to gain more insights into neurological predispositions for transformational leadership.

Research Question 1: Is the interconnection of certain brain areas, in the form of intrinsic brain coherence, related to the occurrence of transformational leadership?

The second research question of this dissertation relates to the biological basis of individual differences, again in the form of intrinsic brain capacity. Neurological research has shown that the brain structure of individuals appears to be influenced by genes (Thompson et al., 2001), which in turn determine 40-60% of personality traits (Ilies, Arvey, & Bouchard, 2006). Hence, it is obvious to investigate whether there is a link between brain structures and personality in order to better understand individual difference. The focus here is on the dark triad personality of leaders - narcissism, machiavellianism and psychopathy (Paulhus & Williams, 2002) - as these traits may have a detrimental impact on the perception of transformational

leadership by followers. But since research on the dark triad focused almost solely on the emergence of leadership in general, there are few or even no studies on transformational leadership. However, the studies carried out, e.g. on narcissism, led to different results (Greaves, Zacher, McKenna, & Rooney, 2014; Ong, Roberts, Arthur, Woodman, & Akehurst, 2016; Resick, Whitman, Weingarden, & Hiller, 2009). In addition, most studies are based on the usual self-assessment of personality. This will be supplemented in my dissertation by the new methodology, a neuronal measurement of brain networks, and should provide new insights into the understanding of individual differences. These considerations lead to the next research question:

Research Question 2: Does intrinsic brain coherence relate to leaders' personality and can it mediate the link of personality to transformational leadership?

In the next step, a more detailed view of transformation leadership is sought, so that criticism of the operationalization of transformation leadership as an overall construct (van Knippenberg & Sitkin, 2013) is taken into account. This leads to the assumption that the sub-dimensions of transformational leadership should be either considered as individual-focused, e.g. individualized consideration and intellectual stimulation, or as group-focused behaviors, e.g. articulating a vision and fostering the acceptance of group goals (Kark & Shamir, 2013; Kunze, De Jong, & Bruch, 2016). Since previous research has shown different effects on leadership outcomes in this respect (Wu, Tsui, & Kinicki, 2010), to the best of my knowledge nothing is known about individual differences in this grouping of behaviors. It is conceivable that differences may also be recognized in relation to the connection of brain areas, depending on whether a group or an individual is addressed, motivated and guided. In this case, however, a different perspective of the brain is considered, namely the reflexive brain that is relevant when

facing a task (Raichle & Snyder, 2007), for example in leadership behavior. In order to gain a better understanding of the functioning of transformational leadership, the neuronal perspective is taken into account in this dissertation. The following research question arises:

Research Question 3: Is the theoretical difference of transformational leadership (individual-focused vs. group-focused sub-dimensions) reflected in the interconnection of certain brain areas, in the form of reflexive brain coherence?

The last research question is linked to the previous one, considering transformational leadership behavior at a more detailed level, namely divided in individual-focused and group-focused behaviors. Expanding the above-mentioned argumentation, a bridge is built here to the outcome variable followers' satisfaction with the leader, that is a component of subjective leader effectiveness (Bass & Avolio, 1997), whereby a mediation mechanism is considered. Again, I refer to a point of criticism in the context of transformational leadership research, that mediating mechanisms have not been sufficiently investigated at a more detailed level (van Knippenberg & Sitkin, 2013). Furthermore, researchers are called upon to improve the understanding of leadership effectiveness by addressing "how" and "why" (Fischer, Dietz, & Antonakis, 2017) and by including new research areas, e.g. neurosciences, to better explain the emergence of effective leadership (Antonakis, 2011). Taking these aspects into account, the following research question is explored in my dissertation:

Research Question 4: How does individual-focused vs. group-focused transformational leadership behavior mediate the relationship between reflexive brain coherence and satisfaction with the leader?

In order to answer my research questions, I developed two empirical studies. Hence, study one is conducted to examine both Research Question 1 and Research Question 2, in order to explore (neuronal) antecedents of transformational leadership behavior. For this purpose, self-assessments of the leaders' position on the dark triad were collected, and a measurement of leaders' intrinsic brain capacity was made, using electroencephalography. Participants of this study performed a role play to simulate a typical leader-follower situation, afterwards the follower rated leaders' transformational leadership behavior. Study two addressed both Research Question 3 and Research Question 4, to determine whether a distinction can be made between the connectivity of brain areas that reflects the divided view of transformational leadership in individual-focused versus group-focused behaviors. Thereby, the reflexive brain was measured on a second-by-second basis, using electroencephalography, during a role play performance, again simulating a leader-follower situation. Afterwards, an assessment of the transformational leadership behavior was made from the follower's point of view. On top, in both studies I included the leader trait emergence effectiveness approach (Judge et al., 2009) and tried to extend it by including a neurological component, so that the investigated relationships of my dissertation are subject to a theoretical model. Consequently, I provide insights into a new perspective of antecedents and mediating mechanisms in transformational leadership.

1.2 Outline of the Dissertation

My dissertation consists of five main chapters, which are subject to a clear structure (cf. Table 1). *Chapter 1* includes the introduction, the overarching goals and research questions, and an outline of this dissertation. *Chapter 2* refers to the theoretical background of the main constructs which are transformational leadership, the dark triad of personality and neuroscience of organizational research, plus the underlying leader trait emergence effectiveness model (Judge

et al., 2009). Within these sections I have drawn on theories, relevant reviews and empirical studies. Further, this chapter presents the research model of this dissertation, which serves to provide an overview and an explanation of the main relations between variables covered within the two empirical studies. It concludes with the most important contributions of my research project. *Chapter 3 and 4* comprise of the two empirical studies carried out within the framework of my dissertation and serve to examine and answer the research questions. Each study is based on the theoretical background, describes the methodology of data collection and analysis, reports the results and discusses them. *Chapter 5* summarizes the main findings of the two empirical studies and draws on contributions to existing theory. Then, limitations of the two studies are discussed which leads to implications for future research and results in an extension of the research model of this dissertation. Likewise, implications for human resource practitioners are elaborated. Finally, this chapter closes with an overall conclusion.

Table 1. *Overview of the Chapters of the Dissertation*

Chapter	**Content**
1	Introduction, Goals and Research Questions, Outline of the Dissertation
2	Theoretical Background
3	Study 1: *Neurological Individual Differences of the Dark Triad and Transformational Leadership Behavior. A Resting State EEG Study*
4	Study 2: *Neurological Insights into Transformational Leadership: A Mediational Framework*
5	Overall Discussion, Summary of Findings, Contribution, Limitations and Future Research, Practical Implications, Conclusion

2. Theoretical Background

> Leadership is a formal or informal contextually rooted and goal-influencing process that occurs between a leader and a follower, groups of followers, or institutions. The science of leadership is the systematic study of this process and its outcomes, as well as how this process depends on the leaders' traits and behaviors, observer inferences about the leaders' characteristics and observer attributions made regarding the outcomes of the entity led (Antonakis & Day, 2018b, p. 5).

Given this definition of leadership, which by the way is one of many, one recognizes various starting points for exploring this phenomenon. The beginning of scientific research to leadership was at the turn of the 20th century with the "great man" theory or trait perspective of leadership with the focus on stable individual differences to differentiate leaders from non-leaders (Mann, 1959; Stogdill, 1948). Although certain traits for predicting leadership were meta-analytically identified over the course of time (e.g. intelligence, personality traits) (Judge, Bono, Ilies, & Gerhardt, 2002; Judge, Colbert, & Ilies, 2004; Lord, de Vader, & Alliger, 1986), criticism of the trait approach was expressed, shifting the focus of research to leadership behavior. Two most crucial theories in behavioral research, that refer to the Ohio State University Studies (Stogdill & Coons, 1957) and Michigan Leadership Studies (Katz, Maccoby, & Morse, 1950), are initiating structure (task-oriented behavior) and consideration (relations-oriented behavior). While initiating structure reflects the behavior of a leader who sets clear goals and standards, organizes the schedule and assigns responsibilities to his or her followers, and controls whether guidelines and rules are followed, consideration means a more follower-oriented leader behavior with support, friendliness and the general well-being of the followers. Derue, Nahrgang, Wellman, and Humphrey (2011) meta-analytically confirmed that leadership

effectiveness is more predicted by leaders' behavior than by leaders' traits. But since it has not been possible to identify a particular leadership style that appears to be effective in all situations, the assumption was made, that the leadership style must be dependent on the task or situation, leading to situational or contingency approaches of leadership. Fiedler (1967) distinguished between task-oriented and employee-oriented leadership styles and proposed that the choice of the most efficient leadership style depends on the situation. In total, three variables are decisive for the leadership situation: leader-follower relation, task structure and position power of the leader. Other situational theories or approaches were postulated for instance by House (1971), Vroom (1976) or Kerr and Jermier (1978). Similarly, contextual factors such as organizational characteristics, national culture or gender were included in other research projects to get a better understanding of the leadership phenomenon (Antonakis, Avolio, & Sivasubramaniam, 2003; Shamir & Howell, 1999). Another focus was placed on the relationship between leader and follower, resulting in the leader-member exchange theory (Graen & Uhl-Bien, 1995), where a distinction is made on the in-group (good, trustful relationship) and the out-group (formal, distanced relationship). A new leadership school or paradigm started in the 80s, by work of Bass and his colleagues (Bass, 1985, 1990; Bass & Avolio, 1990) in which the transactional as well as the transformational leadership had their origins (Antonakis & Day, 2018b). A new research approach that is currently attracting a lot of attention is the biological, natural perspective of leadership (Antonakis, 2011), considering heritability (De Neve, Mikhaylov, Dawes, Christakis, & Fowler, 2013), hormones (Diebig, Bormann, & Rowold, 2016) or neuroscientific techniques (Lee, Senior, & Butler, 2012) to get more insights on leadership.

In the following, more detailed insights into the dark triad personality traits, transformational leadership and neurological processes are given.

2.1 Transformational Leadership

The concept of transformational leadership is first found in the context of politics, in which Burns (1978) analyzed the behavior of political leaders and distinguished between a transactional and transforming leadership style, by also referring to the work of Downton (1973). He presented the transactional leadership as an exchange process in which one person contacts another in order to exchange valuable things, whereas the transforming leadership was described as providing mutual support with a high level of motivation to achieve common goals. Bass (1985, 1990) built on this approach and applied it to the organizational context, by defining four main aspects of transformational leadership, that help to achieve the main goal of leadership style, which is to transform the short-term and egoistic values and goals into higher-order ones. First, inspirational motivation is the ability to motivate and inspire followers by communicating a vision. Second, idealized influence is the appearance as a role model with the purpose that the followers imitate their behaviors and attitudes. Third, individualized consideration means the supporting and helping side of leadership, which considers and fulfils the needs and requirements of followers. Fourth, intellectual stimulation is the ability to encourage followers to come up with innovative and creative ideas and to challenge the status quo.

Further, Avolio and Bass (1991) developed the full range of leadership model, distinguishing between transactional (three dimensions), transformational (five dimensions) and laissez-faire (one dimension) leadership, the latter defining the absence of leadership.

After criticism of this nine factor model, Podsakoff, MacKenzie, Moorman, and Fetter (1990) adjusted this model by differentiating between six sub-dimensions of transformational leadership, namely *identifying and articulating a vision*, *fostering the acceptance of group goals*, *providing an appropriate model*, *high performance expectations*, *intellectual stimulation* and

providing individualized support, one dimension of transactional leadership, contingent reward, and laissez-faire.

Rowold and Poethke (2017) proposed a new approach in their model of integrative leadership by addressing to a broader spectrum of leader behaviors, which all are relevant to success. In addition to transactional, transformational and instrumental leadership, which build a group of strongly active and effective leadership styles, they also include negative leadership, which has a counterproductive effect on effectiveness criteria, and communication styles. Similar to Podsakoff et al. (1990), they define six sub-dimensions of transformational leadership: *Vision* refers to the communication of a positive future of the working group in an abstract, often metaphorical form, with the aim of inspiring the followers and explaining the sense behind the work. *Team spirit* describes the appeal for a collective feeling in the working group, by promoting a positive working atmosphere and encouraging followers to support each other.
Role modeling means that leaders are seen as an example on which followers can align themselves and thus imitate desired behaviors. *Performance orientation* is characterized by formulating and explaining performance-related requirements and goals, and at the same time conveying confidence that these goals can be achieved. *Innovation* means the encouragement to question well-established work routines and procedures and to think about more appropriate alternatives. This supports the followers' involvement of their own ideas and suggestions for improvement. Lastly, *focus on individuality* is the ability to consider the individual desires and needs of each follower, to respect individual strengths and weaknesses in terms of work planning and long term development as well as to express appreciation.

According to empirical studies, transformational leadership is one of the most effective leadership styles, as positive effects could be found on subjective success criteria, e.g.

commitment, organizational citizenship behavior and satisfaction (Banks et al., 2016; Dumdum et al., 2002; Jackson et al., 2013; Sturm, Reiher, Heinitz, & Soellner, 2011) but also on objective success criteria, e.g. task performance, sales numbers and innovation (Judge & Piccolo, 2004; G. Wang et al., 2011). For this reason, research is also interested in the emergence of transformational leadership. So far, intelligence (Daly, Egan, & O'Reilly, 2015), personality traits, especially extraversion and agreeableness (Judge & Bono, 2000), and gender, meaning that female leaders are more engaged in transformational leadership (Eagly et al., 2003), have been identified as predictors. Although there is already initial research in neuroscience, which is expected to lead to further antecedents of transformational leadership, only correlates have been identified so far, that point to an association between right-sided frontal coherence in the brain and visionary communication on the one hand (Waldman, Balthazard, & Peterson, 2011a) and transformational leadership on the other (Balthazard et al., 2012).

2.2 Dark Triad of Personality

The dedication of research to negative personality traits has already increased in the 1970s, when the three most prominent negative personalities, narcissism (Raskin & Hall, 1979), machiavellianism (Christie & Geis, 1970) and psychopathy (Hare, 1985), were first examined as sub-clinical constructs. The difference between sub-clinical and clinical personalities is that the sub-clinical form appears in the "normal" population, i.e. each individual has a certain expression of these dark personality traits, but clinical personal traits refer to the area of personality disorder. Although the three components partly overlap in their characteristics, e.g. emotional deficiency, they nevertheless represent different constructs, which is why they can be researched both dimensionally and typologically (Paulhus & Williams, 2002).

The concept of the dark triad, introduced by Paulhus and Williams (2002), includes these three aforementioned socially-aversive personality traits, whereby narcissism and psychopathy are related to the sub-clinical realm. *Narcissists* are characterized by their high need of admiration and recognition as well as their unusually strong self-love and extreme vanity (Morf & Rhodewalt, 2001; Raskin & Terry, 1988). Furthermore, they are arrogant, believe they are better than others and have a need for authority, striving for power, prestige and status (Nevicka, de Hoogh, van Vianen, Beersma, & McIlwain, 2011). In terms of these attributes, it is not surprising that narcissists see themselves as good leaders with more favourable self-assessments of work deviations. Instead, others rated them negatively on leadership and job performance (Judge, LePine, & Rich, 2006), interpersonal performance and integrity (Blair, Hoffman, & Helland, 2008). Although narcissists are often chosen as leaders within groups, which is termed leader emergence (Brunell et al., 2008), in the long run they are often rejected by their groups because of their arrogance and boastfulness behavior (Paulhus, 1998).

Machiavellians are described as cold, cunning and cynical with a tendency to manipulate others for personal gain (Christie & Geis, 1970), whereby they often use interpersonal strategies, e.g. being charming towards others (Fehr, Samsom, & Paulhus, 1992; Wilson, Near, & Miller, 1996) or applying tactics of impression management (J. Becker & O'Hair, 2007). These strategies are probably the reason why machiavellians are also regarded as charismatic (Deluga, 2001), since otherwise they are perceived as abusive (Kiazad, Restubog, Zagenczyk, Kiewitz, & Tang, 2010) which is due to their exploitation and deception (Jones & Paulhus, 2009; Rauthmann, 2011). Referring to Furnham, Richards, and Paulhus (2013), machiavellians are flexible with regard to the type of tactics used.

Psychopathy is considered to be the darkest trait of the triad (Rauthmann, 2012), as psychopaths are known for their impulsive and sometimes aggressive behavior, ruthlessness and lack of empathy (Hare, 1999a; Jones & Paulhus, 2010). Their cold-heartedness, immoral and antisocial behavior, and low sense of guilt (Hare, 1999b; Rauthmann & Kolar, 2012) lead them to choose hard tactics (Furnham et al., 2013). Both their antisocial behavior and interpersonal manipulation of others (Rauthmann & Kolar, 2012) as well as their corporate irresponsibility (Boddy, 2010) lead to perceptions of high passive leadership, e.g. passive management by exception and laissez-faire (Westerlaken & Woods, 2013), and abusive supervision (Mathieu & Babiak, 2016). The origin of all three dark traits can largely be traced back to genetics, but machiavellianism was found to be the only trait that also appears to be influenced by environmental components (Vernon, Villani, Vickers, & Harris, 2008).

2.3 Neuroscience of Organizational Research

The neurosciences of organizational research are regarded as an interdisciplinary field that concentrates on understanding the behavioral phenomenon of individuals according to brain mechanisms and interactions that evoke cognitive processes and behaviors (Ochsner & Lieberman, 2001). Research into the role of the frontal lobe in cognition, especially of the prefrontal cortex, has been an important focus of cognitive neuroscience work in recent decades (Gazzaley, Lee, & D'Esposito, 2018). It has been confirmed that distinct subregions of the prefrontal cortex are involved to varying degrees in different executive functions, which are typically defined as planning, goal-oriented behavior or self-monitoring (Dosenbach, Fair, Cohen, Schlaggar, & Petersen, 2008; Lezak, Howieson, Bigler, & Tranel, 2012). A distinction is made between the medial, lateral and orbitofrontal cortex (Gazzaley et al., 2018). In the context of organizational behavior, Waldman, Wang, and Fenters (2016) proposed, that neurological

methodology could, in contrast to psychometric methods, provide increased ecological validity in measurement. Becker and Cropanzano (2010) recommend neurological assessment as a supplement and not as a substitute for traditional methods, e.g. survey-based approaches.

There are different neuroscience methods, including e.g. functional magnetic resonance imaging (fMRI), magnetencephalography (MEG) and electroencephalography (EEG), the latter being the method used in the following two studies. Hereby, electrodes are placed on scalp to record voltage fluctuations, which represent the neural activity of the brain (Jack, Rochford, Friedman, Passarelli, & Boyatzis, 2017). A small amount of electroconductive gel is inserted into each electrode. In order to measure the entire scalp, 32 to 64 electrodes are usually attached, however in this study only 6 covering the frontal area. The advantage of this method lies in the high temporal resolution as well as the lower cost compared to fMRI or MEG. Since cognitive, emotional and perceptual processes are fast, occurring in a temporal sequence which can range from hundreds of milliseconds to a few seconds, it is important to have a method that can measure this time frame (M. Cohen, 2014). Although it is not possible to measure more profound brain processes with this method and disturbing influences such as muscle tension can slightly distort the measurement, it is suitable for the organizational context, e.g. during face-to-face interactions, as it is portable and flexible and can be used in ordinary locations (Jack et al., 2017). The brain activity that is recorded resembles a rhythmic activity, which can be classified into five typical frequency bands, from the lowest (e.g. deep sleeping) to the highest arousal (e.g. learning processes): Delta (2-4 Hz), theta (4-8 Hz), alpha (8-12 Hz), beta (15-30 Hz) and gamma (30-150 Hz), which occur in different states of consciousness (Kopell, Kramer, Malerba, & Whittington, 2010; X.-J. Wang, 2010). Similar to prior research on neurological perspectives of leadership (Waldman et al., 2011a; Waldman et al., 2018; Waldman, Wang et al., 2017), beta is

considered in the following studies, as this bandwidth is related to a wakeful state and to mental or cognitive activity.

The measurement of brain activity with the methodology of the EEG can be conducted in two different brain conditions: the *intrinsic brain activity* (resting state) versus the *reflexive brain activity*. Intrinsic research means, measuring the brain activity while the individual is in resting state and shows no particular behavior. Although one may think that the brain in this state is in a kind of time-out, this is not the case (Buckner, Andrews-Hanna, & Schacter, 2008; Cacioppo et al., 2003). Instead, this brain activity is thought to be relatively stable and can reflect the individuals' capacity on behavioral potential and mental functioning. On the other hand, reflexive brain activity is measured during the performance of a particular task or certain behaviors (Raichle & Snyder, 2007).

It has been stated, that complex cognitive processes or behavioral concepts, like leadership behavior, cannot be assigned to a specific area in the frontal cortex in an isolated manner (Cacioppo et al., 2003), but to dynamic interactions within the frontal cortex and other brain regions (Cacioppo, Berntson, & Nusbaum, 2008; Gazzaley & D'Esposito, 2006). These neural connections of different brain areas are also called "neural networks", that can be quantified by applying a coherence measure, which is mathematically explained the degree of similarity between the electrical signals in any set of two different brain regions (Friston, 2011; Thatcher, North, & Biver, 2008).

There are already several studies in the field of organizational behavior that have made use of neuroscience techniques. The most important in the context of leadership are summarized in Table 2. All previous studies, except one using fMRI, have used the neurological method EEG because it is the most flexible for the organizational context.

Table 2. *Summary of Organizational Neuroscience Studies*

Citation	Method	Research Titel	Major Findings
Waldman et al., 2018	Intrinsic Brain, EEG	Psychological and Neurological Predictors of Abusive Supervision	Higher coherence in right prefrontal cortex reduces abusive supervision
Waldman, Wang et al., 2017	Intrinsic Brain, EEG	A Neurological and Ideological Perspective of Ethical Leadership	Higher coherence in right default mode network leads to ethical leadership
Waldman, Wang, Stikic, Berka, Balthazard et al., 2013	Reflexive Brain, EEG	Emergent Leadership and Team Engagement. An Application of Neuroscience Technology and Methods	Leadership emergence is associated with neurometrically team engagement
Hannah et al., 2013	Intrinsic Brain, EEG	The Psychological and Neurological Bases of Leader Self-Complexity and Effects on Adaptive Decision-Making	Neurological bases of leader self-complexity
Balthazard et al., 2012	Intrinsic Brain, EEG	Differentiating Transformational and Non-Transformational Leaders on the Basis of Neurological Imaging	Higher coherence in right frontal, temporal and occipital cortex correlates positively with transformational leadership
Boyatzis et al., 2012	Intrinsic Brain, fMRI	Examination of the Neural Substrates activated in Memories of Experiences with Resonant and Dissonant Leaders	Dissonant condition: negative activation in right / bilateral brain regions Resonant condition: positive activation in left and right brain regions
Waldman et al., 2011a	Reflexive Brain, EEG	Leadership and Neuroscience: Can we Revolutionize the Way that Inspirational Leaders are Identified and Developed?	Right frontal coherence is associated with socialized visionary communication
Peterson, Balthazard, Waldman, & Thatcher, 2008	Reflexive Brain, EEG	Neuroscientific Implications of Psychological Capital - Are the Brains of Optimistic, Hopeful, Confident, and Resilient Leaders Different?	Higher PsyCap is associated with greater left frontal activation

Note. EEG = Electroencephalography; fMRI = functional magnetic resonance imaging

With regard to the timing of the studies it becomes apparent that initially an explorative design was applied, which is obvious in order to dare a first step into a new field of research. Within these studies, regarding transformational leadership, it was found that right frontal coherence is associated with socialized visionary communication (Waldman et al., 2011a) as well as with the overall construct of transformational leadership (Balthazard et al., 2012). Ultimately, the studies of Waldman and colleagues (Waldman et al., 2018; 2017) were based on explicit hypotheses and revealed that higher coherence in the right frontal lobe reduces abusive supervision and strengthens ethical leadership. In order to give a theoretical classification of the neurological perspective in the context of leadership, the leader trait emergence effectiveness model (Judge et al., 2009) is used and described in the following section.

2.4 Leader Trait Emergence Effectiveness Model

As already depicted above, the leader trait perspective was given early attention in leadership research. Building on this, Judge et al. (2009) have conceptualized a model which takes into account evolutionary psychology and behavioral genetics as a source of leaders' traits, their influence on leader emergence and leadership effectiveness as well as some mediators and moderators. Since this is a more complex model, it is shown in Figure 1. Beginning with the sources of personality traits, evolutionary theory predicts that characteristics, including various traits and mechanisms, are the result of a mutation and selection process, that has evolved to enable humans to better manage the demands of the surrounding environment (van Vugt, 2018).

As an example, Judge et al. (2009) introduced the personality traits of agreeableness and conscientiousness, and explained that agreeableness exists because it strengthens cooperation within and between groups and conscientiousness because it facilitate survival through planning and care.

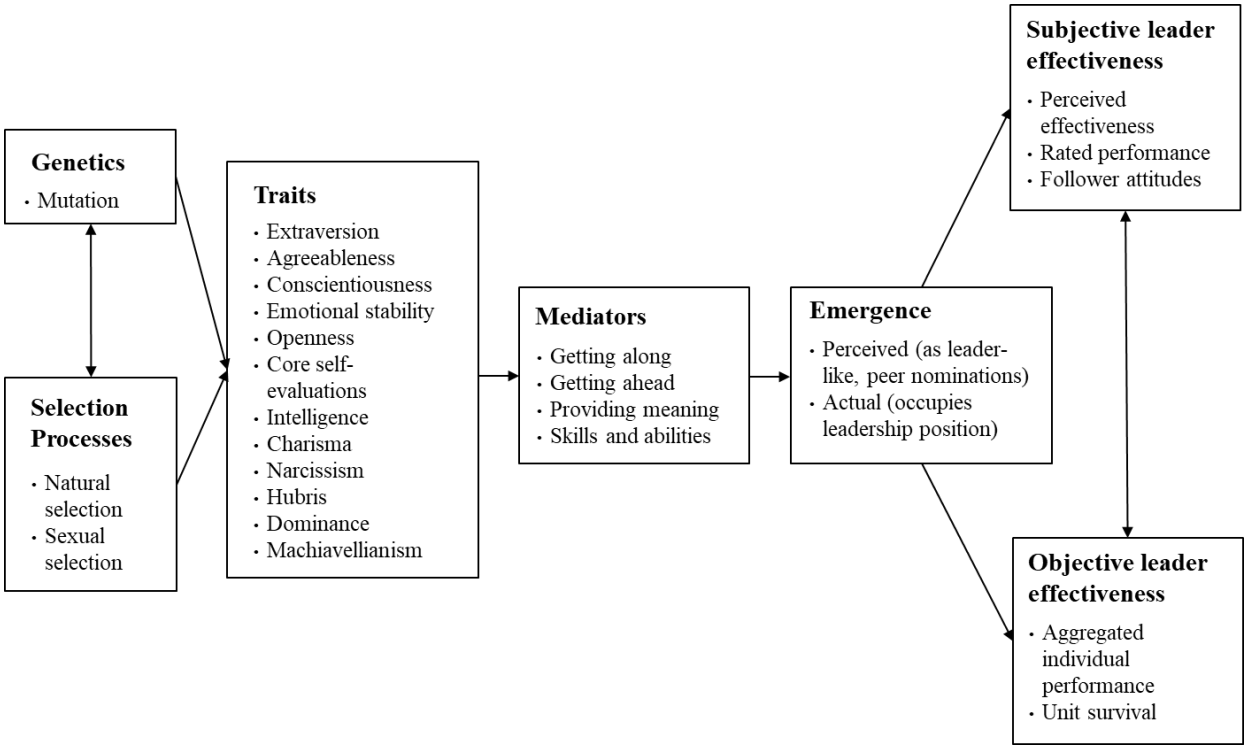

Figure 1. Leader Trait Emergence Effectiveness Model (Judge et al., 2009, p. 862).

Finally, they argued that the possession of certain traits leads to the emergence of a leader, while the absence of certain traits prevents an individual from acting as a leader. The other perspective, which represents behavioral genetics, assumes that stable personality traits can be predicted to 40-60% by heritability (Bouchard & Loehlin, 2001; Ilies et al., 2006). Studies on leader emergence and leadership role occupancy have also shown significant results on heritabilities (Arvey, Rotundo, Johnson, Zhang, & McGue, 2006; De Neve et al., 2013). Judge et al. (2009) draw attention, however, to the statement that genes always interact with the environment and do not represent a separate component, and can therefore only partly be regarded as a predisposition for leadership. To summarize these two sources of personality traits, they postulate, that "genes determine the expression of traits […], but evolutionary processes, in

organizations […] determine which traits are selected in and selected out" (Judge et al., 2009, p. 863).

As far as the character traits of the leader are concerned, the model consists not only of a bright personality (e.g. extraversion, agreeableness, conscientiousness, intelligence), but also of the dark side of traits (e.g. narcissism, machiavellianism, dominance, hubris), which is almost well researched with regard to the emergence of leaders. "Meta-analyses have provided considerable evidence for the validity of a wide range of leader attributes being linked to leadership outcomes" (Zaccaro, Dubrow, & Kolze, 2018, p. 35). In between the relation of leader traits and leader emergence the socioanalytic concepts of Hogan (1996) were placed as mediators, including motives of getting along and getting ahead that are linked with personality traits (Barrick, Stewart, & Piotrowski, 2002) as well the motive of finding meaning (Hogan & Shelton, 1998) that seems to have impact an on leadership.

Concerning the relationship between leader emergence and leadership effectiveness, a distinction is made between subjective leader effectiveness and objective leader effectiveness. The former is usually assessed by the followers and includes, for example, the perceived effectiveness of the leader or satisfaction with the leader, while the latter refers to hard factors such as the actual performance of the organization in terms of sales figures. Moreover moderating factors, such as implicit leadership theories (Keller, 1999) or traits are thought to influence the link between leader emergence and subjective effectiveness whereas threats, resources and culture could influence the link between leader emergence and objective effectiveness (Judge et al., 2009).

2.5 Research Model of the Dissertation

The underlying research model of this dissertation (cf. Figure 2) is intended to provide a comprehensive overview of the assumed relationships between personality traits, brain processes, leadership behaviors and subjective leader effectiveness. It is based on the leader trait emergence effectiveness model of Judge et al. (2009), that was described in the previous section. The main constructs of this model refer to the initial research questions and fundamental theories used to illustrate the relationships between the constructs and their processes.

Regarding studies on leadership behaviors, transformational leadership is one of the best researched (Antonakis, 2011) and one of the most effective leadership styles (G. Wang et al., 2011). It is therefore not unusual that several predictors of transformational leadership have already been studied in recent decades. Beginning at the left-hand portion of the research model of this dissertation and focussing on leaders' traits, more precisely on personality traits, previous emphasis was placed on the five factor model, also called the big five (McCrae & Costa, 1994). However, it appeared that transformational leadership can be attributed only to a small extent to the big five personality traits, mainly to extraversion and agreeableness (Bono & Judge, 2004; Judge & Bono, 2000). So far, less attention has been paid to the dark personality traits related to transformational leadership. For example, few studies were conducted that show inconsistent effects on transformational leadership with respect to narcissism and negative effects with respect to psychopathy (Greaves et al., 2014; Ong et al., 2016; Resick et al., 2009; Westerlaken & Woods, 2013). It appears that further studies of dark personality traits and other individual aspects are needed to predict transformational leadership. Referring to Antonakis (2011, 2012), it is reasonable that other individual differences may also have an influence on the emergence of leadership processes, e.g. biological bases, which are still in their infancy in the leadership context. The first study examines such a neurological base, in the form of leaders' intrinsic brain

capacity, whereby the connection between the intrinsic brain capacity and transformational leadership is considered on the one hand and the link between all three aspects of the dark triad and intrinsic brain capacity on the other. It is also conceivable that there is not only a direct relationship between stable personality and leadership, but that mediating processes (cf. Judge et al., 2009) play a role. The first study is intended to answer the first two research questions. *RQ1: Is the interconnection of certain brain areas, in the form of intrinsic brain coherence, related to the occurrence of transformational leadership? RQ2: Does intrinsic brain coherence relate to leaders' personality and can it mediate the link of personality to transformational leadership?*

Turning to the right-hand portion of the research model of this dissertation, the following triangle is considered: Reflexive brain processes, transformational leadership and subjective leader effectiveness. A deeper consideration of transformational leadership is made here, so that not the overall construct is analyzed, but two different groups of behaviors, namely individual-focused and group-focused. This theoretical grouping was previously carried out by other researchers who found that there was a different influence on the result criteria depending on the group (Kark & Shamir, 2013; Kunze et al., 2016). To the best of my knowledge, there are no studies that relate this grouping to individual differences of the leader. Accordingly, in addition to the intrinsic brain processes already considered in Study 1, the reflexive brain processes of the leader that occur during leadership behavior are now taken into account in the research model. It seems obvious that, depending on group- or individual-focused behavior, a distinction can also be made regarding brain processes. Consequently, Study 2 examines the relationship between the reflexive brain and transformational leadership, the path from leadership to subjective leader effectiveness, and a mediation process from reflexive brain through leadership behavior to the perception of satisfaction with the leader. The third and fourth research questions are to be

answered by the second study. *RQ3: Is the theoretical difference of transformational leadership (individual-focused vs. group-focused sub-dimensions) reflected in the interconnection of certain brain areas, in the form of reflexive brain coherence? RQ4: How does individual-focused vs. group-focused transformational leadership behavior mediate the relationship between reflexive brain coherence and satisfaction with the leader?*

This dissertation contributes to the existing research of organizational behavior in three major points. First, it extends the current research on antecedents of transformational leadership by regarding not only psychometric measured constructs, but beyond that fathoming a neurological basis for this leadership phenomenon. Referring to Antonakis et al. (2012), who argue for innovative methods to explore leadership and individual differences, an innovative method, electroencephalography, is used to measure brain waves of leaders both at rest and during leadership behavior. This leads to the second contribution which refers to the extension of previous neuroscience studies in the leadership context, as this dissertation focuses on a hypothesis-based approach and considers the transformational leadership at a more detailed level, distinguishing individual- and group-focused behaviors. Consequently, this dissertation improves the knowledge of transformational leadership and its predictors by examining what favors this leadership style and what happens in the brain during these processes, distinguishing between individual-focused versus group-focused behaviors. Third, new insights are gained into mediating processes in the relation between leader traits and transformational leadership via neurological processes, but also between neurological processes and subjective success criteria via transformational leadership on a detailed level, which extends the approach of leader trait emergence effectiveness.

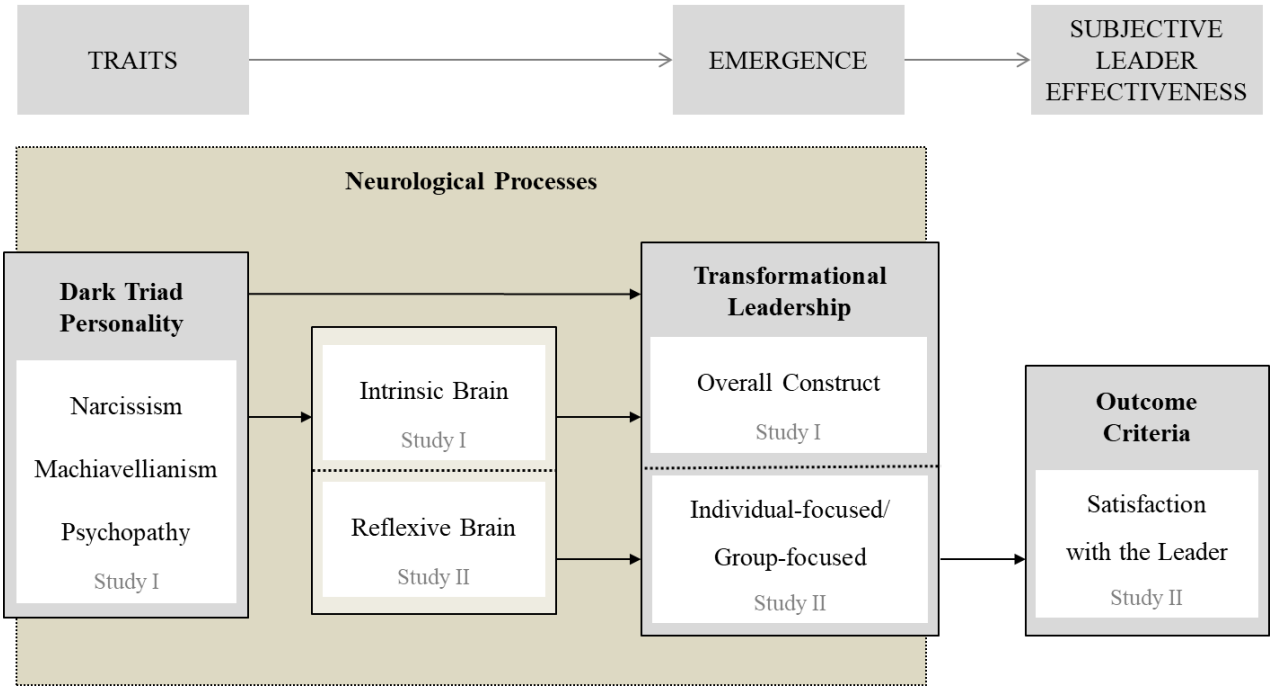

Figure 2. Research Model of the Dissertation.

3. Study 1 - Neurological Individual Differences of the Dark Triad and Transformational Leadership Behavior. A Resting State EEG Study

3.1 Introduction

A number of previous studies have investigated the phenomenon of leadership emergence by exploring the personality traits of leaders, with the focus on the five factor model. Findings indicate extraversion as the most consistent predictor of leadership (Bono & Judge, 2004; Judge et al., 2002). But also components of negative traits such as sub-clinical narcissism, machiavellianism and sub-clinical psychopathy, called the dark triad (Paulhus & Williams, 2002), have already been examined in the organizational context that reveal negative consequences, e.g. counterproductive work behavior, abusive supervision, or laissez-faire leadership (Grijalva et al., 2015; Judge et al., 2006; Kiazad et al., 2010; O'Boyle et al., 2012; Westerlaken & Woods, 2013). Because of the negative effects, not only positive traits should be investigated, but a stronger focus on negative traits should be added to raise awareness that such individuals also emerge in higher positions.

Given that transformational leadership is still one of the most effective leadership styles (G. Wang et al., 2011) and its explanation of variance through personality amounts to only a small part (Bono & Judge, 2004), there is a need to explore further constructs in order to gain a better understanding of the fundamental antecedents. This was already partly taken into account in the leader trait emergence effectiveness model (Judge et al., 2009), where some mediators, e.g. leaders motives, (social) skills and abilities, were placed between leader traits and leadership emergence. Each of these components of the postulated mechanism is based on psychometric evaluation, however, genetic aspects have been considered that precede the stable traits and predict personality to 40-60% (Ilies et al., 2006).

Now a possible extension of this model is proposed by applying a new methodological approach in the context of neurological metrics. Since neuronal activity during resting state, when an individual is not involved into a particular task or activity (Raichle, 2010), is considered relevant to predict behavior (Northoff et al., 2010), the investigation of the intrinsic brain capacity of leaders through electroencephalography aims to establish associations with the dark triad and to fathom a "neuronal profile" of transformational leadership. Previously only one explorative neurological study on transformational leadership was conducted (Balthazard et al., 2012), hence the underlying study contributes to the emerging field of organizational neuroscience research. In a mediational framework and under consideration of the emotional contagion theory (Hatfield, Cacioppo, & Rapson, 1993), I examine whether the relationship of the dark triad and the transformational leadership can be explained by the resting state of the leaders' brain.

3.2 Theory and Hypotheses

Besides the common personality traits, e.g. Big Five (Costa, McCrae, & Dye, 1991), which are already well researched in leadership psychology and serve as indicators for the emergence of leadership (Judge et al., 2002), there are also negative, socially aversive traits. Best known are subclinical narcissism, machiavellianism and subclinical psychopathy, the so-called dark triad (Paulhus & Williams, 2002). While the three sub-dimensions are independent constructs, they are all characterized by a common basis of emotional deficiencies, especially callousness (low empathy) (Jonason, Lyons, Bethell, & Ross, 2013; Jones & Paulhus, 2011; Wai & Tiliopoulos, 2012). The subclinical narcissism introduced into the context of social personality by Raskin and Hall (1979) is characterized by an exaggerated self-image, self-love and grandiosity. In addition, narcissists are always looking for praise and admiration and are

intolerant of criticism or rejection. Other people perceive them as arrogant and aggressive (Campbell, Reeder, Sedikides, & Elliot, 2000; Resick et al., 2009). Machiavellianism is characterized primarily by manipulative and calculating behavior that goes hand in hand with emotional coolness. Machiavellians exploit other people to their personal advantage by lying, betraying and using manipulative techniques. They also have a cynical view of human nature, which leads them to regard other people as untrustworthy and vicious (Christie & Geis, 1970; Hawley, 2006; Jones & Paulhus, 2009). The third component, psychopathy, was initially regarded as a clinical disorder such as narcissism, but later also as a personality trait (Levenson, Kiehl, & Fitzpatrick, 1995). Psychopaths are characterized by manipulative behavior, but without any consideration for others, even if it harms others. They feel no compassion, guilt or remorse. In addition, they are often impulsive, immoral and ruthless, but also violent. They lack self-control, emotional social attitudes and interpersonal behavior (Hare, 1999b; Williams & Paulhus, 2004). As far as the biological side of the dark triad is concerned, it has been shown that all three traits are based on genetic components. It should be added that only machiavellianism is also affected by environmental influences (Vernon et al., 2008; Veselka, Schermer, & Vernon, 2012).

With regard to the consequences, a meta-analysis referring to the effects of the dark triad in the work context was able to show that machiavellianism and psychopathy lead to a reduction in the quality of job performance. In addition, all three components of the dark triad seem to promote counterproductive work behavior (O'Boyle et al., 2012). Furthermore, results of another study showed, that narcissistic leaders tend to regard themselves as good leaders, while others tend to rate them negatively. Although there was a positive effect between narcissism and other reported leadership in the sub-study, this effect was explained by a short-term relationship between the leader and the assessor, since narcissists focus on immediate self-gain which is more

important to them than long term relationships (Judge et al., 2006). Leaders' machiavellianism was positively linked to followers' perception of abusive supervision (Kiazad et al., 2010) and negatively to ethical leadership (Den Hartog & Belschak, 2012). Moreover, psychopathy showed positive correlations with passive leadership behavior and abusive supervision, as well as negative correlations with followers' job satisfaction (Mathieu & Babiak, 2016; Westerlaken & Woods, 2013).

3.2.1 Dark Triad and Transformational Leadership

Based on the leader trait emergence and effectiveness model (Judge et al., 2009), which assumes that personality traits influence leadership emergence, the following hypotheses are derived.

With regard to the characteristics of narcissists, having a good reputation seems to be important, as well as arousing admiration in others, as they feel particular unique in contrast to other people (Judge et al., 2009). Therefore, these individuals strive for a leadership position (Brunell et al., 2008) and see themselves as good leaders (Furtner, Rauthmann, & Sachse, 2011). The leadership position gives them the opportunity to receive the attention they desire and satisfies their need to exercise power over others, which gives them affirmation and increases their self-confidence (Rosenthal & Pittinsky, 2006).

Studies that focused on the dyadic perspective of the consequences of narcissism also investigated the relationship between narcissism and leadership. First, increased leadership emergence among narcissists could be explored during a leaderless discussion, that shows consistency across rating sources, which makes sense, as narcissists like to express their point of view confidently and with greater certainty, which in turn influences others (Brunell et al., 2008). Second, narcissistic personalities were regarded as highly charismatic (Deluga, 1997), with the

difference that narcissists formulate bold visions but not socialized ones (Galvin, Waldman, & Balthazard, 2010). Popper's (2002) study further showed that narcissists are positively related to personalized charismatic leadership, but negatively related to socialized charismatic leadership. This means that they are usually able to develop and communicate visions that focus exclusively on their own personal well-being and psychological needs, not on the values and goals of the whole organization, which is at the core of transformational leadership. Since narcissistic leaders are uncritical, intolerant, and beyond that do not admit their own mistakes, but blame others for them (Hogan, Raskin, & Fazzini, 1990), it is obvious that they will fail in the long run, whether in terms of success or the interpersonal relationships built for their achievement. They therefore do not set a good example for their followers. Their egocentricity and lack of empathy make them unlikely to support their followers, motivate them to question their own working methods or promote group work, as they are largely focused on their own interests.

Based on Braun's (2017) review, which shows that narcissists see themselves as good leaders but are not perceived as such by their followers, and in line with the studies by Greaves et al. (2014) and Judge et al., (2006), which have already shown that narcissistic leaders are seen as less transformational by others, the following hypothesis is posited:

Hypothesis 1a: Narcissism is negatively associated with transformational leadership.

Machiavellians are characterized by their cold-hearted, manipulative and immoral behavior for their own personal gain, without considering the interests and needs of others (Jones & Paulhus, 2009; Wilson et al., 1996). In order to achieve their long term goals such as power and status, they develop a strategy and apply different influence tactics (Dingler-Duhon & Brown, 1987). As leaders, they generally pursue a pragmatic leadership style, because a functional approach and clear structures help them to succeed. However, charismatic leaders

have also been found to have a moderate degree of machiavellianism, as both are associated with influential, persuasive and expressive behavior that is only beneficial to themselves (Bedell, Hunter, Angie, & Vert, 2006).

Their relationships with followers are strategic, which means that machiavellians are not interested in the personal interests and values of their followers, which is due to their lack of empathy (Paulhus & Williams, 2002). Nevertheless, they can be very friendly and cooperative during these interactions with their followers, dazzle them and influence them for their own advantage. But in reality they exploit them for their own gain, control them and abuse the power they have as leaders (McHoskey, 1999). These characteristics do not go hand in hand with a transformational leader who really cares about the well-being of his followers and engages in conversations about their individual development potentials and goals. Because machiavellians are usually cynical about others and do not trust them (Brown & Treviño, 2006; Rauthmann & Will, 2011), they are unlikely to inspire their followers intellectually or make them feel that they can achieve ambitious goals. Since they are often tempted to lie to succeed, as confirmed in a study in which salespersons with a high degree of machiavellianism showed a higher willingness to lie (Ross & Robertson, 2000) and lack of transparency in communication (Walter, Anderson, & Martin, 2005), they do not set a good example for their followers, which, however, is an important component of transformational leadership style. Machiavellianism is also positively associated with self-directed work commitment and negatively with organizational and team commitment (Zettler, Friedrich, & Hilbig, 2011), which contradicts the component of promoting group goals.

Since machiavellian leaders are positively associated with followers perceptions of abusive supervision (Kiazad et al., 2010) and negatively associated with ethical leadership

(Brown & Treviño, 2006), it appears reasonable that machiavellian leaders are likely to be less transformational in their leadership behavior.

Hypothesis 1b: Machiavellianism is negatively associated with transformational leadership.

Psychopathy can be considered in two different forms: as a personality disorder in a clinical context and as a personality trait in a sub-clinical context. The difference between these two forms, however, is not the general pattern of behavior, but in the intensity and frequency with which the behavior is shown (Gustafson & Ritzer, 1995). It is therefore not unusual that these individuals, who have a high psychopathic level, can also be found in the upper management levels (Babiak & Hare, 2006). Although psychopaths have destructive characteristics and thus show impulsive and reckless behavior (Hare, 1999a), the study by Babiak, Neumann, and Hare (2010) found a positive link to charisma and presentation skills such as creativity, good communication and strategic thinking, but also negative effects on responsible behavior, e.g. leadership skills, teamwork and performance. A distinction is made between successful or so-called corporate psychopaths and criminal psychopaths, whereby successful psychopaths are assigned to the subclinical form of psychopathy (Hare & Neumann, 2008). The charisma abilities mentioned above could favour transformational leadership behavior. In this way, psychopaths could initially leave a positive impression and try to disguise the negative for their own aspirations, but this would not succeed in the long run (Babiak et al., 2010). Assuming that there is a difference between positive and negative charisma, corporate psychopaths are more likely to be expected to internalize the dark side. These individuals relate exclusively to their own interests, act deceitfully, manipulate others ruthlessly and are in a defensive attitude towards others (Conger, 1990; Parry & Proctor-Thomson, 2002; Yukl, 1989). It is unlikely that

corporate psychopaths will lead their followers in a transformational way because they do not feel responsible towards others and do not promote or consider teamwork important, but they are central components of transformational leadership.

Previous studies that have investigated leaders with a tendency towards psychopathy in terms of their leadership style have shown that they generally exhibit passive and destructive behaviors (Mathieu & Babiak, 2016; Mathieu, Neumann, Hare, & Babiak, 2014), and try to completely avoid contact with followers. When contact is unavoidable, they are not afraid to use exploitative strategies and behave inappropriately. In addition, the relationship to transformational leadership was also examined, demonstrating an overall negative effect (Landay, Harms, & Credé, 2019), especially on the sub-dimension individualized consideration (Mathieu, Neumann, Babiak, & Hare, 2015; Westerlaken & Woods, 2013). Therefore, the following hypothesis is stated:

Hypothesis 1c: Psychopathy is negatively associated with transformational leadership.

3.2.2 Dark Triad and Frontal Lobe Coherence

Literature suggests that the intrinsic brain reflects the potential of an individual's behavioral patterns and cognitive abilities. This brain activity is measured while the individual does nothing specific, i.e. does not pursue any task. It should be added that the intrinsic brain is not inactive in any way, but is in a kind of standby mode that is relatively stable over time (Cacioppo et al., 2003; Raichle & Snyder, 2007). Therefore, it would appear obvious that brain activity measured at rest can be associated with personality traits of an individual that also seems to be relatively stable over time (McCrae & Costa, 1994). While other studies examined neurological mechanisms and volume differences in the frontal area of the brain for personality traits, e.g. extraversion, neuroticism, conscientiousness (Deckersbach et al., 2006; DeYoung et

al., 2010; Kunisato et al., 2011), the following hypotheses also focus on the frontal cortex. It should be noted that many studies have dealt with the properties of the dark triad in a clinical context. However, the hypotheses are based on studies carried out with healthy individuals.

Narcissism and the Frontal Lobe Coherence

Similar to the other two components of the dark triad, the low empathic capacity is one of the core characteristics of narcissism (Hepper, Hart, & Sedikides, 2014; Watson, Grisham, Trotter, & Biderman, 1984). Evidence-based, empathy is a multidimensional construct composed of the cognitive and affective/emotional component, where cognitive empathy is the recognition and understanding of the emotions of others and affective empathy is the experience of the emotional state of others (Decety, Jackson, Sommerville, Chaminade, & Meltzoff, 2004; Decety & Moriguchi, 2007; Preston & de Waal, 2001). These two forms of empathy are based on different processes. On the one hand, affective empathy is based on the emotional contagion theory, which describes a natural and unconscious process in which one is receptive to the feelings of others and can empathize with them (Hatfield et al., 1993). On the other hand, cognitive empathy can be explained by the theory of mind, which primarily describes the cognitive ability to recognize and understand the feelings of others (Leslie, 1987).

Research has shown that narcissists have lack impairment in understanding the emotions of others, as demonstrated by the positive correlation between narcissism and cognitive empathy (Turner, Foster, & Webster, 2019; Wai & Tiliopoulos, 2012). Nevertheless, narcissists were found to have limited affective empathy, the form of empathy that allows them to empathize with the emotional states of others (Jonason & Krause, 2013; Turner et al., 2019). Individuals who were highly rated on narcissism, experienced positive feelings when looking at images of sad faces (Wai & Tiliopoulos, 2012).

The meta-analysis of Fan, Duncan, de Greck, and Northoff (2011) found that the differences between these two main types of empathy are also reflected in neuronal activity in the brain, so that affective empathy is associated with a higher activation of the right anterior insula, which is interconnected with the orbitofrontal cortex, a region of prefrontal cortex (Jakab, Molnár, Bogner, Béres, & Berényi, 2012). Cognitive empathy is associated with a higher activation of the dorsal anterior mid-cingulate cortex. In addition, the right dorsal-anterior cingulate cortex, the right dorsomedial thalamus and the midbrain are activated during affective empathy. In another fMRI study, which examined the neuronal correlates of narcissists, reduced activity of the right anterior insula was observed with high levels of narcissism (Fan, Wonneberger et al., 2011). A recent study dealing with narcissism and its underlying neuronal networks found that individuals with a high degree of narcissism had less connectivity in the prefrontal cortex and the ventral striatum (Chester, Lynam, Powell, & DeWall, 2016).

Another characteristic of narcissists is the high degree of self-enhancement, as narcissists have an exaggerated positive self-perception and an increased need for positive feedback on their self-image (Paulhus & Williams, 2002). Paulhus and John (1998) proposed to distinguish between two forms of self-enhancement, an egoistic form with exaggerated self-worth relating to the need for power and social status, and a moral form reflecting adherence to social norms to satisfy the need for acceptance. Accordingly, narcissists can be assigned to the egoistic form of self-enhancement, which is particularly associated with the medial prefrontal cortex (Barrios et al., 2008; Luber, Lou, Keenan, & Lisanby, 2012).

The medial prefrontal cortex is also responsible for self-evaluation, which can be recognized in two ways, either ‘directed’, how one perceives oneself or ‘reflected’, how others perceive one's own self. In narcissists it is more likely to adhere to a directed self-evaluation

because they are egocentric and self-absorbed, which activates the right prefrontal cortex and anterior cingulate cortex (Ochsner et al., 2005). Since narcissists have an unrealistic perception of the self and their self-esteem is both, exaggerated and unstable, it seems that directed self-evaluation does not work properly, suggesting a low involvement of these brain areas.

The attributes mentioned above, which are contrary to those of narcissists, are associated with a majority of activated brain areas in the right frontal region. Narcissists should therefore show less brain activity in the right-sided frontal area.

Hypothesis 2a: Narcissism is negatively associated with the coherence of the right frontal cortex.

Machiavellianism and the Frontal Lobe Coherence

Although machiavellians have weaknesses in empathy and social competence (Jonason et al., 2013), a distinction must also be made here between the two types of empathy. Previous research has identified negative correlations between machiavellians and emotional empathy, the ability to empathize with the emotional states of others (Jonason & Krause, 2013; Turner et al., 2019; Wai & Tiliopoulos, 2012). With regard to cognitive empathy, one study reported a negative correlation between machiavellianism and cognitive empathy (Jonason & Krause, 2013; Wai & Tiliopoulos, 2012), and another recently published study confirmed a positive correlation through a structural equation model, that included various measures of both cognitive empathy and machiavellianism (Turner et al., 2019). It should be noted that these results entirely refer to psychometric self-assessments.

According to the results of non-psychometric methods, machiavellians experienced positive affect when confronted with sad faces and negative affect when confronted with happy faces, which leads to the assumption of low affective empathy. They also had problems correctly

recognizing happy and sad emotions, the cognitive form of empathy (Wai & Tiliopoulos, 2012). In addition, deficits could be identified, when machiavellians performed typical theory of mind tasks, that represent the cognitive empathy (Ali & Chamorro-Premuzic, 2010; Lyons, Caldwell, & Shultz, 2010). Consequently, both affective and cognitive empathy seem to be low among machiavellians, although they attribute to themselves in part the ability to recognize and understand the feelings of others. The focus should therefore be on the results of the non-psychometric assessment of empathy, as this tests the actual ability rather than one's own perception.

Fan, Duncan et al. (2011) investigated neuronal correlates of both forms of empathy in their meta-analysis. The interpretation of the results suggest, that machiavellians generally have a lower activation of the left- and right-sided anterior insula and a lower activation of the left dorsal anterior mid-cingulate cortex, both linked to the prefrontal cortex. These regions are associated with affective and cognitive empathy. Another study investigating neurological activities in machiavellians during theory of mind tasks found low activity in the left and right temporo-parietal junction, a region between parietal and temporal cortex, left and right precuneus located near the occipital cortex and especially in the right medial prefrontal cortex (Bagozzi et al., 2013).

Nevertheless, machiavellians succeed in exploiting others through interpersonal relationships, which is not necessarily due to mind reading or empathy, but rather by making inference from the others' behavior (Bereczkei, 2018; Czibor & Bereczkei, 2012), which in turn is associated with various brain areas, e.g. thalamus, anterior cingulate cortex and inferior and middle frontal gyrus (Bereczkei, Deak, Papp, Perlaki, & Orsi, 2013; Liakakis, Nickel, & Seitz, 2011). The inferior frontal gyrus, a part of the prefrontal cortex, was also activated in

machiavellians during decision-making in a trust game, which is an experiment to measure trust in economic decisions, leading to the assumption that they monitor others and adjust their behavior accordingly (Bereczkei et al., 2013; Bereczkei et al., 2015). Machiavellians' core competence manipulation was found to be associated with the left middle frontal gyrus (Cairo, Liddle, Woodward, & Ngan, 2004; Liu et al., 2012). In addition, higher activation in the left anterior orbitofrontal cortex was associated with machiavellians, which is explained by the fact that this area is relevant for goal-oriented behavior and decision-making in unpredictable situations where flexibility is required (Spitzer, Fischbacher, Herrnberger, Grön, & Fehr, 2007). According to Furnham et al. (2013), machiavellians are flexible in their choice of manipulation strategy.

In summary, machiavellians have less left frontal activity with regard to the frontal lobe in empathy situations, but this area is activated when they exhibit exploitative or controlling behavior. On the other hand, the statements regarding a low level of activity in the right frontal area of machiavellianists appear to be somewhat more consistent.

Hypothesis 2b: Machiavellianism is negatively associated with the coherence of the right frontal cortex.

Psychopathy and the Frontal Lobe Coherence

Psychopathy is considered the main predictor of empathy deficits within all the characteristics of the dark triad, as deficits have been found not only in affective empathy, but also in cognitive empathy and in the description of feelings (Wai & Tiliopoulos, 2012). According to earlier studies, individuals with high psychopathic ratings had difficulty correctly recognizing emotions, which indicates that they could not recognize various emotions in the facial expressions of others who were happy, angry and fearful. When they were supposed to

describe their own feelings while observing different emotions in the facial tasks, there was no agreement between the facial expression and their own feelings, e.g. they felt negative feelings when they saw a happy face. This means that psychopaths are not able to interpret the feelings of their counterparts correctly and also are not able to empathize with them. With regard to the self-assessment of empathy, psychopaths also consider themselves to be slightly cognitive and affectively empathic (Jonason & Krause, 2013; Wai & Tiliopoulos, 2012), except in the study by Turner et al. (2019), where only the negative correlation was significant for affective empathy.

From a neurological point of view, individuals with both types of empathy deficits, such as those with a high level of psychopathy, exhibit lower neuronal activity in the left and right anterior insula and in the left dorsal anterior midcingulate cortex (Fan, Duncan et al., 2011). Referring to the frontal lobe dysfunction theory (Gorenstein & Newman, 1980), that postulates antisocial behavior as a consequence of frontal lobe deficiency, a study of Snowden, Gray, Pugh, and Atkinson (2013) confirmed the dysfunction of orbitofrontal cortex, a subregion of the prefrontal cortex, in subclinical psychopaths. Furthermore, individuals with psychopathic traits showed lower activity in the left anterior cingulate, which is connected with the prefrontal cortex, and in the superior frontal gyrus, which is part of the frontal lobe (Kim & Jung, 2014). In addition to the reduced activity in certain prefrontal areas of psychopaths, lower functional connectivity between the ventromedial prefrontal cortex and the amygdala could also be investigated (Motzkin, Newman, Kiehl, & Koenigs, 2011). The connectivity of ventromedial prefrontal cortex and amygdala is particularly important in the regulation of emotions and social behavior (Davidson, 2002; Delgado, Nearing, Ledoux, & Phelps, 2008), both aspects which are weak in psychopaths. The results of a meta-analysis examining 43 brain imaging studies in antisocial individuals, showed significantly reduced function and structure throughout the

prefrontal cortex. In particular, impulsive behavior patterns and low behavioral control, that are indicative of psychopaths (Paulhus & Williams, 2002), were associated with a reduction of the left dorsolateral prefrontal area (Yang & Raine, 2009).

Taken together, all these results suggest a generally low activation of the prefrontal lobe in psychopaths, but especially the activity seems to be lowest in the left frontal area.

Hypothesis 2c: Psychopathy is negatively associated with the coherence of the left frontal cortex.

3.2.3 Frontal Lobe Coherence and Transformational Leadership

Northoff et al. (2010) report in their review, that the neuronal activity of the resting state is relevant for the prediction of behavior patterns. In addition, resting state patterns can be used to understand cognitive abilities and emotions (Lindquist, Wager, Kober, Bliss-Moreau, & Barrett, 2012). Consequently, it can be assumed that leadership also depends on certain neurological patterns at rest, as Waldman, Balthazard, and Peterson (2011) have already noted. Particular attention should be paid to the frontal lobe, as this area is responsible for executive functions, e.g. organizing, planning and problem solving (Kaufer & Lewis, 1999), which in turn is generally relevant to the occurrence of leadership (Atwater, Dionne, Avolio, Camobreco, & Lau, 1999; Kellett, Humphrey, & Sleeth, 2006; Lord et al., 1986).

Considering transformational leadership in its entirety, it contains a large repertoire of different behavioral patterns. Overall, the values and objectives of each individual follower are changed and adjusted in line with the company's long term goals by various behavior patterns, which can be separated into six sub-components: formulating and communicating an appealing vision, being a role model, supporting teamwork, expectation of high performance, intellectual stimulation and individual support (Podsakoff et al., 1990). With reference to earlier research in

social neuroscience (Cacioppo et al., 2003; Lindquist et al., 2012), such complex behavior cannot be attributed to a specific location in the brain, but rather to the connection of several areas. For that reason this is considered in the following.

Since transformational leadership is often described as an emotional leadership style, leaders not only need cognitive but also emotional skills to inspire and motivate their followers (Yammarino & Dubinsky, 1994). Gainotti's (2018) review summarizes the results of various studies on emotional function in the brain. Finally, taking into account experimental studies, lesion studies and the assumption of frontal lobe asymmetry, cf. Davidson (1992), a dominance of the right hemisphere for emotions was identified. In detail, he suggests that the right amygdala is responsible for the evaluation of emotional stimuli, while the right anterior insula is a basis for subjective emotional states. In addition, the right ventromedial prefrontal cortex is crucial for controlling emotional reactions. Transformational leaders inspire their followers through emotional expression, e.g. through enthusiastic communication of a vision, with the goal of conveying this positive feeling and making them strive for it (Bono & Ilies, 2006). Awareness of the feelings of followers allows transformational leaders to respond individually to their needs and then systematically promote and develop them (Bass & Riggio, 2008). Ashkanasy, Härtel, and Daus (2002) examined the core competencies of a transformational leader, which include emotional self-awareness, empathic abilities and sensitivity to the emotional needs of their followers. Accordingly, a more activated or interconnected right frontal cortex should promote these "emotional" core competencies. Furthermore, social behavior and cooperative processes are also located in the right frontal cortex (Decety et al., 2004; Tranel, Bechara, & Denburg, 2002).

In addition to emotional competencies, specific cognitive abilities such as problem-solving, reasoning, divergent thinking and cognitive flexibility are also key attributes for leadership functions (Zaccaro, LaPort, & Jose, 2013). In order to establish a vision, it is necessary to take a longer-term perspective, plan and imagine what the overall goal of the organization should be and how individual followers can contribute to achieving this goal. Also here, the right frontal area in particular is responsible for planning processes and strategy development (Burgess, Veitch, de Lacy Costello, & Shallice, 2000; Robinson et al., 2015). Moreover, during intellectual stimulation, problem solving techniques are used to discuss and elaborate with the followers new ways for tasks and procedures (Sarros & Santora, 2001), which is associated with the right dorsolateral prefrontal cortex (Tomasino & Fabbro, 2016).

Taken together, the right frontal cortex seems to be a kind of basis for transformational leadership, as already shown by the study of Balthazard et al. (2012), which was the first study on neurological correlates of transformational leaders with an explorative approach. They also found a negative correlation between left frontal coherence and transformational leadership.

Hypothesis 3: Right frontal coherence is positively associated with transformational leadership.

3.2.4 The Mediating Effect of Leaders' Dark Triad via Frontal Lobe Coherence on Transformational Leadership

In the above sections it was postulated, that the dark triad traits have a direct negative influence on the transformational leadership behavior. Then, a negative association between dark triad traits and frontal lobe coherence was suggested. Finally, it was described that the right frontal lobe coherence positively influences the transformational leadership behavior. Below, a mediating effect of frontal lobe coherence on the relationship between leaders' dark triad traits and transformational leadership is assumed.

According to the leader trait emergence effectiveness model by Judge et al. (2009), an influence of the personality traits of leaders, e.g. dark traits, on the perceived leadership is assumed. These personality traits are generally considered to be relatively stable over time (Jonason & Webster, 2010). Furthermore, the model suggests some mediating processes, such as the abilities and skills of a leader, which can be described as decision-making, problem solving or oral communication (Hoffman, Woehr, Maldagen-Youngjohn, & Lyons, 2011). Since all these constructs of this model are psychometrically determined, a neurological component that reflects the resting state of the leaders' brain is included in the model as a possible extension. Resting neural activity is responsible for predicting the mental states of individuals and their behaviors (Northoff et al., 2010). Hence, it can be assumed that connections in the frontal area of the brain serve as precursors for leadership behaviors in the resting state. Raichle and Snyder (2007) describe the resting state as relatively stable in adulthood, but with regard to the plasticity of the brain circuity, a long term modification over time seems to be possible (Bavelier, Levi, Li, Dan, & Hensch, 2010). There is no study that reports whether personality is influenced or caused by the resting state of the brain.

For this reason, and the time-lagged measurement in this study, it is postulated that the resting state acts as a mediating variable in the relationship between dark triad and transformational leadership. Since in the previous hypotheses hemispherical differences were assumed, e.g. machiavellians and narcissists seem to have a reduced right frontal coherence and psychopaths a reduced left frontal coherence, this is maintained in the following mediation hypotheses. Since the left hemisphere is considered in psychopaths, it should be added that left frontal coherence was previously negatively associated with transformational leaders (Balthazard et al., 2012). Therefore, it is hypothesized:

Hypothesis 4: The relationship between narcissism and transformational leadership (4a) and machiavellianism and transformational leadership (4b) is mediated by right frontal coherence. The relationship between psychopathy and transformational leadership is mediated by left frontal coherence (4c).

3.3 Method

3.3.1 Sample and Procedure

The total sample of this study consisted of 128 participants - 104 students, but also including 24 leaders and followers from real organizations - recruited by research assistants. Before attending the study, all participants stated that they had no neurological or psychiatric disorders or alcohol or drug abuse. As part of this study was based on a role play, students were randomly divided into 52 dyads for the roles of leader and follower while participants from the real organisational context remained in their usual roles, representing 12 dyads. Consequently, the final sample comprised of 64 leaders. Of these, 40.6% were male and the age ranged from 18 to 56 years, with an average of 25.66 (SD = 9.16). 76.2% stated to have higher education level, 19% a university degree and 4.8% a secondary degree. In terms of practical experience, 70.3% reported having already worked in or for an organization. Only 28.1% had leadership experience.

The data was collected at two measurement points, with a three-week time lag. At the first measurement point, the leaders were asked to conduct a self-assessment on the dark triad personality traits and to answer questions on demography. The second measurement point, which was conducted only in the morning, was divided into two sections. Right at the start, participants gave their written consent to the collection of neurological data and were informed that they could decide to end their participation at any time. Then, a neurological method for measuring brain waves at rest was performed, which is described in more detail in the following section on

neural-based measures. Participants were then asked to take 30 minutes to prepare for a role play. Both participants were given a description of the scenario with basic information about a fictitious pump manufacturing company in a business-to-business context and information about the current situation and the newly introduced open-plan office. The role of the leader relates to a team leader who has been working in the complaints department for five years. Additional information was given that he is initiator for the implementation of the new office with the aim of achieving a better cooperation between the whole team. In addition, he also received an overview of the follower's performance in the past year and two complaints from colleagues and clients. The role of the follower was given, in addition to the basic information, a description of his personal view of the new open-plan office and the resulting sleep and concentration disturbances. The scenarios did not explicitly state that the leader should show certain leadership behavior or bring certain arguments. The subsequent conversation lasted between 10 and 15 minutes (M = 12.12, SD = 4.04). Afterwards, the follower assessed the perceived transformational leadership.

3.3.2 Neural-Based Measure

The leaders of this study attended an intrinsic brain measurement before the role play, sitting comfortably on their chairs and keeping their eyes closed without concentrating on any particular task, so that the brain was in a resting but alert state. Previous studies in organizational neuroscience also used this at rest measurement (Hannah et al., 2013; Waldman, Wang et al., 2017). The resting brain measurement reflects a person's relatively stable intrinsic capacity (Raichle & Snyder, 2007).

Electroencephalography, a basic method for recording brain waves, has been used to measure the intrinsic capacity of the brain. A high-accuracy biosignal amplifier (g.USBamp) and

recording software (g.Recorder) from g.tec were used. A cap with a set of six electrodes (FP1, FP2, F3, F4, F7, F8) arranged on the frontal lobe according to the international 10/20 system (Jasper, 1958) was placed on the head of the participant and the electrodes filled with gel to increase the electrical conductivity. An ear electrode was used as a reference electrode and a mid-forehead electrode (FPz) as a ground electrode to reject common mode. Before starting the measurement, the impedance test, a tool from g.USBamp, ensured that the measured values did not exceed 10 Ω in order to obtain high-quality data. Participants were asked not to speak during the measurement and to avoid body movements, especially head movements, in order to minimize artifacts. The electrical activity of the brain was recorded for 120 seconds at a digitization rate of 256 Hz and a notch filter was set to suppress the 50 Hz power line frequency.

The following data preparation was performed offline with MATLAB (version 2016; MathWorks) and the toolbox EEGLAB (version 14; Delorme & Makeig, 2004). An automatic channel rejection was implemented and a bandpass filter was set so that only frequencies below 40 Hz were permitted in the data set, which can be assigned to the beta frequency and represents the alert or attentive brain. This frequency range has also been investigated in other studies in organizational neuroscience (Waldman et al., 2018; Waldman, Wang et al., 2017). To remove eye and muscle movement artifacts, independent component analysis (ICA) was used for the entire data set. With the processed data, the average EEG coherence for the frontal brain area of both hemispheres was determined by first calculating the coherence values of each electrodes pair and then the mean value. A coherence index was calculated for the left frontal area with electrodes FP1, FP3 and FP7 and one for the right frontal area with electrodes FP2, FP4 and FP8. Coherence represents a statistical measure that indicates, as a percentage, how synchronously cortical areas of the brain or brain voxels interact. This means, for example, that 90% coherence

implies relatively high interaction between brain areas, while 10% coherence means relatively low synchronicity. The consistency of time or phase differences is taken into account (Thatcher, Krause, & Hrybyk, 1986).

3.3.3 Survey-Based Measures

Dark triad. To measure the traits of the dark triad, the short dark triad (SD3) (Jones & Paulhus, 2014) was used in a German version with the back-translation method (Brislin, 1970). The measure includes 27 items, nine for each trait: Machiavellianism (e.g. "Avoid direct conflict with others because they may be useful in the future.", Cronbach's alpha of .73), narcissism (e.g. "I know that I am special because everyone keeps telling me so.", Cronbach's alpha of .65 and psychopathy (e.g. "People who mess with me always regret it.", Cronbach's alpha of .67). The rating scale ranged from 1 ("disagree strongly") to 5 ("agree strongly").

Transformational leadership. The followers rated the perceived transformational leadership behaviors on a validated German scale, the *Integrative Leadership Survey* (Rowold & Poethke, 2017), which consists of 24 items, four for each of the six dimensions. Exemplary items are: "My supervisor shows new ways to interpret tasks and goals.", "My supervisor explains why best performance is required." and "My supervisor appeals to the team members' sense of belonging." Items were rated on a 5-point scale, ranging from 1 ("strongly disagree") to 5 ("strongly agree"). The Cronbach's alpha for this measure was .92.

Control variables. The gender of the leaders was considered as a control variable, as it might have an effect on the dark triad personality traits (Paulhus & Williams, 2002) and also on the transformational leadership behavior (Eagly & Carli, 2003; Kark, Waismel-Manor, & Shamir, 2012). Furthermore, the age and leadership experience (0 = no, 1 = yes) of the leader were considered as controls.

3.4 Results

Means, standard deviations and correlations among all variables are reported in Table 3. The mean of the coherence variables, the right frontal coherence at rest (M = 42.40, SD = 13.71) and the left frontal coherence at rest (M = 44.97, SD = 16.44) are similar to the reported mean coherence values from other studies in organizational neuroscience (e.g. Hannah et al., 2013; Waldman, Wang et al., 2017). Besides, some correlations are worth mentioning. First, gender correlated positively with the three subscales of the dark triad, narcissism (r = .29, p < .01), Machiavellianism (r = .36, p < .01) and psychopathy (r = .39, p < .01), suggesting that men score higher on dark triad than women do, which is in line with other studies (e.g. Jonason & Webster, 2010). Second, all three subscales showed positive intercorrelations. Narcissism correlated with machiavellianism (r = .37, p < .01) and psychopathy (r = .40, p < .01). Machiavellianism correlated with psychopathy (r = .67, p < .01), which is also confirmed by previous studies (e.g. Jones & Paulhus, 2014).

In order to test the hypotheses H1 to H3 hierarchical regression analysis were performed with SPSS 22.0, controlling for demographics. The results are shown in Table 4.

Hypothesis 1 stated that leaders' narcissism (1a), machiavellianism (1b) and psychopathy (1c) are negatively related to transformational leadership behavior. A significant negative effect of machiavallianism on transformational leadership (ß = -.32, p < .01) could be shown, but not of narcissism (ß = .02, *ns*). Unexpectedly, psychopathy has a significantly positive effect on transformational leadership (ß = .36, p < .01). Thus, hypothesis 1b is confirmed, but hypothesis 1a and 1c have to be rejected.

Table 3. *Study 1: Means (M), Standard Deviations (SD), and Correlations*

Construct	*M*	*SD*	1	2	3	4	5	6	7	8	9
1. $Gender_{Leader}$[a]	0.41	0.49									
2. Age_{Leader}	25.66	9.11	.21**								
3. Leadership experience[b]	0.31	0.47	.16*	.53**							
4. Narcissism	2.81	0.50	.29**	.13	.20**	(.65)					
5. Machiavellianism	2.71	0.62	.36**	-.10	-.21**	.37**	(.73)				
6. Psychopathy	2.01	0.56	.39**	-.06	.10	.40**	.67**	(.67)			
7. Right frontal coherence (rest)	42.40	13.71	.06	-.02	.13	-.17**	-.06	-.11			
8. Left frontal coherence (rest)	44.97	16.44	-.05	-.11	-.02	-.13	-.07	-.14	.60**		
9. Transformational Leadership	3.63	0.58	.05	-.01	-.12	-.09	-.06	.11	.26**	.09	(.92)

Note. $N = 64$. Internal consistencies (Cronbach's Alpha) are reported in the parantheses on the diagonal.

[a] gender coded as 0 = female and 1 = male; [b]leadership experience coded as 0 = no and 1 = yes.

** $p < .01$; * $p < .05$.

Hypothesis 2 proposed that narcissistic leaders have reduced right frontal lobe coherence at rest (2a), machiavellian leaders have lower coherence in the right frontal lobe (2b) and psychopathic leaders have a weaker coherence in the left frontal brain area (2c). Results show a significant negative effect of leaders' narcissism on right frontal coherence (ß = -.26, $p < .01$) and of leaders' psychopathy on left frontal coherence (ß = -.23, $p < .01$), supporting hypotheses 2a and 2c. No significant effect, however, could be shown by leaders' machiavellianism on the right frontal coherence (ß = .15, *ns*).

Hypothesis 3, which assumed a positive effect of right frontal coherence on transformational leadership, is confirmed according to the results (ß = .39, $p < .001$).

The mediational framework (H4a-H4c) was tested using PROCESS macro (Hayes, 2013) with 5,000 bootstrap resamples to examine the indirect effects of the dark triad (predictor) on transformational leadership (outcome variable) via left or right frontal lobe coherence (mediator), controlling for leaders' gender, leaders' age and leadership experience. The indirect effect of leaders' narcissism via right frontal coherence on transformational leadership was significant ($ß_{ind.}$ = -.09, 99% *CI* [-.22, -.02]), which confirms hypothesis 4a. Also the indirect effect of leaders' psychopathy via left frontal coherence on transformational leadership was significant ($ß_{ind.}$ = -.04, 95% *CI* [-.08, -.00]), supporting hypothesis 4c. The suspected indirect effect of machiavellianism via right frontal coherence on transformational leadership, unfortunately could not be confirmed ($ß_{ind.}$ = -.02, 95% *CI* [-.08, .03]), leading to the rejection of hypothesis 4b.

Table 4. *Study 1: Results of Regression Analysis*

	Right frontal coherence (rest)		Left frontal coherence (rest)		Transformational Leadership	
	Step 1	Step 2	Step 1	Step 2	Step 1	Step 2
	Beta		Beta		Beta	
Controls						
$Gender_{Leader}$[a]	.09	.17*	-.00	.07	.08	.03
Age_{Leader}	-.13	-.16	-.05	-.19*	.08	.18*
Leadership experience[b]	.20*	.30**	.07	.16	-.19*	-.39**
Study variables						
Narcissism		-.26**		-.15		.02
Machiavellianism		.15		.13		-.32**
Psychopathy		-.19		-.23*		.36**
Right frontal coherence (rest)						.39***
Left frontal coherence (rest)						-.03
R^2	.04	.12	.02	.07	.03	.21
ΔR^2		.08		.05		.18

Note. $N = 64$. Standardized regression coefficients are reported.

[a] gender coded as 0 = female and 1 = male; [b]leadership experience coded as 0 = no and 1 = yes.

***$p < .001$; ** $p < .01$; * $p < .05$.

3.5 Discussion

The aim of this study was to implement a mediational framework to investigate the relationship between the dark triad traits and transformational leadership behavior with regard to the resting state coherence patterns of the brain. There are surprising effects in terms of the relationship between the dark triad and transformational leadership, since only the hypothesized negative effect of machiavellianism on transformational leadership was significant, but not the further expected negative effects of narcissism and psychopathy.

Referring to the study by Resick et al. (2009), which also reported a non-significant effect of narcissism on transformational leadership behavior, the explanation was that transformational leadership was considered as an overall construct. Since at the facet level there was at least a negative influence on the individualized consideration. Another argument that can be mentioned here is the length of the role play, in which the negative side of narcissism could not be reflected in leadership behavior (Harms, Spain, & Hannah, 2011). According to Paulhus (1998), narcissists are often rejected by their groups in the long term because of their arrogance and self-assertion, but enjoy short-term popularity (Back, Schmukle, & Egloff, 2010). In addition, the low Cronbach's alpha of .42 can also be a reason for the lack of significant effect.

Instead of the assumed negative effect of psychopathy on transformational leadership, a positive effect was found. Although previous research has shown negative effects of psychopaths on positive leadership (Landay et al., 2019; Mathieu et al., 2015; Westerlaken & Woods, 2013), these individuals are nevertheless described as good communicators with good presentation skills and high charisma ratings (Babiak et al., 2010; Yang & Raine, 2008), which could misleadingly lead to higher ratings of transformational leadership, especially in the short-term (Babiak et al., 2010).

With regard to the neurological patterns of the dark triad, both the assumed negative relationship between narcissism and right frontal coherence and between psychopathy and left frontal coherence was confirmed, while machiavellianism was not significantly related to right frontal coherence. It should be noted that in previous studies machiavellianism was the only component of the dark triad that was not only based on genetics but also influenced by environmental factors (Vernon et al., 2008; Veselka et al., 2012) and therefore can be modified in life span (Jones & Paulhus, 2011). This may be the reason why there is no resting state pattern that reflects machiavellianism. It should be also added here that the associations of brain areas with the psychological processes of machiavellians, that were mentioned previously in the hypothesis derivation were inconsistent with respect to the hemispheres. It is therefore difficult to identify a neurological network in a particular hemisphere.

In accordance with the study by Balthazard et al. (2012), a positive link between right frontal coherence and transformational leadership was found. The results of the explorative study could now be replicated with a deductive method. This means that leaders with a high level of coherence in the right frontal lobe are likely to lead more transformational.

Looking at the mediating analyses, there was no significant effect of machiavellianism on transformational leadership via right frontal coherence. Since there was only a direct negative effect of machiavellianism on transformational leadership, but not on right frontal coherence, it seems that leaders with high ratings on machiavellianism are bad in leading transformational, regardless of frontal lobe coherence. However, for narcissism and psychopathy, indirect effects on transformational leadership via frontal lobe coherence were observed. This leads to the assumption that narcissists behave less transformational due to their low right frontal coherence level, which was previously indicated as a resting state basis or condition for transformational

leadership (Balthazard et al., 2012). Interestingly, psychopaths seem to have an indirect negative impact on transformational leadership, explained by their low left frontal coherence, while the direct relationship was positive. Obviously, the low coherence in the left frontal area makes a difference in this context, so that the indirect effect becomes negative. This goes hand in hand with the finding that there is a negative link between low coherence in the left frontal area and transformational leadership (Balthazard et al., 2012).

In summary, the leader trait emergence effectiveness model (Judge et al., 2009) can be extended by the neurological component, resting state of the frontal lobe coherence, in which it can be placed as mediator between leaders' traits and the emergence of leadership.

3.5.1 Limitations and Future Directions

Some limitations of this study should be mentioned here. First, the proposed extension of the leader trait emergence effective model by the neurological component as mediator should be examined in further studies, as it is still controversial whether the personality develops first or the resting state of the brain. Since both components are often described as traits in the literature (Cacioppo et al., 2003; McCrae & Costa, 1994; Raichle, 2010; Raichle & Snyder, 2007), the neuronal plasticity of the brain assumes modifiability of brain structures over time (Bavelier et al., 2010). Accordingly, a longitudinal study should be conducted to get more insights about these mediating mechanisms and the causal sequencing. Furthermore, the effectiveness of the leader could be included to complete the model, since little is known about the long term effect of personality on leader effectiveness (Harms et al., 2011).

The use of electroencephalography as a neurological method for measuring the resting state of leaders' brain is innovative in organizational behavior research. Compared to other neurological methods such as functional magnetic resonance imaging or blood oxygen level

dependent imaging, which are bound to a laboratory due to the technology or machines used, electroencephalography is a procedure that requires less effort and costs. The measurement is non-invasive and thus completely harmless for humans. Unfortunately, this method only measures the surface of the brain in the form of voltage differences and not the underlying structures, such as the amygdala, which is relevant for emotional processes (Delgado et al., 2008). Since emotional processes are central in both the dark triad and the transformational leadership, the activity of the amygdala should be additionally considered in further studies.

A further limitation is of course the small sample size and the composition of the sample, as it mainly consists of students. However, the higher complexity of this study and similar sample sizes of other neuronal studies narrow this problem down slightly. Furthermore, it is not assumed that the external validity is extremely low, since the mean value of transformational leadership behavior is comparable to the values of the validation study (Rowold & Poethke, 2017). Additional studies should explore transformational leadership in more detail so that the sub-dimensions are examined.

This study extends the research of organizational behavior by providing new insights into the neurological perspective of the dark triad traits and transformational leadership. The deductive procedure and the testing of a mediational framework on a neurological basis were carried out in this form for the first time.

3.5.2 Practical Implications

The above results lead to some practical implications. First, caution is required when individuals with highly rated dark personality traits are in leadership positions. Followers and colleagues may not initially recognize them as malicious because they misuse elements of transformational leadership for their strategy, e.g. psychopaths with their charismatic appearance

and convincing presentation style (Babiak et al., 2010). Ideally, organizations should be careful not to hire leaders with dark personalities (e.g. narcissists, machiavellians, psychopaths), as it may be not be possible to fundamentally change their personality. Second, the resting state, which is the intrinsic capacity of an individual, appears to be a potential metric for predicting transformational leadership behavior. Referring to brain plasticity (Bavelier et al., 2010), which allows neurological patterns to be modified, Waldman et al. (2011) considered neurofeedback as a tool for altering intrinsic brain networks to develop effective leaders. However, this method is better established in the field of meditation or sports, where electroencephalography is commonly used to record the electrical activity of the brain to improve performance (Brandmeyer & Delorme, 2013; Mirifar, Beckmann, & Ehrlenspiel, 2017). Since neuroscience research in the context of organizational behavior is still in its infancy, the use of this method in practice should be treated with caution. Therefore, it is suggested, that neuronal measurement should initially be used as an additional tool to the already established transformational leadership development programs, which is usually based on psychometric 360° feedback (Abrell, Rowold, Weibler, & Moenninghoff, 2011). The intrinsic brain capacity of participants could be measured at regular intervals during leadership training to determine whether their right frontal coherence has improved.

3.5.3 Conclusion

This study contributes to the transformational leadership literature by broadening the understanding of the dark triad and transformational leadership processes of leaders from a neurological perspective. The intrinsic capacity of leaders seems to be considered as a mechanism between personality traits and transformational leadership.

4. Study 2 - Neurological Insights into Transformational Leadership: A Mediational Framework

4.1 Introduction

Previous studies were able to predict transformational leadership behavior, to some extent, through psychological constructs such as personality traits or intelligence (Bono & Judge, 2004; Judge et al., 2004). However, there have already been calls for more interdisciplinary research in organizational behavior to better understand individual differences and leadership qualities, e.g. linking biological sciences or neurosciences with leadership constructs (Antonakis, 2011; Antonakis et al., 2012). In fact, biological and genetic processes in leadership research have gained increasing interest in recent years (Diebig et al., 2016; Li et al., 2012), so that the first steps towards a broader perspective and a better understanding of the complex phenomenon of transformational leadership have already been taken. In order to pursue this appeal further and to advance interdisciplinary research fields, this study deals with neurological processes of transformational leadership. So far, only one study has examined this relationship, using an explorative approach, and showing that neuronal differences exist between transformational and non-transformational leader (Balthazard et al., 2012).

However, criticism has been expressed in leadership literature that transformational leadership is measured as an overall construct, although the individual facets are different and cannot therefore simply be summarized as one construct. Moreover, the lack of research on mediating processes at a more detailed level was also pointed out (van Knippenberg & Sitkin, 2013), meaning that there is not enough knowledge about the underlying processes of different transformational leadership patterns. This problem is also addressed in the neurosciences, since transformational leadership as an overall construct seems too complex to draw conclusions about

brain connections. Therefore, the field of neuroscience should be used to identify single key processes underlying the complex construct (Jack et al., 2017).

Therefore, in this study I have conducted a more detailed analysis of the transformational leadership style, separated into group-focused and individual-focused behaviors, so that the underlying sub-dimensions are taken into account (Kark & Shamir, 2013). In addition, I have further divided these sub-dimensions into more detailed behavioral components to establish a relationship to neurological patterns. Based on the leader trait emergence effectiveness model (Judge et al., 2009), which assumes relationships between the traits, behaviors, and effectiveness of leaders, a mediation framework is developed that considers neurological aspects of leadership as antecedents of transformational leadership and indirectly relates them to subjective leadership effectiveness. Although there are many studies dealing with positive outcome criteria (G. Wang et al., 2011), so far this has not yet been investigated in the context of neuroscience.

Overall, this study makes three main contributions to existing leadership research. First, a bridge is built between neurological and psychological constructs that allows a broader view of transformational leadership. In this study, the measurement of brain processes by electroencephalography represents an innovative method in the leadership context. Based on emotional contagion theory and social identity theory (Hatfield et al., 1993; Hogg, 2001), explicit hypotheses are derived. This complements the previous research on neuroleadership, which deals with ethical leadership and abusive supervision (Balthazard et al., 2012; Waldman et al., 2011a; Waldman et al., 2018; Waldman, Wang et al., 2017). Second, the previous leader trait emergence effectiveness model (Judge et al., 2009) is extended by including a neurological perspective of leadership behavior. Third, a detailed consideration of the transformational

leadership is made by examining the sub-dimensions, so that a better understanding of mediating pathways of leaders' behavior is enabled.

4.2 Theory and Hypotheses

Transformation leadership is a concept of leadership that aims to increase the motivation of followers by raising awareness of common interests in order to achieve the organization's outstanding goals (Antonakis et al., 2003). It is the best researched leadership phenomenon to date and is considered the most successful form of leadership, as many studies have found positive consequences that influence both internal and external factors within the organization, such as follower motivation, commitment and job satisfaction, leader effectiveness or organizational performance (Judge & Piccolo, 2004; G. Wang et al., 2011). According to Podsakoff et al. (1990), there are six sub-dimensions that describe the behavior of transformational leadership that all aim to transform values and appeal to high performance and effort: individualized consideration, intellectual stimulation, high performance expectation, providing an appropriate role model, fostering the acceptance of group goals and articulating a vision.

4.2.1 Neurological Antecedents of Transformational Leadership

Previous research has focused mainly on different categories related to antecedents of transformational leadership behavior. In addition to demographic characteristics such as gender (Eagly et al., 2003), certain personality traits (Bono & Judge, 2004), individual differences such as intelligence (Judge et al., 2004), and moods and emotions of leaders (Ashkanasy, Härtel, & Zerbe, 2000; Gooty, Connelly, Griffith, & Gupta, 2010) were identified as relevant for the emergence of transformational leadership. Awareness of the need to establish a link between biological processes of the human body and leadership behavior has increased in recent years.

For example, unique genetic factors have been shown to predict transformational leadership behavior to some extent (Li et al., 2012). So far, however, few studies have focused on the neuroscience of leadership, especially with regard to transformational leadership. Therefore, this study emphasizes how neurologically processes are related to the sub-dimensions of transformational leadership and further to the success criterion, satisfaction with the leader.

In view of the interdisciplinary research of physiological psychology, which is defined as the relationship between brain and behavior and various underlying cognitive processes (Fosnot & Perry, 1996), the following hypotheses are developed, mentioning that human behavior is explained by cognitive processes. For the measurement of brain waves, electroencephalography (EEG) is used, in which neurological processes are recorded by electrical signals from different parts of the brain. Since transformational leadership occurs during an interaction between a leader and one or more followers, it makes sense to focus on the reflexive view of brain function (Raichle, 2010), which reflects brain functionality during cognitive performance. Although there have been some contradictory results about the spatial location of executive functions in the brain, as researchers have found several areas involved in these processes, many studies have shown that cognitive functions such as planning, control of complex behaviors, emotional processing in decision-making, and social competence are specifically associated with the frontal area of the brain (Alvarez & Emory, 2006). As these executive functions mentioned above are also embedded in leadership behavior (Lord et al., 1986), this study focuses exclusively on the frontal area of the brain. According to Cacioppo et al. (2003), complex behaviors such as transformational leadership cannot be assigned to one specific position in the brain, but require connections in the brain (Lindquist et al., 2012). Therefore, considerations refer to the measure

of coherence that represents the functional connectivity of different areas of the brain (Thatcher et al., 1986).

The sub-dimensions of transformational leadership can be assigned to two specific behavioral categories: group-focused leadership and individual-focused leadership (Kark & Shamir, 2013; Kunze et al., 2016; Wu et al., 2010). Accordingly, the behavioral components "vision" and "team spirit" relate to followers as a whole group, while the components "innovation" and "performance orientation" refer to a dual relationship in which each follower is treated as an individual. Since both categories are subject to different psychological processes and the approach of hemispheric asymmetry (Hellige, 1990) assumes that the left and right brain hemispheres are proportionally differently involved in thought processes and behavioral processes, it seems obvious that the networking of the brain areas also differs with regard to group-focused and individual-focused sub-dimensions of transformational leadership. As research on neuroleadership is still very limited, the following hypotheses proceed in such a way that the sub-dimensions are broken down into specific cognitive functions that are fundamental to transformational leadership behaviors. For this purpose, studies are used that have already neurologically examined these cognitive functions.

Group-Focused Behavior and Frontal Lobe Coherence

Vision, also known as "identifying and articulating a vision" (Bass, 1985) is defined as building up an attractive, emotional and clear picture of the future for the whole unit or organization. In order to give every follower an orientation for his or her work and to clarify the sense and purpose of his or her work, the vision must be sufficiently abstract to contain the values and goals of all followers. Consequently, the leader must be able to decompose different components into a simple vision with which each follower can identify. A fundamental aspect for

the development of such a vision is the ability of abstract thinking, with a focus on the form of temporal abstraction, which means that abstract thoughts are associated with long term goals (Nee, Jahn, & Brown, 2014). The review by Dumontheil (2014) considered lesion studies as well as functional and structural neuroimaging studies to explain the development of abstract thinking that appears to be associated with the rostral prefrontal cortex. Other essential factors for the development of a vision are the ability to plan, think ahead and generate strategies that can be measured, for example, by the Wisconsin Card Sorting Test, a neuropsychological test for detecting executive function in individuals with frontal brain disease (Anderson, Damasio, Jones, & Tranel, 1991). Previous studies have shown that these executive functions are generally associated with the prefrontal cortex (Shallice & Cipolotti, 2018), but especially the right lateral frontal region appears to be relevant for planning processes (Burgess et al., 2000) and for strategy development and implementation (Robinson et al., 2015).

The second group-focused behavior *Team Spirit*, or fostering the acceptance of group goals, contributes to the creation of a collective identity with the aim of mutual support and cooperation within the team on the way to a common goal. The underlying process can be described with the theory of social identity of intergroup behavior, which reflects the affiliation of leaders and followers to a social unit (Hogg, 2001; Tajfel, 1978; Tajfel & Turner, 1979). Here, the leader is regarded as the most prototypical member who has the ability to influence followers to transform personal aspirations into common values and objectives, leading to increased identification with the collective. The leader must consider decisions that take into account the well-being of all followers without losing sight of the common goal. From a neurological perspective, the region of medial prefrontal cortex has been identified as increasingly active in group decision-making (Volz, Kessler, & von Cramon, 2009), and in group membership and

identification (Molenberghs & Morrison, 2014). In addition, previous lesion studies as well as studies based on functional magnetic resonance imaging (fMRI) have shown that the right frontal cortex in particular is associated with social behavior and cooperative processes (Decety et al., 2004; Tranel et al., 2002). These fundamental skills make it possible at all to promote group-related goals and to create a positive working atmosphere for followers.

Individual-Focused Behavior and Frontal Lobe Coherence

Innovation (Intellectual Stimulation; Bass, 1985) means that leaders encourage their followers to question established work procedures or methods and thus foster their creative thinking and ability to reflect and solve problems. At the same time, they point out that new suggestions and approaches are always welcome and tolerated without criticism. Following these behavioral components, leaders must have the ability to pay attention to their followers and listen to them actively so that they have the opportunity to make ideas and suggestions. Neurological studies have shown that this process of active listening primarily relates to the motor cortex, which is located in the dorsal part of the frontal lobe (Burton, Small, & Blumstein, 2000), more specifically in the left area (Watkins, Strafella, & Paus, 2003).

In addition, leaders need to empathize with each follower and know how to reach and address them to support their idea generation. This psychological mechanism can be explained by the theory of mind, which describes the ability to understand mental states of others, e.g. feelings, intentions and thoughts, for the purpose of predicting their behavior (Leslie, 1987). Research on neuroimaging has shown that there is a core network consisting of parts of the medial prefrontal cortex and the bilateral posterior temporo parietal junction representing the neurological processes of the theory of mind (Amodio & Frith, 2006; Schurz, Radua, Aichhorn, Richlan, & Perner, 2014). It should also be noted that the form of the task determines which part

of the network becomes more involved. The activation of the medial prefrontal cortex increases with tasks relating to the social values and personality traits of individuals over a longer period of time to specific events (Schurz et al., 2014), e.g. predicting the behavior of the respective counterpart (Gallagher, Jack, Roepstorff, & Frith, 2002), which could be similar to the sub-dimension innovation of transformational leadership, whereby the leader tries to understand what is going on in the followers' mind and reflects how he can intellectually stimulate him or her.

While they encourage their followers to explore new ways of working and develop alternative approaches, the positive attitude of the leader can be transferred to the follower through emotional contagion (Hatfield et al., 1993), leading to a positive and motivating state. The theory of emotional contagion means that individuals have a natural tendency to imitate other people's emotions, which can be applied to the leadership context in which the follower captures the leaders emotions (Bono & Ilies, 2006). It is assumed that in particular the prefrontal cortex is responsible for the perception, processing and regulation of emotions. Harmon-Jones, Gable, and Peterson (2010), for example, have summarized in their review that most studies based on the assumption of asymmetric frontal cortical activity in affect have found the experience of positive affect associated with the left frontal region of the brain, primarily in the dorsolateral prefrontal area. However, they also indicated in the context of the motivational direction model (Harmon-Jones, 2003) that it is more the approach motivation and behavior that is linked to the left frontal side regardless of valence (Harmon-Jones & Gable, 2018). The motivational approach refers to the impulse to work towards a positive goal or desired outcomes (Harmon-Jones, Harmon-Jones, & Price, 2013) which may be, for example, the overarching goal of the organization the leader is striving for.

Performance Orientation, also known as high performance expectation, means that the leader clearly defines what he or she expects from his or her followers in terms of their performance, which can be described as the highest quality and excellence of work. Furthermore, the leader shows a high degree of trust in each follower and his or her ability to accomplish the tasks set (Podsakoff, MacKenzie, & Bommer, 1996). In contrast to the group-focused behavior, where all members or followers are treated collectively (Kark & Shamir, 2013), it is important that the leader recognizes and encourages realistic personal best at the individual level of a follower. Neurologically, there are three specific brain areas associated with trust behavior: the basal ganglia, the limbic system, and the frontal cortex (Riedl & Javor, 2012). Particularly the medial frontal area is activated when deciding whether to trust someone or not (Riedl, Mohr, Kenning, Davis, & Heekeren, 2014). Since the leader has an optimistic view of the followers' goal attainment, it seems obvious that this feeling passes over to the follower, which can also be explained by the approach of emotional contagion (Hatfield et al., 1993). The activation of the left upper frontal region, part of the left prefrontal cortex, was associated with optimism (De Pascalis, Cozzuto, Caprara, & Alessandri, 2013).

Taking into account these group- (individual-) related abilities, which are assumed to be assigned to the frontal cortex, especially the right (left) side, it is hypothesized that the behavioral components of transformational leadership are also related to this brain area. More precisely, the connection, so-called coherence, within the right frontal cortex should show higher values in the expression of group-focused sub-dimensions and within the left frontal cortex in the expression of individual-focused sub-dimensions. Therefore the hypotheses to be tested are:

Hypothesis 1: Right frontal coherence is positively associated with the transformational leadership behavior (a) vision and (b) team spirit, and left frontal coherence is positively

associated with the transformational leadership behavior (c) innovation and (d) performance orientation.

4.2.2 Satisfaction with Leader as Attitudinal Outcome Criteria of Transformational Leadership

So far, transformational leadership is considered the most effective leadership behavior because it predicts many different positive consequences. These include in particular behavioral outcomes, e.g. follower, team and organizational task performance (G. Wang et al., 2011) and attitudinal outcomes, e.g. follower motivation and perceived leader effectiveness (Judge & Piccolo, 2004). Here, with regard to the direct interaction between leader and follower, the focus is on the subjective leader effectiveness, satisfaction with the leader. This construct is a main part of general job satisfaction, which is defined as a pleasant and positive state of the follower related to his or her own job evaluation (Locke, 1976). Both could be found as positive effects of transformational leadership behavior (Banks et al., 2016; Felfe & Schyns, 2004; Judge & Piccolo, 2004; Walumbwa, Lawler, Avolio, Wang, & Shi, 2005).

Although these studies referred to the whole construct of transformational leadership, researchers investigating the sub-dimensions of transformational leadership were able to report that individualized consideration, providing an appropriate role model and formulating a vision had the most positive effect on followers' overall satisfaction, while high performance expectation had a negative effect (Podsakoff et al., 1996). Furthermore, all four facets of Bass' (1985) theory were positively related to followers' satisfaction with supervision (Judge & Bono, 2000). In this study the focus is on the sub-dimensions vision, team spirit, innovation and performance orientation (Rowold & Poethke, 2017), in which the leader behaves either in group-focused or individual-focused interactions with the followers. The articulation of an attractive vision of the future offers each follower the opportunity to achieve a common goal that

represents the overarching target of the organization. By keeping the vision abstract, it becomes easier for the followers to identify with it and to see their own work as part of the whole. The team spirit of the leaders promotes mutual support and gives every follower the opportunity to use his or her own skills to the full, so that all team members complement each other. These two group-focused sub-dimensions ensure that individuals form a unit, are motivated and create a supportive team climate (Kark & Shamir, 2013; Kunze et al., 2016). With innovation, each follower receives individual attention and respect for new constructive concepts that are intended to strengthen his or her self-esteem and well-being with leadership. By setting ambitious goals and demanding high performance, but also trusting the follower that these goals can be achieved, it is obvious that the follower feels valued and satisfied. These two individual-focused sub-dimensions give each individual follower the feeling of being an important and indispensable part of the organization.

Since these mentioned components reflect leaders' behavior, which includes a combination of dual and group interactions that contribute to the personal satisfaction of the followers, it can be assumed that this satisfaction largely refers to the leader. Therefore the hypothesis to be tested is:

> *Hypothesis 2: Vision (a), team spirit (b), innovation (c) and performance orientation (d) will be positive related to followers' satisfaction with the leader.*

4.2.3 The Mediating Effect of Transformational Leadership on the Relationship of Frontal Lobe Coherence and Followers' Satisfaction with Leader

On a theoretical basis, the leader trait emergence effectiveness model of Judge et al. (2009) postulates that a leader can only be effective when previously emerging as a leader before. In other words, leaders must first be perceived as leaders, e.g. through their behavioral expression, before subjective or objective effectiveness can be attributed to them. Accordingly,

the previously formed hypotheses assume direct effects of transformational leadership behavior on satisfaction with the leader, which is a component of subjective leader effectiveness. Looking at the left portion of the leader trait emergence effectiveness model, there is a link between traits and leader emergence, whereby both constructs are considered from by psychometric assessment. To add a new methodological component to this model, neurological processes in the form of brain coherence are included.

Since it is not clearly proven whether the brain influences behavior or vice versa, a temporal sequence can only be assumed on the basis of the methodological approach. As having assumed in the previous sections, the coherence value of the reflexive brain is a predictor of transformational leadership behavior, since this behavior is not classified as reactive but as intentional, while the leader reflects his thoughts in terms of information processing and then acts consciously (Fosnot & Perry, 1996). Therefore, it can be seen as a temporal sequence that first the different brain areas connect and then leadership behavior occurs that is perceived by others. Because brain coherence is not directly perceptible to the followers, it would not make sense to expect a direct effect of brain functions on satisfaction with the leader, which is why it can be argued that satisfaction can only be assessed on the basis of perceived leadership behavior. Since there is no study to date that examines an indirect effect within the framework of "neuroleadership", mediation hypotheses are formed on the basis of the individual-focused and group-focused sub-dimensions of transformational leadership.

Frontal lobe coherence in the brain is thought to be proportionally differently involved in certain behaviors: more right frontal coherence in group-focused leadership behaviors and more left frontal coherence in individual-focused leadership behaviors and all these sub-dimensions pursue the same goal, namely the transformation of individual values into organizationally

relevant ones (Podsakoff et al., 1990), it is obvious that there is a more or less strong but positive relationship between these sub-dimensions and satisfaction with the leader. Therefore the hypothesis to be tested is:

> *Hypothesis 3: The relationship between the right frontal coherence and satisfaction with the leader is mediated by vision (a) and team spirit (b) and between the left frontal coherence and satisfaction with the leader by innovation (c) and performance orientation (d).*

4.3 Method

4.3.1 Sample and Procedure

An overall sample of 128 participants, consisting of 104 students and 24 employees, was recruited by research assistants to participate in this study. For this purpose, they sent an invitation and an overview of information on the EEG measurement by e-mail to contacts in their personal environment. It was ensured that only healthy volunteers with no mental illness or addiction to drugs or alcohol were included in the study. Participants were also asked to provide information on demographic variables. Individual appointments were made with the participants to perform the EEG measurement during a simulated role play. Regarding the simulated role play of this study, the student sample was randomly divided into 52 dyads, while the employee sample remained in its familiar relationship as leaders and followers and forming a total of 12 dyads. Both sub-samples are described in the following sections.

Within the student sample, 34% of the “leaders position” was male and the average age was 22.54 (*SD* = 1.85). 84% stated that they have a higher education and 15% a university degree. Most of them reported having work experience (78%) but only 13% worked on average for less than half a year (69%) or up to one year (30%) in a leadership position. A narrow

majority (61%) came from economics. Similarly, 44% of the “followers position” were male with an average age of 22.92 (*SD* = 2.23), of whom 78% reported a higher level of education and 19% a university degree. 80% of them had work experience.

66% of real leaders were male with an average age of 39.42 (*SD* = 15.08). 41% indicated they have level of education, 33% a university degree and 25% a secondary education level. Most of them worked full-time (75%), as freelancers (41%) or as salaried employees (33%). 17% of the real follower sample were male with an average age of 31.25 (*SD* = 12.20). Among these persons, high education attainment and university degree were equally represented (41%). The majority worked full-time (67%).

The data was collected in one day with time-lags between measurements of each construct. The role play with EEG measurement always took place in the morning in an ordinary office in order to achieve equal conditions. After the participants were invited into the office, they were first asked to sit at a table with two seats facing each other. The procedure was explained and a short introduction to the EEG measurement was given, including the determination of the circumference of the head for the correct cap size. In addition, they were informed that the measurement could be stopped at any time if they felt uncomfortable. Then they were instructed to prepare for a simulated role play for about 30 minutes without exchanging information in the meantime.

Both participants received a description of a scenario with some facts about a fictitious company that produces machines in the business-to-business context and information about the current situation and the newly introduced open-plan office. The role of the leader, who has been team leader in the complaints department for five years, was informed that he was initiator for the implementation of the new office with the aim of achieving better cooperation between the

entire team. He also got an overview of the follower's performance in the past year and two complaints from clients and colleagues. The role of the follower was given a description of his personal view of the new open-plan office and the resulting concentration and sleep problems. The scenarios did not indicate that the leader should show certain leadership behavior or put forward certain arguments. The subsequent conversation was supposed to last 10 to 15 minutes (M = 12.12, SD = 4.04) while the electrical activity of the brain was measured on a second-by-second basis. Completing the role play followers were asked to assess the perceived transformational leadership behavior as well as the satisfaction with the leader.

4.3.2 Neural-Based Measure

To measure the electrical activity of the brain, electroencephalography (EEG), an electrophysiological measure, was used with the equipment from the medical engineering company g.tec, which included ring electrodes, a biosignal amplifier (g.USBamp), and biosignal recording software (g.Recorder). Six electrodes (FP1, FP2, F3, F4, F7, F8), integrated in a cap, were placed on specific scalp positions of the frontal lobe specified by Jasper (1958) in a standardized international 10-20 system to compare results. In addition, an earlobe electrode served as a reference and a mid-forehead electrode (FPz) as a ground electrode used for common mode rejection. Before recording began, the impedance of the attached electrodes was measured with a special tool of g.USBamp to ensure that values did not exceed 10 Ω to obtain high quality data. Data collection began at the same time as the role play, in which participants were asked to minimize body movement, especially abrupt head movements, in order to reduce artifacts. The sampling rate was 256 Hz and a notch filter was set to suppress the 50 Hz power line frequency.

The subsequent data preparation was conducted offline with MATLAB (version 2016; MathWorks) and the toolbox EEGLAB (version 14; Delorme & Makeig, 2004). Automatic

channel rejection was implemented and a bandpass filter was set to obtain only frequencies up to 40 Hz, including beta frequencies which predominate in mental activities such as dialogue during simulated role-playing. Independent component analysis (ICA) was performed every 2 seconds over the entire data set to remove eye and muscle movement artifacts. Based on this proceeded data, the average connectivity for the left and right frontal lobe was calculated and averaged over 2 minutes segments. To reduce the amount of data, three randomly selected segments were used as EEG parameters for further data analysis to represent the recording over the entire conversation. The measure of connectivity, called coherence, is the degree of phase synchronicity which represents the connection of different spatial locations of the brain (Thatcher et al., 1986; Thatcher, North, & Biver, 2005). These coherence values were calculated for each pair of electrodes (e.g. Fp1 and F3) in the beta frequency range (14 to 30 Hz) and then aggregated to indices representing left and right frontal coherence.

4.3.3 Survey-Based Measures

Transformational leadership. The followers evaluated the perceived sub-dimensions of transformational leadership behavior using a validated German scale, the *Integrative Leadership Survey* (Rowold & Poethke, 2017), which consists of four items for each dimension: Innovation (e.g. “My supervisor shows new ways to interpret tasks and goals.”, Cronbach’s alpha of .58), performance orientation (e.g. “... explains, why best performance is required.”, Cronbach’s alpha of .74), team spirit (e.g. “... appeals to the team members’ sense of belonging.”, Cronbach’s alpha of .86) and vision (e.g. “... communicates his/her vision of long term opportunities, tasks and goals in an enthusiastic way.”, Cronbach’s alpha of .84). The rating scale ranged from 1 (“strongly disagree”) to 5 (“strongly agree”).

Satisfaction with leader. The perceived satisfaction with the leader was assessed by followers with two items of the *Multifactor Leadership Questionnaire* (MLQ; Bass & Avolio, 1997) in a German validated version (Rowold, 2005), including e.g. "My supervisor ensures satisfaction through his leadership behavior." The rating scale ranged from 1 ("strongly disagree") to 5 ("strongly agree") and the Cronbach's alpha was .78.

Control variables. Given that the gender of leaders may have an influence on transformational leadership (Eagly & Carli, 2003; Kark et al., 2012) and on EEG coherence (Koles, Lind, & Flor-Henry, 2010), it was considered as a control variable to minimize the bias of influence on perceived leadership behavior and on neurological coherence values. In addition, the age of the leaders and their leadership experience (0 = no, 1 = yes) might influence perceived leadership behavior and satisfaction with the leader. Therefore, these variables were also controlled.

4.4 Results

Table 5 contains mean values, standard deviations, intercorrelations and internal consistencies of the controls and study variables.

Results of the regression analysis which were conducted with SPSS 22.0 are reported in Table 6. The first model shows the results of hypothesis testing 1a to 1d, controlling for demographics. Significant effects of gender on performance orientation were found (ß = .16, $p < .05$), meaning that male leaders are supposed to have high performance expectations. In addition, leadership experience had a negative impact on innovation (ß = -.23, $p < .05$) and performance orientation (ß = -.27, $p < .01$).

Table 5. *Study 2: Means (M), Standard Deviations (SD), and Correlations*

Construct	*M*	*SD*	1	2	3	4	5	6	7	8	9	10
1. $Gender_{Leader}$[a]	0.41	0.49										
2. Age_{Leader}	25.66	9.11	.21**									
3. Leadership experience[b]	0.31	0.47	.16*	.53**								
4. Right frontal coherence	42.83	15.17	.10	-.18*	-.01							
5. Left frontal coherence	44.22	17.12	.09	-.15*	-.16*	.63**						
6. Vision	3.16	0.85	.08	.05	-.01	.08	.04	(.84)				
7. Team Spirit	3.53	0.91	.02	-.11	-.14	.24**	.04	.49**	(.86)			
8. Innovation	3.93	0.64	.05	.05	-.13	.14	.18*	.56**	.35**	(.58)		
9. Performance Development	3.75	0.78	.12	-.09	-.22**	.10	.21**	.52**	.35**	.54**	(.74)	
10. Satisfaction with Leader	3.86	0.82	-.17*	-.14	.02	.07	-.05	.42**	.42**	.50**	.20**	(.78)

Note. N=64. Internal consistencies (Cronbach's Alpha) are reported in the parantheses on the diagonal.

[a] Gender coded as 0 = female and 1 = male; [b]Leadership experience coded as 0 = no and 1 = yes.

** $p < .01$; * $p < .05$.

Hypothesis 1 stated that leaders' right frontal coherence is positively related to vision (1a) and team spirit (1b) and leaders' left frontal coherence is positively related to innovation (1c) and performance orientation (1d). There was a significant positive effect of right frontal coherence on team spirit (ß = .37, $p < .001$), but not on vision (ß = .13, *ns*). Furthermore, leaders' left frontal coherence had a positive effect on performance orientation (ß = .19, $p < .05$), but not on innovation (ß = .15, *ns*). Hypothesis 1b and 1d are supported, but 1a and 1c have to be rejected.

The second model refers to the results of hypothesis testing 2a to 2c. It was postulated that vision (2a), team spirit (2b), innovation (2c) and performance orientation (2d) are positively related to satisfaction with the leader. While controlling for demographics and coherence variables, vision (ß = .41, $p < .001$) team spirit (ß = .40, $p < .001$), innovation (ß = .58, $p < .001$) and performance orientation (ß = .23, $p < .01$) showed the assumed effects. Control variables had no influence on the satisfaction with the leader. Hypotheses 2a to 2d are confirmed.

For Hypotheses 3a-d, mediational analyses with PROCESS macro (Hayes, 2013) with 5,000 bootstrap resamples were performed to test indirect effects of right frontal coherence on satisfaction with the leader via vision (3a) and team spirit (3b) and indirect effects of left frontal coherence on satisfaction with the leader via innovation (3c) and performance orientation (3d). Leaders' gender, leaders' age, leadership experience and the coherence of the other hemisphere were included as controls in the regression analysis. The results show that the indirect effect of right frontal coherence on satisfaction with the leader is significant via team spirit ($ß_{ind.}$ = .15, 99% *CI* [.05, .29]) but not via vision ($ß_{ind.}$ = .05, 95% *CI* [-.02, .14]). The indirect effect of left frontal coherence on satisfaction with the leader is significant via performance orientation ($ß_{ind.}$ = .05, 95% *CI* [.01, .11]) but only marginally significant via innovation ($ß_{ind.}$ = .09, 90% *CI* [.00, .20]). Hypothesis 3b, and 3d are supported, 3c partially supported, but 3a has to be rejected.

Table 6. *Study 2: Results of Regression Analysis*

Model 1	Vision		Team Spirit		Innovation		Performance Orientation	
	Step 1	Step 2	Step 1	Step 2	Step 1	Step 2	Step 1	Step 2
	Beta		Beta		Beta		Beta	
Controls								
$Gender_{Leader}$ [a]	.08	.05	.08	.04	.04	-.01	.16*	.14
Age_{Leader}	.11	.14	-.03	.05	.17	.24*	.03	.06
Leadership experience[b]	-.08	-.10	-.14	-.20*	-.23*	-.23**	-.27**	-.24**
Study variables								
Right frontal coherence		.13		.37***		.12		-.03
Left frontal coherence		.00		-.18		.15		.19*
R^2	.02	.03	.03	.11	.04	.10	.08	.11
ΔR^2		.01		.08		.06		.03
Model 2	Satisfaction with Leader							
Controls								
$Gender_{Leader}$ [a]	-.14	-.16*	-.14	-.16*	-.14	-.14*	-.14	-.17*
Age_{Leader}	-.12	-.17*	-.12	-.13	-.12	-.25**	-.12	-.13
Leadership experience[b]	.09	.13	.09	.17	.09	.23**	.09	.15
Study variables								
Right frontal coherence	.14	.09	.14	-.01	.14	.07	.14	.14
Left frontal coherence	-.07	-.07	-.07	.01	-.07	-.16	-.07	-.11
Vision		.41***						
Team Spirit				.40***				
Innovation						.58***		
Performance Orientation								.23**
R^2	.05	.21	.05	.19	.05	.34	.05	.09
ΔR^2		.16		.14		.29		.04

Note. N=64. Standardized regression coefficients are reported.

[a] Gender coded as 0 = female and 1 = male; [b]Leadership experience coded as 0 = no and 1 = yes.

***$p < .001$; ** $p < .01$; * $p < .05$.

Supplemental Analyses

In order to obtain an overview of the overall frontal lobe coherence and not only on certain hemispheres, the coherence values were determined more precisely by looking at each electrode pair separately. Figure 3 shows the significant paths of supplementary mediation analysis based on these pairs. Regarding the four sub-dimensions of transformational leadership, there is a different pattern of coherence for each of them. For team spirit, an increased network of electrode pairs within the right frontal lobe and a connection from right to left frontal lobe (FP2-F3) could be shown. Although hypothesis 3a could not be confirmed for the entire right frontal lobe, there was a significant mediation of FP2-F8 on satisfaction with the leader via vision. Surprisingly, there were many connections within the entire frontal lobe for innovation and one specific connection (FP2-F3) for performance orientation, which also indicates an interconnection between the right and left frontal lobe. To check whether the mediation effect also applies to the other two internal success factors, extra effort and effectiveness, a further analysis was performed. The effects were confirmed for all three internal success factors.

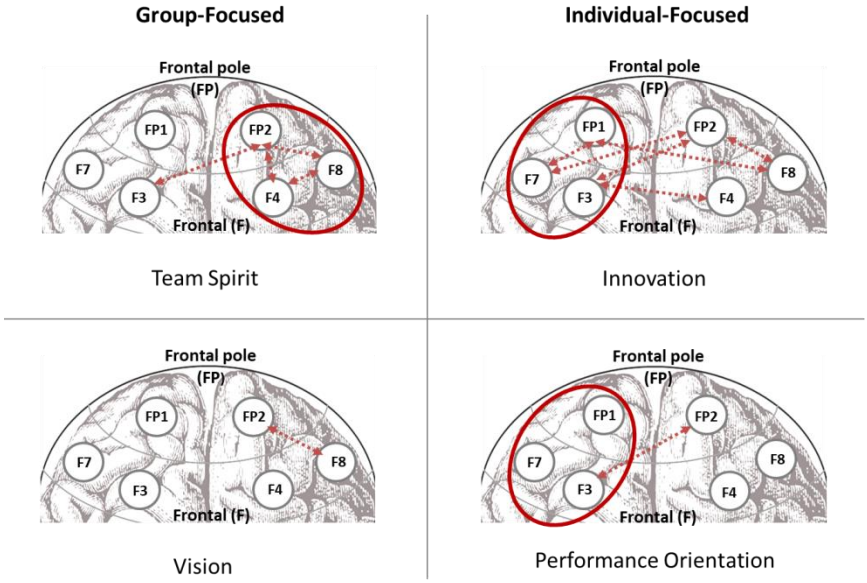

Figure 3. Supplemental Analyses, with Coherences based on Scalp Positions.

4.5 Discussion

The overall purpose of this study was to establish a mediation model with new insights into neurological antecedents of transformational leadership and their consequences for followers' satisfaction with the leader. Indeed, there seems to be a relationship between the entire frontal lobe and transformative leadership behavior, but there are also differences between the two hemispheres. The results show that coherence in the right frontal lobe promotes the group-focused behavior team spirit and coherence in the left frontal lobe enhances the individual-focused behavior innovation and performance orientation. No significant effect could be found on the sub-dimensions vision.

However, a study by Waldman et al. (2011) showed a positive influence of the right frontal brain network of leaders on socialized visionary communication, that is comparable to the sub-dimension vision of transformational leadership. With regard to the supplemental analysis of mediation hypotheses on pairs of electrodes, it could be shown that there is only a connection between pair of electrodes FP2-F8 and not the entire right frontal cortex. Thus, it is also possible that only this unique coherence path is related to vision. This specific neurological structure, FP2-F8, could be reflected in the specific cognitive components for the formulation of a vision, e.g. abstract thinking or planning. Regarding the left frontal coherence and innovation behavior, the bivariate correlation shows only small effects (J. Cohen, 1988) that do not seem robust enough, which is why the effect was marginal.

So far, there has only been one study on transformational leadership in neuroscience, but the focus has been on the overall construct. The result of Balthazard et al. (2012) was that there is a positive relationship between right frontal coherence and transformational leadership. However, this is not fully comparable with the underlying study, since the sub-dimensions of transformational leadership were examined here. Furthermore, they focused on resting state data

of the leaders' brain and applied an exploratory approach by performing a discriminant analysis. But the underlying study was based on explicit hypotheses and the brain of the leader was observed during cognitive activity.

As expected, all sub-dimensions seem to have a positive influence on satisfaction with the leader. It is noteworthy that the effect of performance orientation on satisfaction with the leader is the lowest, as followers may feel a little under pressure when the leader demands above-average performance.

With regard to the mediational framework, it could be shown that right frontal coherence fully mediates satisfaction with the leader via team spirit and left frontal coherence via innovation and performance orientation. Unfortunately, there was no influence on the sub-dimension vision, but if the additional analyses are taken into account, the coherence of FP2-F8 promotes the exercise of a vision.

4.5.1 Theoretical Implications

The current research extends the understanding of the psychological phenomenon transformational leadership by using neurological parameters as antecedents. As this form of leadership is considered to be the most effective (Bass, 1985; G. Wang et al., 2011), it is important to conduct interdisciplinary research (Antonakis et al., 2012) to gain more insights into the mechanisms of transformational leadership. Thus also a contribution to an extension of the leader trait emergence effectiveness model (Judge et al., 2009).

Although several areas of the brain are always interconnected and therefore no specific position responsible for a particular behavior can be identified (Lindquist et al., 2012), this study identified a pattern that shows that coherence in the right frontal area seems to promote group-related behavior of transformational leadership and coherence in the left frontal area seems to

promote individual behavior. Consequently, different networks in the brain seem to be responsible for whether the leader leads a whole group and thus has to interact with several followers or whether he has to deal with individual followers. In relation to the study by Balthazard et al. (2012), which showed that transformational leaders tend to have more right frontal coherence than non-transformational leaders, this research provides a more detailed view of transformational leadership by highlighting the sub-dimensions.

Furthermore, the positive influence of transformational leadership on satisfaction with the leader, as well as on the two other components extra effort and effectiveness, which had already been shown in earlier studies (Banks et al., 2016; Felfe & Schyns, 2004; Judge & Piccolo, 2004), could now also be confirmed at the sub-dimensional level. With regard to the mediation model, all variables were collected with a time lag, so that it is assumed that at first certain brain areas network, then leadership behavior is shown and perceived by the employee and finally this behavior has an influence on the employee so that he or she assesses the perceived satisfaction with the manager. In this way, it contributes to the current neuroscience research in leadership processes.

4.5.2 Practical Implications

Considering the results of this study, some managerial implications can be made. Since transformational leadership, no matter whether individual-focused or group-focused behavior, directly influences followers' satisfaction with the leader, it seems obvious to implement and promote this leadership behavior in organizations. Transformational leadership training, whose effectiveness has been confirmed, is recommended to raise leadership awareness and develop leadership qualities (Abrell et al., 2011) and should therefore be included as a part of leadership development.

Since coherence between different parts of the brain seems to influence transformational leadership and its effectiveness, the integration of a neuronal instrument into leadership development could be considered. Waldman et al. (2011) refer in their work, for example, to neurofeedback, a method used in combination with the intrinsic at-rest activity to provide feedback on brain capacity and possible predictions of leadership behavior. However, this study focused on reflexive brain activity, where neurological activity is measured on a second-by-second basis, so this feedback tool could be used within training during exercises in both individual and team context. A parallel EEG measurement with video recording could be performed during these exercises to obtain real-time feedback on the connected brain areas. Possibly, a potential development of brain coherence and thus transformational leadership behavior could be observed over a longer period of time.

4.5.3 Limitations and Future Directions

Some limitations of the study should be reflected here. What is immediately conspicuous is the relatively small sample size, which is common in neurological studies due to the high effort involved. Nonetheless, the sample consists mainly of students, but 12 leaders and followers from the real working environment could be recruited for this study. Although the scenario used for the role play is similar to real organizational problems, this research should be further investigated in real interactions. Furthermore, different methods and sources were used for this study, on the one hand the unique methodology to measure the brain of leaders by the electroencephalograph and on the other hand the evaluation of the leadership behavior and internal success criteria from the perspective of the follower, which in turn enhances the study as possible bias effects were tried to limit (Podsakoff et al., 2003).

Second, due to the high complexity of the neurological methodology, the assessment of leadership behavior was only performed once after the role play from the perspective of the follower. However, the scale does not allow any statement to be made about the frequency of the various leadership behavior patterns. This study could be extended by the evaluation of the video with time sequences, since the neurological measurement has a very good temporal resolution and thus more detailed insights can be gained.

Third, there are many advantages of the neurological measurement by the electroencephalograph. Using such a measurement, high temporal resolution can be achieved, so that millisecond accurate data can be acquired. In addition, this method enables the participants to simulate an almost real situation so that an interaction can actually take place in which two participants sit comfortably opposite to each other. However, this method can only measure the surface of the brain and the processes directly below it, so that no insights into deeper brain structures are possible. Since the entire brain is connected at all times by different synapses, future research should try to include the deeper areas, e.g. amygdala that is responsible for emotional processing (Delgado et al., 2008), so that more information can be gained and better insights are possible.

With regard to the sub-dimension innovation, however, the results should be treated with caution, as the internal consistency of .58 is a poor value. Future studies should also consider the two sub-dimensions individuality focus and role model function to complete the study. It should also be mentioned that causal relationships cannot be assumed, as it is uncertain whether leadership behavior is determined by neuronal activity or vice versa.

4.5.4 Conclusion

Overall, this study contributes to previous research on leadership by broadening the understanding of the sub-dimensions of transformational leadership and subjective leader effectiveness from a neurological perspective. Different reflexive brain networks seem to have an indirect influence on subjective leader effectiveness, depending on the category of leadership behavior. Further approaches for future research could be offered, as this field of research is still in its infancy.

5. Overall Discussion

The overarching goal of this dissertation, which is based on two empirical studies, was to investigate the neurological perspective in the context of leadership by examining leaders' interconnection of brain areas as antecedent of transformational leadership behavior and as a link to leaders' personality under the consideration of mediating mechanisms. An extension of the leader trait emergence effectiveness model (Judge et al., 2009) by neuronal processes was aimed at. In short, the most important findings of this dissertation are the following:

First, a high intrinsic right frontal coherence was found to predict transformational leadership. Second, a link between the dark triad and transformational leadership via intrinsic frontal coherence was mostly revealed. Third, I partially confirmed the theoretical reflection of individual-focused and group-focused leadership behaviors on the reflexive frontal coherence, whereby the mediating process between leadership and subjective effectiveness was mostly shown by all sub-dimensions.

Study one revealed that transformational leadership is promoted by leaders' high intrinsic right frontal coherence. Further, narcissism was associated with low intrinsic right frontal coherence, while psychopaths showed low intrinsic left frontal coherence. The only significant negative direct effect of the dark triad on transformational leadership was that of machiavellianism. Surprisingly, psychopaths were highly rated in transformational leadership. Furthermore, an indirect negative effect of the dark triad on transformational leadership was found via right frontal coherence for narcissism and via left frontal coherence for psychopathy. Study two identified significant effects of leaders' reflexive right frontal coherence on the group-focused behavior team spirit and of leaders' left frontal coherence on the individual-focused behavior performance orientation. All sub-dimensions of transformational leadership had a

positive influence on the satisfaction with the leader. In addition, indirect effects of reflexive frontal coherence on satisfaction with the leader were found for right frontal coherence via the group-focused behavior team spirit and for left frontal coherence via the individual-focused behaviors performance orientation and innovation. However, the indirect effect of left frontal coherence on satisfaction with the leader via innovation could only be confirmed at the 90 percent confidence level. Moreover, supplementary analysis showed a significant indirect effect of a certain link in the right frontal brain (FP2-F8) on satisfaction with the leader via vision.

5.1 Summary of Contributions and Findings

The main contribution to the field of leadership lies in expanding the innovative approach of organizational neuroscience by considering leaders traits, leadership behavior and subjective leader effectiveness. In this context, a new perspective is implemented in the existing model of Judge et al. (2009), which refers to the component of neurological processes measured both at rest and in the reflexive state of the leader. More precisely, three contributions can be made by this dissertation. First, the research on antecedents of transformational leadership is extended, since I have not only conducted a psychometric but also a neurometric assessment of leaders traits (dark triad). Thus, a neurological basis for transformational leadership could be fathomed. The results are in line with the previous research on brain processes of transformational leadership (Balthazard et al., 2012) and extend it by a hypothesis-based approach. Furthermore, regression coefficients are reported in this study and not just correlations, as was often the case in previous studies. Second, bearing in mind the criticism of van Knippenberg and Sitkin (2013), transformational leadership was considered on a twofold perspective, namely the individual-focused and the group-focused (Kark & Shamir, 2013; Kunze et al., 2016). The sub-dimensions were analyzed according to the outcome criterion subjective leader effectiveness and related to

reflexive brain processes in order to gain insights into whether the theoretical division reflects the networking of different brain areas. Thus, the dissertation not only enriches the research on transformational leadership by finding positive relationships of all sub-dimensions on followers' satisfaction with the leader, but it also offers an extension of the previous research in organizational neuroscience, which has already analyzed reflexive brain processes in relation to visionary communication (Waldman et al., 2011a), by indicating a hemispheric difference in coherence due to the grouping of transformational leadership behaviors. Third, the analysis of mediation processes contributes to a more comprehensive understanding of the functioning of transformational leadership by distinguishing between neurological processes in the form of intrinsic and reflexive brain coherence.

From a methodological point of view, my two empirical studies used different approaches to reducing methodological bias (Podsakoff et al., 2003). First, predictor, mediator and criterion variables were measured from different sources, e.g. self-assessment of personality by leaders, neurometric measure of brain coherences, or assessment of leadership and subjective leader effectiveness by follower perception, and by different methods, e.g. survey-based and measurement of brain waves. Second, the measurement of independent and dependent variables was time-lagged. Third, validated questionnaires from established scales were used. For the short-dark triad (Jones & Paulhus, 2014), which is currently only available in English, a translation using the back-translation method (Brislin, 1970), was prepared.

In the following sections the findings of my two empirical studies will be linked to the initially research questions.

Study one was conducted to examine the first research question (*RQ1: Is the interconnection of certain brain areas, in the form of intrinsic brain coherence, related to the*

occurrence of transformational leadership?). The results showed that the higher the intrinsic right frontal coherence of the leader, the more likely he or she is to lead transformational. The intrinsic right frontal coherence seems to have a positive influence on the occurrence of transformational leadership, as this part of the brain appears to be responsible for some competences relevant to transformational leadership, leading to the assumption of the same underlying neurological mechanisms. Given that transformational leadership is seen as an emotional leadership style (Yammarino & Dubinsky, 1994), it is necessary that the leader has emotional core competencies, which seem to be located in the right frontal part of the brain (Gainotti, 2018). Furthermore, this area of the brain is associated with other capabilities, such as social behavior and cooperative processes (Decety et al., 2004; Tranel et al., 2002), planning and strategy development (Burgess et al., 2000; Robinson et al., 2015) as well as problem solving (Tomasino & Fabbro, 2016), which are relevant to transformational leadership behavior, e.g. for the development of a vision, promotion of followers, or intellectual stimulation of followers. Thus, intrinsic right frontal coherence can be seen as a potential neurological basis for this leadership style. In line with the previous findings of Balthazard et al. (2012), transformational leadership can be identified through neurological variables. With regard to the leader trait emergence effectiveness theory (Judge et al., 2009), insights can be gained about new predictors for the emergence of leadership.

Study one also aimed to examine the second research question (*RQ2: Does intrinsic brain coherence relate to leaders personality and can it mediate the link of personality to transformational leadership?*), focusing on the dark triad personality, which, although there is empirical evidence of overlap are conceptualized independently (Paulhus & Williams, 2002). Accordingly, I wanted to find out whether these differences in traits are also reflected on a

neuronal basis in the intrinsic capacity of the brain, and whether there is a process of mediating personality to transformational leadership through this neuronal capacity. The results demonstrate that personality is indeed related to intrinsic capacity in the form of coherence, except machiavellianism. In particular, narcissists appear to have less intrinsic coherence in the right frontal region and psychopaths less intrinsic coherence in the left frontal region. These findings correspond to previous research that identified links between neuronal processes of the frontal brain and the dark triad of personality, with hemispheric differences observed in narcissism and psychopathy, in particular lower right-sided activity in narcissists and lower left-sided activity in psychopaths (Fan, Duncan et al., 2011; Fan, Wonneberger et al., 2011). However, the results on machiavellianism, as reported by some researchers, were not quite clearly hemisphere-related and concerned left-, right- or bilateral frontal lobe deficits in brain activity (Bagozzi et al., 2013; Fan, Duncan et al., 2011). While these studies are based on empathy and theory of mind tasks, the current brain activity was measured, which does not necessarily correspond to intrinsic activity. Further research is needed to determine whether there are specific intrinsic coherences within the left or right frontal brain that do not spread across the entire area.

These results are reflected in the analysed mediation mechanisms, as no significant results on machiavellianism were found here either. Nevertheless, there was an indirect negative path from narcissism via the intrinsic right frontal coherence to transformational leadership and from psychopathy via the intrinsic left frontal coherence. Consequently, the process between personality and leadership can mostly be explained by the leaders' intrinsic brain capacity. This means that narcissistic leaders show less transformational leadership because of their low

intrinsic right frontal coherence, while psychopathic leaders show less transformational leadership because of their low intrinsic left frontal coherence.

Taking into account van Knippenberg's and Sitkin's (2013) critique of the measurement of transformational leadership as an overall construct, I examined it in more detail in the second study by focusing on individual-focused sub-dimensions and group-focused sub-dimensions (Kark & Shamir, 2013) to answer the third research question (*RQ3: Is the theoretical difference of transformational leadership (individual-focused vs. group-focused sub-dimensions) reflected in the interconnection of certain brain areas, in the form of reflexive brain coherence?*). In terms of the results, the theoretical differentiation of transformational leadership can mostly be reflected in the neurological networking of brain areas, which means that individual-focused behavior appears to be primarily located in the left frontal lobe and group-focused behavior in the right frontal lobe. In particular, vision seems to require a certain connection of two points in the right frontal brain and not in the whole area. Earlier research on the reflexive brain was concerned only with visionary communication, which was also assigned to the right frontal area (Waldman et al., 2011a). The results are important because, to the best of my knowledge, there is no study that has attributed these differences in transformational leadership to antecedents or neuronal mechanisms. Hence, it can be assumed that there are differences not only in outcomes in terms of the dual perspective, as has been shown in previous studies (Kunze et al., 2016; Wu et al., 2010), but also in neuronal mechanisms, which helps to improve the understanding of the phenomenon of transformational leadership. More precisely, transformational leadership is subject to different psychological processes, especially in terms of whether the group as a whole or each follower is addressed and managed as an individual. These psychological processes, in turn can, be traced back to different neuronal mechanisms. With regard to group-focused

behavior patterns, these are group decisions, group identities and cooperative processes as well as the planning and generation of strategies, for example in the development of a vision, which are increasingly linked to the right frontal cortex (Burgess et al., 2000; Decety et al., 2004; Molenberghs & Morrison, 2014; Volz et al., 2009). With regard to individual-focused behavior patterns such as active listening, empathy with others, understanding and confidence-building, a link to the left frontal area is assumed (Gallagher et al., 2002; Riedl et al., 2014; Schurz et al., 2014; Watkins et al., 2003). Further research should also consider the sub-dimensions role modelling and focus on individuality in order to examine whether the neurological pattern is reflected there.

Finally, the second study also serves to answer the fourth research question relating to a mediating mechanism of neuronal processes, leadership and subjective leadership effectiveness (*RQ4: How does individual-focused vs. group-focused transformational leadership behavior mediate the relationship between reflexive brain coherence and satisfaction with the leader?*). Again, a tendency can be observed based on the results that group-focused behaviors mediate the process between right frontal coherence and satisfaction with the leader and individual-focused behaviors mediate the process between left frontal coherence and satisfaction with the leader. It seems as if there is a temporal sequence so that first brain regions are connected, then the transformational leadership behavior - depending on the grouping - is perceived by the follower and finally this is decisive for his or her perception of the satisfaction with the leader. Again, it should be noted that vision is based on one specific connection of two positions in the right frontal cortex and not the entire brain. Supplemental analyses which were carried out in more detail with regard to the single positions of the left and right frontal area showed that innovation is also associated with connections across hemispheres as well as team spirit to a certain point.

Therefore, future studies should further analyze these processes in more detail in relation to the sub-dimensions of transformational leadership.

5.2 Limitations and Future Research

This subchapter refers to the main limitations of the two empirical studies of this dissertation, taking into account methodological and content-related aspects. Implications for future research are presented to overcome these limitations.

The first methodological limitation concerns the design of the studies with regard to the relatively small sample size, the sample composition and the application of a simulated appraisal interview in the context of a role play that does not resemble typical leadership research. Although small sample sizes are problematic because of their low power (Button et al., 2013), it should be noted that this small sample size is common in context of neurological studies due to the higher effort involved (Waldman et al., 2018; Waldman, Wang, Stikic, Berka, Balthazard et al., 2013). The sample composition, which mainly consists of students, as well as the simulated role play in the studies, which contained a typical organizational problem, poses the limitation of external validity, thus results cannot be transferred directly to the organizational context. Therefore, future studies should replicate the results with a larger sample size and in an organizational context, for example by performing a neurological measurement on leaders before and during a staff meeting.

Second, electroencephalography as a common non-invasive method used in organizational neuroscience, offers advantages due to its high temporal resolution and the possibility of its use in realistic interactions. However, it only measures the neural activity of the cerebral cortex by recording voltage fluctuations on the surface of the scalp. Therefore, it cannot provide insights into the deeper brain structures, which leads to a low spatial resolution. Since

transformational leadership is an emotional leadership style and the amygdala, a part of the limbic system in the brain, is the main component in emotion processing (Delgado et al., 2008), these functions cannot be measured directly with electroencephalography. Furthermore, despite data correction, measurement may still be impaired by artifacts caused by eye blinks or muscular activity because it is very sensitive to other electrical sources (Jack et al., 2017). For example, imaging techniques could be used to support and extent the results.

Third, although both studies represent a timely separate measurement no causal conclusions can be drawn on the direction between predictor and outcome variables. It is quite possible that there are vice versa influences of the measured variables. For example, I have postulated in my research model that intrinsic and reflexive brain processes are predictors of transformational leadership behavior. But it is also possible that leadership behavior causes brain processes because the brain is constantly active, before, during and after cognitive activities and thus brain processes are constantly changing (Healey & Hodgkinson, 2014). Waldman et al. (2016), for example, stated a causal sequencing model of brain activity in relation to behavior, assuming that behavior causes brain activity in the form of reflexive brain assessment, often used in experimental settings, and that individual differences in intrinsic brain activity can influence individual behavior. Since research in organizational neuroscience is still in its infancy, further investigation of intrinsic and reflexive brain activity in relation to leaders' personality and leadership behaviors is needed to replicate findings and gain more insights into causal sequencing as well as a more precise positioning of neurological constructs in the leader trait emergence effectiveness model. Harms et al. (2011) also mentioned that there is little known so far about how leaders' personality influences changes in leadership effectiveness over time, which should also be considered in future research.

To address these issues, for example, a longitudinal design could be used to explore the temporal stability of intrinsic brain coherence by recording leaders' intrinsic capacity at several measurement times and testing the relationship to leaders' personality, leadership style and leaders' effectiveness. A temporal analysis of leaders' behavior and effectiveness is also necessary, since "dark" leaders may initially be perceived incorrectly positively by followers (Babiak et al., 2010; Ong et al., 2016). Furthermore, with regard to the reflexive brain, a video-based assessment of transformational leadership behavior could be made on the basis of an employee interview or meeting that is exactly timed with the measured brain coherence. For this purpose, the frequency of the emerged leadership behavior should also be observed in order to obtain several measurement points.

The first content-related limitation refers to the consideration of transformational leadership at a more detailed level, which was only applied in the second empirical study of this dissertation. Mediation analyses showed that there are differences between the leadership behavior with regard to the coherence of brain areas. Future studies should therefore also examine the sub-dimensional level of transformational leadership in relation to the intrinsic brain capacity and the dark triad traits. It needs to be investigated whether there are differences in the neuronal basis for different leadership behaviors and whether the dark triad traits can have positive effects on certain sub-dimensions of transformational leadership in addition to the negative effects. Since the first study explored a positive relationship between psychopathy and transformational leadership, it would be important to identify which dimensions are positively influenced by this personality trait.

Second, this dissertation examined only the phenomenon of transformational leadership as an effective leadership construct. Rowold's and Poethke's (2017) integrative model of

leadership, however, propose a framework that combines a broad spectrum of success-relevant behaviors, including not only transformational leadership, but also transactional and instrumental leadership as well as the negative side of leadership. Since the different leadership behavior patterns are based on different psychological processes, a differentiation in the connection of brain areas is also necessary here. As neurological research on leadership is very scarce, these leadership styles should also be investigated in the future. In addition, further outcome criteria should also be considered, as only the subjective leader effectiveness was examined in the second study. With regard to the natural aspects of a leader, other neurological and biological markers, such as electrical activity of the heart, skin conductance and muscle activity, should be included in leadership research to better understand the leadership phenomenon, as Antonakis (2011) already pointed out.

Third, since leadership is defined as a process based on the interaction between leader and follower (Antonakis & Day, 2018a), it leads to the assumption that both parts can have an impact on different aspects of this leadership process. For instance, similarities between leader and follower, e.g. in relation to their personality, have been identified as important prerequisites for the perception of transformational leadership (Felfe & Schyns, 2009; Shamir, House, & Arthur, 1993). It is conceivable that being “on the same wavelength” may lead to an increased perception of the transformational leadership by the follower. It would be interesting to find out whether these similarities can also be found on the neuronal level. Therefore, in addition to the brain activity of the leader, the brain activity of the follower should also be measured. Waldman, Wang, Stikic, Berka, and Korszen (2013) proposed to associate emotional contagion (Hatfield et al., 1993), the imitation of another individuals’ emotions, with mirror neurons, which means that the transfer of emotions can be reflected in the neurological pattern of both individuals. While

transformational leadership is an emotional leadership style, some elementary behaviors, such as vision, can be traced back to this theory. It would be interesting to investigate what happens in the brain of followers during transformation leadership, i.e. what the 'neuronal' perception of the transformational leadership is, and whether the activity or connection of the leaders' and followers' brain is synchronized (Waldman, Wang, Stikic, Berka, & Korszen, 2013). Therefore, the research model of this dissertation should be extended by followers' personality and followers' neurological processes. Figure 4 shows the above-mentioned possible implications for future research as an extension of the research model of my dissertation.

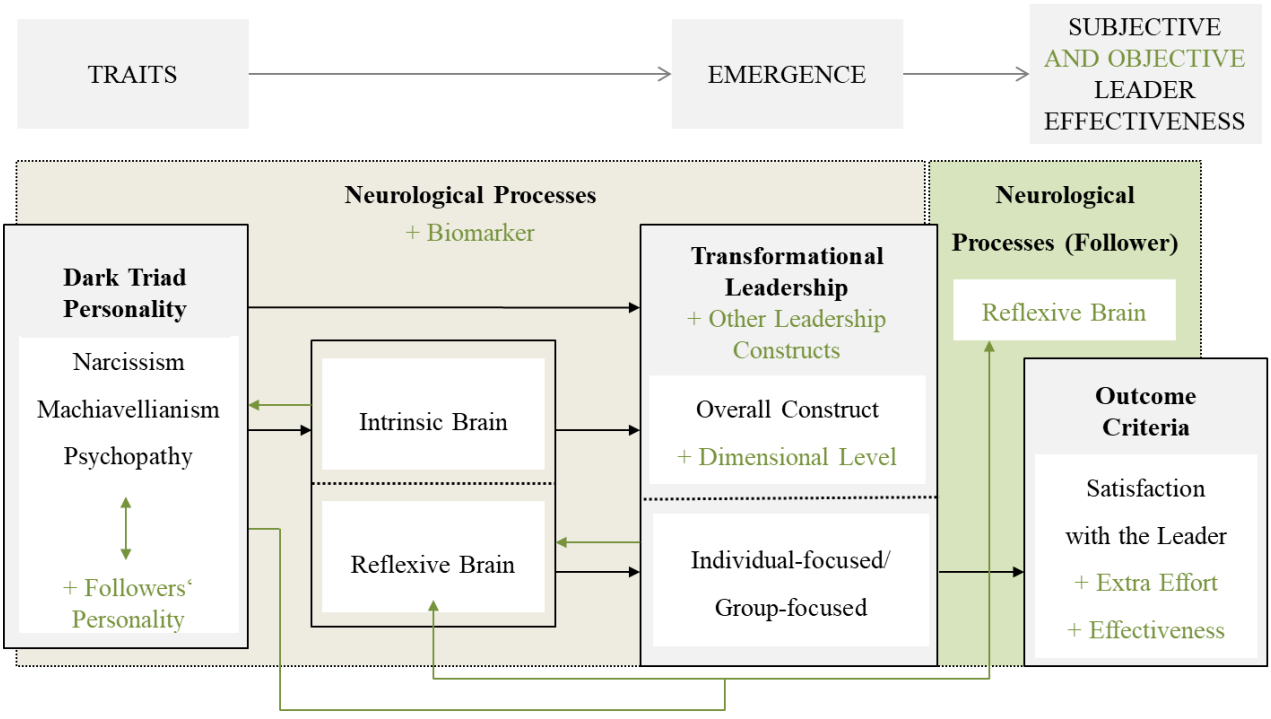

Figure 4. Extended Research Model for Future Research.

5.3 Practical Implications

Based on the results of my two empirical studies, some practical implications for the selection and development of leaders can be derived. Firstly, when selecting future leaders,

organizations should use scientific tests to measure the extent to which a candidate bears a risk potential due to the characteristics of the dark triad. Although psychopathy was positively related to transformational leadership in the first study, this can be explained by the fact that psychopaths do not appear as such at first glance due to their charismatic nature and good presentation techniques (Babiak et al., 2010). Even narcissists can attract attention at first glance through their self-confident appearance and charismatic qualities, as Brunell et al.'s (2008) study reports. This is dangerous because these qualities are essential for leadership positions and therefore human resource professionals often choose these candidates wrongly, leading to management derailment, which means the failure of supposed high potentials (Kanning, 2014). In the long term, leaders with negative personalities cause damage to the organization (Grijalva et al., 2015; O'Boyle et al., 2012). In addition to the assessment of personality traits that could be measured with the Hogan Development Survey (Hogan & Hogan, 2009) because derailment factors are also measured in addition to the dark triad, other methods should be used, such as simulations in the form of role plays or case studies, as questionnaires always bear the risk of bias due to social desirability (Podsakoff et al., 2003).

In order to identify effective leaders, reference has so far been made to high ratings of the personality traits extraversion and conscientiousness, as these are positively associated to transformational leadership (Bono & Judge, 2004; Judge & Bono, 2000). With respect to the positive relationship between high intrinsic right frontal brain coherence and transformational leadership shown in Study 1, there appears to be a neuronal basis for transformational leadership, meaning that a particular neurological capacity favors leadership behavior. It is conceivable that in the future neurological measures will be used as an additional method in personnel selection when the research field has become better established and ethical components (Lindebaum, Al-

Amoudi, & Brown, 2018)are taken into account. At present, however, such statements cannot be made due to the insufficient state of research.

With regard to leader development, it will be difficult to change already hired managers with high levels in the dark triad, as personality traits are stable and persistent. Furthermore, the longitudinal study by Harms et al. 2011 showed that the dark triad has a negative relationship with changes in leadership behavior, making it difficult to develop leaders with dark personalities in terms of their leadership competencies. Since the effectiveness of transformational leadership was also confirmed in this dissertation on the sub-dimensional level with regard to subjective leadership effectiveness, this leadership style should be promoted in organizations with the support of leadership development programs. In particular, training in high-quality management techniques has proved to be effective and also improves transformational leadership behavior (Abrell et al., 2011; Barling, Weber, & Kelloway, 1996). As part of leader development, a 360-degree feedback is usually used as a preliminary step, whereby the leadership behavior is evaluated by various relevant groups from the work environment in order to identify strengths and potential for improvement. This has been shown to improve leadership qualities (Kelloway, Barling, & Helleur, 2000; Smither, London, & Reilley, 2005). Waldman et al. (2011, 2013) suggest that neuronal measurements, related to intrinsic brain capacity, could be used to track leadership development and thus act as an additional tool in the traditional leadership development programs. This so-called neurofeedback refers to the concept of neuroplasticity (Bavalier et al., 2010), that assumes modifiability of brain structures over time. For example, the intrinsic coherence of the leader could be measured over time to check whether an improvement was achieved in the right frontal area. Further validation of the neuronal basis for

transformational leadership and ethical considerations (Lindebaum et al., 2018) are necessary to apply this technique in practice.

5.4 Conclusion

In summary, my dissertation represents an important step towards a better understanding of neurological antecedents and the underlying processes of transformational leadership. In particular, the idea of integrating new research disciplines into leadership research was broadened. The results show that there seems to be a neurological basis in the form of a strong intrinsic connection in the right frontal brain area that favors transformational leadership, and that the relationship between the dark triad of personality and transformational leadership is mediated through specific neurological networks. Furthermore, the duality of transformational leadership can be reflected in the reflexive form of neurological networks, which also reveal mediating processes on the subjective effectiveness of the leader. Taken together, my dissertation expands the new research field of the neurological perspective in leadership research and offers new starting points for future research.

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