Master thesis

The influence of arousal during transactional and transformational leadership on leader effectiveness: Exploratory organizational neuroscience research into the use of skin conductance in leadership research

Jasper J.A. Versteegh, BSc

s1006762

Master of Science Business Administration

Track: Service & Change Management

University of Twente

Faculty of Behavioral, Management and Social Sciences

Department Change Management & Organizational Behavior

Examination Committee:

A.M.G.M. Hoogeboom, MSc

Prof. Dr. C.P.M. Wilderom

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THE INFLUENCE OF AROUSAL DURING TRANSACTIONAL AND TRANSFORMATIONAL LEADERSHIP ON LEADER EFFECTIVENESS: EXPLORATORY ORGANIZATIONAL NEUROSCIENCE RESEARCH INTO THE USE OF SKIN CONDUCTANCE IN LEADERSHIP RESEARCH

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NOTE

In this paper, “leader”, “he”, “his” and “him” are used only in masculine form for ease of writing and reading. However, they refer to all feminine leaders as well.

INTRODUCTION

The world is getting more and more digital at a fast pace. At the moment, we are not only more connected digitally, we also use technical aids to gather data ourselves. We do so by Quantified Self-tracking tools, such as the Samsung Gear (2013), that has an accelerometer and gyro sensor, or the Apple Watch (2015), that includes a heart rate sensor, accelerometer and GPS, to monitor personal health, physical activity, energy expenditure, and sleep patterns (Swan, 2009; Lupton, 2013). This Quantified Self-tracking is defined as the regular collection of any data about the self, such as biological, physical, behavioral or environmental information, which are mostly health and fitness related (Swan, 2009; Smarr, 2012; Picard & Wolf, 2015). The Quantified Self focusses on gaining more knowledge about yourself in terms of the four pillars of health: nutrition, exercise, sleep, and stress management (Smarr, 2012; Quantified Self, 2012).

Thus, there is a rising awareness for the ambulatory collection of physiological data. Recent technological advances have opened up our understanding of the human brain (Becker & Cropanzano, 2010). Scholars now explore whether this 'organizational cognitive neuroscience' approach can provide a deeper understanding of organizational processes (Butler & Senior, 2007). In the Leadership Quarterly 25th Anniversary Issue, Dinh, Lord, Gardner, Meuser, Liden, and Hu (2014) identify established and emerging theories from 10 important journals over the period 2000-2012 and noted a number of emerging approaches that are difficult to classify, but which deserve special recognition because of their increasing popularity, which included 'biological approaches' to leadership. They state that only 11 papers on neuroscience in leadership can be found, leading to the description "trend in its infancy", but emphasize that cognitive neuroscience to the study of leadership can bring a new line of information (Dinh et al., 2014). Organizational neuroscience is still in the exploratory phase, but has been important in its short existence (Butler, O'Broin, Lee, & Senior, 2015).

Hence, neuroscientific research of leadership is sparse (Waldman, Balthazard, & Peterson, 2011a), but several organizational science fields have already embraced neuroscience in other organizational sciences such as decision making, economics, marketing, emotions, intuition and justice (Becker, Cropanzano, & Sanfey, 2011; Lee, Senior, & Butler, 2011; Butler et al., 2015). Scholars emphasized that neuroscience can offer major insight into current organizational theory (Lee et al., 2011; Lee, Senior, & Butler, 2012; Butler et al., 2015), but is often omitted because of unfamiliarity with these methods (Scherbaum & Meade, 2013). However, it can shed new light on existing organizational issues and highlight problems that might not have been considered otherwise (Becker et al., 2011).

One of the available ambulatory physiological methods within the organizational neuroscience is skin conductance, which has been used to index general states of arousal (Dawson, Schell, & Filion, 2007). Arousal can be seen as activation, attention and stimulus intensity because it is a relatively direct and undiluted representation of sympathetic and autonomic activity (Dawson et al., 2007, p. 167, 168, 176; d'Hondt, Lassonde, Collignon, Dubarry, Robert, Rigoulot, Honoré, Leopore, & Sequeira, 2010) and emotional processing (Potter & Bolls, 2012; p. 110; 114). Stimuli could both be unpleasant and pleasant, leading to the same level of arousal regardless of their valence (D'Hondt et al., 2010). This specific type of neuroscientific measurement method is chosen, because of the unobtrusiveness of the measurement to maintain the real-life situation during field research. The ambulatory skin conductance method has been developed since 2009, showing that technological advances in physiological data collection have made physiological measures more widely available to organizational researchers (Akinola, 2010). Leadership assessment partially based upon neurological variables may provide an addition to the arsenal of tools used to assess leadership, but it inherently adds a new and complex dimension to theory development (Balthazard, Waldman, Thatcher, & Hannah, 2012).

With this research, another dimension is added to the paradigm of transactional and transformational leadership. When examining this full-range model of leadership, most studies rely on quantitative survey measures only (Antonakis, Avolio, & Sivasubramaniam, 2003; Hunter, Bedell-Avers, & Mumford, 2007). However, these measures do not correspond with actual leader behavior (Hoogeboom & Wilderom, 2015b) but only with the biased perceptions of followers of their leaders (Gupta, Wilderom, & van Hilligersberg, 2006). Quantitative survey measures can also lead to common source bias, which can be diminished if different sources of information are used (Hater & Bass, 1988). Using a mixed-methods design, evolving beyond only using surveys, would increase the validity of leadership studies. This can be valuable for the leadership literature by not only increasing validity, but also by incorporating new variables into the analysis, such as the arousal of the leader. This study will build upon previously conducted studies that included video coded behavior (see van der Weide, 2007; Gupta et al., 2009; Hoogeboom & Wilderom, 2015a, 2015b; also see Kauffeld & Lehmann-Willenbrock 2012; Lehmann-Willenbrock, Meinecke, Rowold, & Kauffeld, 2015). But, it goes one step further, by combining the observed leader behavior with his simultaneous arousal during transactional and transformational behavior. As arousal is measured objectively, we overcome the measurement of biased perceptions. In this paper, results of the combination of skin conductance data with video-observed transactional and transformational leadership are presented.

The goal of this study is twofold. First, it contributes to the literature by introducing organizational neuroscience methods to the field of leadership behavior research. This is conducted by developing a research method that combines arousal at a specific point in time with simultaneously observed behaviors, which has not been performed before. Thus, there is an explicit and apparent methodological goal. Second, it exploratorily investigates the explained variance of arousal during transactional and transformational behavior on leader effectiveness, by using this new research method. The effects of arousal during transactional and transformational leader behavior on leadership performance are tested.

THEORY AND PROPOSITIONS

Organizational cognitive neuroscience

Organizational cognitive neuroscience is defined as applying neuroscientific methods to analyze and understand human behavior within the applied setting of organizations, which may be at the individual, group, organizational, and inter-organizational levels (Butler & Senior, 2007). It can be seen as a deliberate and rational approach to bring neuroscience and organizational science together (Becker & Cropanzano, 2010; Senior, Lee, & Butler, 2011). Organizational cognitive neuroscience is the study of processes within the brain that underlie or influence human decisions, behaviors, and interactions, within or around organizations (Lee & Chamberlain, 2007). Explorations of the brain and behavior tend to emphasize the role of nonconscious processing, while most current theories of organizational behavior focus on conscious choices (Becker et al., 2011). Including these implicit measures to directly observable processes improves the available information about leader behavior (Becker & Menges, 2013).

Though there are ample opportunities for the organizational cognitive neuroscience field, there is also criticism on the approach (Spector, 2014). According to these scholars, several aspects about using neuroscientific methods should be recognized. First, one should use proper sample sizes to have statistically sound conclusions (Ashkanasy, Becker, & Waldman, 2014; Lindebaum & Jordan, 2014). Second, a detailed description of the method should be added to allow replication of the study (Lindebaum & Jordan, 2014). Third, there should be an adequate answer to the 'so what?' question for the results to be applied (Ashkanasy et al., 2014; Lindebaum & Jordan, 2014; Butler et al., 2015). Not only technological and methodological challenges have to be addressed, it should also be applicable and have a scientific and practical merit (Ashkanasy et al., 2014). Fourth, both the neural and behavioral aspects should be included for a complete overview, instead of only focusing on brain systems in isolation (Butler et al., 2015; Ashkanasy et al., 2014) because one cannot understand an organizational phenomenon by looking at brain activity solely without taking into account the organizational context (Butler et al., 2015).

To use neuroscientific methods to its full potential, a wider theoretical understanding of both the neuroscientific and organizational literature is needed to reach a fundamental theoretical foundation (Butler et al., 2015). A key challenge is to make theoretical connections to overcome searches for relationships between vaguely conceived neurological variables and survey measures on the other (Waldman, Balthazard, & Peterson, 2011b). This could be realized by first looking at leadership variables or behaviors, and then explore the neural basis for those elements (Arvey, Wang, Song, & Li, 2013). A connection between brain activity and leader behavior would first need to decompose the leader behavior into relevant categories, and then attempt to map that behavior to particular brain activity (Waldman et al, 2011a). Organizational cognitive neuroscience is therefore concerned not only with the application of neuroscience methodologies to organizational research questions, but to multidisciplinarily combine theories and methods of both research streams (Butler et al., 2015).

The assessment based upon neurological variables can provide a good addition to survey assessment (Waldman et al., 2011a) and may help providing a better understanding of why leaders behave in the manner in which they are observed (Balthazard et al., 2012). Using organizational situations as a context moves neuroscience closer to how human beings operate in more true-to-life situations (Butler et al., 2015). This way, neuroscience can provide insight into the background of organizational behavior. It should not replace, but augment behavioral research (Huettel & Payne, 2009). Hence, when observed behaviors of leaders are augmented with neuroscientific measures, this enhances our understanding of the effectiveness of these behaviors.

Skin conductance

A specific technique within the neuroscience literature is skin conductance measurement (Senior et al., 2011), which is a specific way of measuring electrodermal activity. The term electrodermal activity was first defined by Johnson and Lubin (1966), as “a common term for all electrical phenomena in skin, including all active and passive electrical properties which can be traced back to the skin and its appendages”. Various types of electrodermal activity measurement are available (see figure 1).

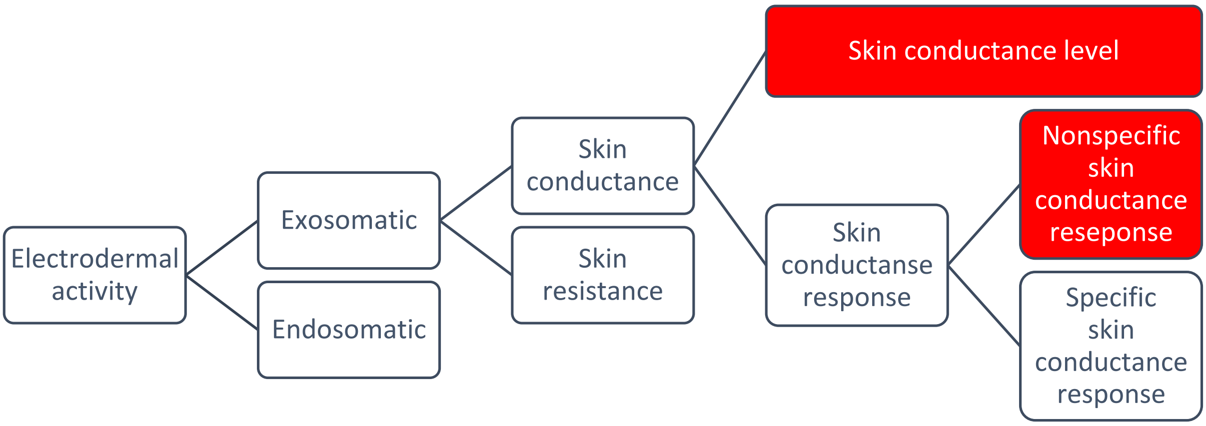


Figure 1: Different types of electrodermal activity measurement and measures

The first distinction of measurements is made between the application of an external electric signal (‘current’ or ‘amperage’) from the device. There are methods where there is no electric signal applied to the skin, called endosomatic, as opposed to methods where there is, called exosomatic (Boucsein, 2012, p. 2; Dawson et al., p. 159). Exosomatic measures are easier to analyze, less affected by electrode artefacts, and are studied more often (Boucsein, 2012, p. 246). It is the by far most frequently used, most chosen method among contemporary researchers and recommended method for obtaining electrodermal measures (Venables & Christie, 1980, p. 7; Dawson et al., 2007, p. 159; Boucsein, 2012, p. 103, 121, 125).

Within the exosomatic research method, a distinction is made between methods based on the voltage (i.e., the electric strength) of the electric signal that is applied. In a skin resistance method, voltage is not kept constant but depends on resistance of the skin (Boucsein, 2012, p.2). In a skin conductance measurement, voltage is kept constant and the conductance of the skin is measured (Dawson et al., 2007; Boucsein, 2012, p.2). Skin conductance measurement devices are widely available, more commonly used, and have a good temporal resolution (Boucsein, 2012).

The skin conductance measurement method distinguishes between two different types of measures. There is a skin conductance level and a skin conductance response (Boucsein, 2012, p. 2), which are presented in table 1. Skin conductance level can be seen as the tidal drifts of skin conductance, where the skin conductance response refers to the small waves on top of these tidal drifts (Lykken & Venables, 1971; Dawson et al., 2007, p. 164).

SKIN CONDUCTANCE LEVEL	**SKIN CONDUCTANCE RESPONSE**
• "SCL", "Tonic"	• "SCR", "Phasic"
• Slow, long duration changes in the level of skin conductance (Cacioppio & Petty, 1983; Boucsein, 2012, p. 140)	• Fast, short duration responses in the level of skin conductance (Cacioppio & Petty, 1983)
• Tidal drifts of skin conductance (Lykken & Venables, 1971; Dawson et al., 2007, p. 164)	• Small waves on top the tidal drifts of the skin conductance level (Lykken & Venables, 1971; Dawson et al., 2007, p. 164)
• Average skin conductance over a time period (Westerink, Ouwerkerk, de Vries, & de Waele, 2009)	• Momentary increase in the skin conductance after the exposure of a certain stimulus (Potter & Balls, 2012, p. 121)

Table 1: Characterizations of the skin conductance level and skin conductance response measures

Within the skin conductance response category, literature distinguishes between two types of measures: specific responses and nonspecific responses (Boucsein, 2007, p. 2). A specific response is likely to come after the “presentation of a novel, unexpected, significant, or aversive stimulus”, where the research design is influencing the presentation of those stimuli (Dawson et al., 2007, p. 164; Venables & Christie, 1980, p. 9; Potter & Bolls, 2012; p. 111; 121). All other skin conductance responses that occur without identifiable, external stimulus are called nonspecific, which is the case if daily-life situations are analyzed (Dawson et al., 2007, p. 164; Venables & Christie, 1980, p. 9; Potter & Bolls, 2012; p. 111; 121). As no specific stimuli are presented in this study, nonspecific skin conductance responses are used and when skin conductance response is denoted, nonspecific responses are referred to.

Both the nonspecific skin conductance response frequencies in a certain time interval and the skin conductance level can be used as tonic measures (i.e. the long duration changes in skin conductance), but they are not simply interchangeable (Venables & Christie, 1980; Boucsein, 2012, p. 220). Usually, in the same situation a high skin conductance level and frequent skin conductance responses will occur, but the correlations are usually not very high because they may represent partially independent sources (Boucsein, 2012, p. 174; Dawson et al., 2007, p. 166). One type of continuous stimulus situation that will reliably produce increases in skin conductance involves the necessity of performing a task, which will increase both the skin conductance level and skin conductance responses (Dawson et al., 2007, p. 171). Both tonic measures are used in this study.

Arousal

Measurement of skin conductance has been used to index general states of arousal, activation, attention, anxiety, and stimulus intensity, because it is a relatively direct representation of sympathetic activity (Dawson et al., 2007, p. 167, 168, 176; Akinola, 2010; Boucsein et al., 2012). Skin conductance reflects broad arousal within the brain and has been successfully used to measure important unconscious processes such as stress, affective arousal and cognitive processing (Becker & Menges, 2013). It can also be used as a measure of emotional processing or emotional arousal, which is the level of activation within the emotional and motivational systems (Akinola, 2010; Potter & Bolls, 2012; p. 110; 114). Skin conductance is a sensitive measure of emotional and empathic responsiveness and social-emotional processing (Marci, Ham, Moran, & Orr, 2007). High skin conductance levels are an indication of increased inner conflict, where the opposite suggest the presence of habit or bias (Becker & Menges, 2013). Arousal is therefore proposed to be higher when one is actively involved in a meeting. Skin conductance can be used as reflection of responsiveness to individual stimuli (Dawson et al., 2007, p. 173) to give insight in mental processing of emotional content (Potter & Bolls, 2012, p. 123). This implies that during active behaviors, when one is talking or explicitly involved, the leader is expected to be more aroused then when one is passively listening. Hence, the following is proposed:

Proposition 1: A leader is more aroused during active behaviors, then he is during listening.

One cannot say that arousal is directly related to work engagement, which is defined as a positive, fulfilling work-related state of mind that is characterized by vigor, dedication, and absorption (Schaufeli, Bakker, & Salinova, 2006), as the arousal linked to leadership behavior at a specific point in time cannot be readily connected to a state of mind in general. Neither can arousal be matched with job satisfaction, job involvement or organizational commitment (Meyer, Stanley, Herscovitch, & Topolnytsky, 2002). All these concepts are broader, more general and defined over a longer term time period.

The full-range model of leadership

The full-range model of leadership comprises the transformational and transactional leadership style, and has been given much attention in leadership research. Burns (1978) identified these two distinct types of leadership styles. Bass (1985) viewed them as complementary constructs and developed the Multifactor Leadership Questionnaire (MLQ). The MLQ is a well-known questionnaire to examine the full-range model of leadership (Bass, 1985; Lowe, Galen Kroeck, & Sivasubramaniam, 1996; Avolio & Bass, 2004; Hoogeboom & Wilderom, 2015a).

Transformational and transactional leadership has never been examined using a neurophysiological lens before the research of Balthazard et al. (2012). They asked themselves the question: “Is there a neurological pattern associated with transformational leadership?” and their proposition is that the answer may be *yes*. They demonstrated that transformational leaders can be distinguished from non-transformational leaders on the basis of EEG output (i.e. measuring electrical activity of the brain along the scalp). A dominance of the frontal part of the brain, where planning, foresight, emotion handling, and adding meaning to verbal communication are located, is found to be associated with transformational leadership (Balthazard et al., 2012). No other studies are found on the full-range model of leadership in organizational cognitive neuroscience. This research is the first that combines the full-range model of leadership with the arousal of the leader, no previous research has been found on the combination of arousal and leadership as presented in this study.

As complementary constructs, most leaders show both transactional and transformational leadership behavior, but in different amounts and intensities (Lowe et al., 1996; Bass, 1985, p. 22, 26). When a leader is both transactional and transformational, he is seen as the most effective, which is known as the augmentation effect. This effect means that transformational leadership augments, amplifies or extents transactional leadership, or transformational leadership is even viewed as a special case of transactional leadership, meaning one cannot look at them distinctively (Bass, 1985; Hater & Bass, 1988; Avolio & Bass, 1995; Lowe et al., 1996; Bass et al., 2003; Judge & Piccolo, 2004; van der Weide & Wilderom, 2006; Gupta et al., 2009; Hoogeboom & Wilderom, 2015a).

TRANSACTIONAL	TRANSFORMATIONAL	
Contingent reward: Actively and positively transacting, exchanging and bargaining rewards, returns, recognition and penalties with followers for meeting expectations, necessary effort, goals, contracts and accomplishments.	*Charismatic leadership:* Instilling pride, faith, respect and trust by providing and transmitting an articulated and ethical sense of mission and vision to increase excitement, inspiration and identification Often mentioned as or with:	*Inspirational motivation:* Communicating and expressing high expectations enthusiastically, with symbols, and in simple ways by acting as role model to appeal, inspire, energize and challenge followers to high standards.
Active management by exception: Closely monitoring and controlling task progress, execution, processes and performance, and intervening or pro-actively correcting when exchanges, rules or standard procedures are in danger.	*Attributed idealized influence:* Being admired, respected, trusted and perceived as confident, powerful and focused on higher-order ideals and ethics by having socialized charisma.	*Individualized consideration:* Sincerely and authentically noticing, supporting, respecting and attending personal, unique needs, goals and skills to enhance individual potential, development and experiences.
	Behavioral idealized influence: Focusing on and centering values, beliefs, and a sense of missions through charismatic acts that cause identification with the leader.	*Intellectual stimulation:* Intellectually challenging and cooperating to use analytical, reasoning and problem-solving skills, use intelligence, and question prevailing ideas, procedures, problems and assumptions.

Table 2: Characterization of transactional, transformational and laissez-faire leadership (Hater & Bass, 1988; Bass, 1990; Howell & Avolio, 1993; Bycio, Hackett, & Allen, 1995; Lowe et al., 1996; Den Hartog, Van Muijen, & Koopman, 1997; Avolio, Bass, & Jung, 1999; Antonakis et al., 2003; Bass, Avolio, Jung, & Berson, 2003; Judge & Piccolo, 2004; van der Weide & Wilderom, 2006; Gupta et al., 2009; O'Shea et al., 2009; Michel et al., 2010; Hoogeboom & Wilderom, 2015a; 2015b)

As described in the augmentation thesis, the basis of the full-range model of leadership is transactional leadership. The transactional leadership style can be characterized as reactive and down-to-earth, and can be seen as a transaction between leaders and followers of something of value, such as rewards for performance, mutual support or bilateral disclosure, where followers are motivated by reward and punishment (Bass, 1985; Bass, 1990; Howell & Avolio, 1993; Bycio et al., 1995; Lowe et al., 1996; Den Hartog et al., 1997; van der Weide & Wilderom, 2006; Gupta et al., 2009; Hoogeboom & Wilderom, 2015b). Transactional leadership is postulated to result in followers achieving the negotiated level of performance (Howell & Avolio, 1993; Den Hartog et al, 1997). The dimensions of transactional leadership, and accompanying references, can be found in table 2. Contingent reward is defined as a negotiation between followers and leaders, which is expected to lead to anxiety and a higher intensity of emotions, and thus a higher arousal. Active management by exception is defined as monitoring and intervening, and thereby expected to be leading to attention on the task progress and eliciting emotions when one is pro-actively correcting. Therefore, it is proposed that transactional leadership behavior is more effective when the leader is more aroused. The influence is tested this on leader effectiveness, extra effort, and satisfaction with leader (Avolio & Bass, 2004).

Proposition 2a: A leader who is more aroused during transactional behavior is more effective.

Proposition 2b: A leader who is more aroused during transactional behavior provokes extra effort of followers.

Proposition 2c: A leader who is more aroused during transactional behavior is more satisficing.

Transactional leadership is augmented by transformational leadership. The transformational leadership style can be characterized as pro-active, and can be seen as emotionally inspiring and influencing followers to work for and extend extra effort in collective organizational or team-relevant goals and interests and move beyond their own self-interests, where both parties raise one another to a higher level of motivation, awareness and morality (Bass, 1990; Bycio et al., 1995; Lowe et al., 1996; Den Hartog et al., 1997; van der Weide & Wilderom, 2006; Gupta et al., 2009; Hoogeboom & Wilderom, 2015b). Thus, the transformational style is more effective when the leader is emotionally and actively involved, so when he is more aroused. Transformational leadership is seen as going beyond the negotiated level of performance of transactional leadership, which was emphasized by Bass (1985)'s title: leadership and performance beyond expectations (Den Hartog et al., 1997; Wang, Oh, Courtright, & Colbert, 2011). Many studies have shown that transformational leadership leads to better results (e.g. Lowe et al., 1996; Judge & Piccolo, 2004, van der Weide, 2007; Wang et al., 2011). It is typically operationalized in several dimensions which can be found, with the accompanying references, in table 2. Idealized influence is defined as charismatic attributes and behaviors on an emotional level, and excitement and inspiration resemble arousal. Inspirational motivation comprises energizing and inspiring followers, which is closely linked to arousal as well, as is enthusiasm. Individualized consideration is defined on a very personal and authentic level and is thus closely linked to emotional processing and attentiveness. In general, transactional leadership is defined with e.g. emotionally inspiration, motivation and awareness. Therefore, it is proposed that transformational leadership is more effective when the leader is more aroused. The influence is tested this on leader effectiveness, extra effort, and satisfaction with leader (Avolio & Bass, 2004).

Proposition 3a: A leader who is more aroused during transformational behavior is more effective.

Proposition 3b: A leader who is more aroused during transformational behavior provokes extra effort of followers.

Proposition 3c: A leader who is more aroused during transformational behavior is more satisficing.

As complementary constructs, transformational and transactional leadership do not represent opposite ends of a single continuum but are seen as theoretically separate concepts (Judge & Piccolo, 2004; O'Shea et al., 2009; Michel et al., 2010). Leaders who are solely transformational perform quite effectively, but including transactional behaviors is even more effective as augmentation implies that there should be something to amplify (O'Shea et al., 2009). Because of the augmentation effect, it is expected that arousal during transformational leadership has a bigger influence on leadership performance than the arousal during transactional leadership. By emotionally and actively appealing to followers, which implies a higher arousal (Akinola, 2010), leader performance is increased (Lowe et al., 1996) and followers are expected to go beyond expectations (Den Hartog et al., 1997). The influence is tested this on leader effectiveness, extra effort, and satisfaction with leader (Avolio & Bass, 2004).

Proposition 4a: A leader's arousal during transformational behavior is more important for leader effectiveness, then a leader's arousal during transactional behavior.

Proposition 4b: A leader's arousal during transformational behavior is more important for extra effort of followers, then a leader's arousal during transactional behavior.

Proposition 4c: A leader's arousal during transformational behavior is more important for leader satisfaction, then a leader's arousal during transactional behavior.

METHODS

Design of the study

This study has a cross-sectional design, with three different data sources: (1) a questionnaire for both the leaders and their followers, containing the relevant items of the MLQ-5X-Short, assessing perceptual measures of transformational and transactional leadership, and leadership effectiveness, extra effort of followers, and satisfaction with the leader; (2) reliably and systematic video-based coded behavior of leaders during staff meetings; and (3) skin conductance wristband measurement of arousal during those staff meetings. Both the video-observation literature and the organizational neuroscience (e.g. Scherbaum & Meade, 2013) note that current management research rely heavily on self- and other-reported rating scales to the exclusion of other methods. This is overcome by this multimodal research design, which moves away from self-report biases (Akinola, 2010).

Sampling, data collection, and research setting

Data was gathered from 46 randomly selected permanent work teams in a big Dutch governmental organization. For each work team, a regular team meeting was analyzed. During this meeting, videotaping took place of the leader and followers to be able to analyze behaviors, skin conductance was recorded to measure the arousal of the leader, and both leaders and followers were asked to fill out a questionnaire directly after the meeting to get insight in the MLQ items. Of course, all data was treated anonymous and confidential.

From these 46 meetings, 3 were excluded because of technical problems in video recording, so that no behavioral data were available. 10 were excluded because no wristband was worn, so there were no skin conductance data available. 4 were excluded because the wristband was not turned on in sight of the camera, so no coupling between skin conductance and behaviors was possible. 2 were excluded because the recording of skin conductance failed and no valid data were recorded.

Although these 19 exclusions appear to be high, it is important to notice that the method of recording is new and experimental for this research setting. Furthermore, the exclusions are random and do not appear more in the beginning or end of the data gathering. The random sample thus consisted of 27 leaders and their teams. The sample included 18 men (67%) and 9 women (33%), who were on average 48.0 years of age (SD = 7.5; [31, 60]).

Video observation method

During the meetings, the leader and his followers are videotaped based on procedures as seen in previous research using this video observation method (e.g. van der Weide, 2007; Gupta et al. 2009; Hoogeboom & Wilderom, 2015a, 2015b). Before each meeting, three cameras were placed at fixed positions in the meeting room where staff meetings normally take place to preserve the normal and real-life situation. One of these cameras was aimed only at the leader, the other two cameras recorded the behavior of the followers. These cameras became quickly forgotten by the leader and followers. This was emphasized by the score on two questions, both on a 7-point Likert scale ranging from totally different to not different at all: “To what extent was this meeting different to non-recorded meetings?” (M = 5.39; SD=0.68) of which the results indicated that the randomly selected and videotaped meetings are highly representative, and “To what extent was the behavior of your leader during this meeting different to non-recorded meetings?” (M = 5.86; SD=0.39) of which the results indicated even stronger that behaviors of the leader were not affected by the sampling or recording. This indifference towards the camera was also emphasized in previous research (Hoogeboom & Wilderom, 2015a, 2015b). To systematically analyze leader behavior, a detailed behavioral coding scheme was used. This behavioral coding scheme is part of a detailed behavioral observation manual, designed and developed in previous studies (e.g. Van der Weide, 2007; Gupta et al., 2009; Hoogeboom & Wilderom 2015a, 2015b). The 19-page coding manual includes 20 mutually exclusive behaviors, as shown in appendix A. With this precisely defined coding scheme, a team of two coders minutely coded the leader’s and followers’ behavior (i.e., for every sentence, word, moment), taking both verbal and non-verbal behavior into account to categorize.

The group of 13 coders were all either students of the bachelor studies of science in Business Administration or the master studies of science in Business Administration. The aim of this systematic observation is for properly trained observers to produce identical results from the same actual behavior (Noldus et al., 2000). The coders were therefore trained in advance in the use of the software and coding manual. This analysis was carried out using a specialized event-recording software program “The Observer XT 12.5”, that has been developed since the late 1980s (Noldus, 1991; Noldus, Trienes, Hendriksen, Jansen, & Jansen, 2000; Zimmerman, Bolhuis, Willemsen, Meyer, & Noldus, 2009), see figure 2. It is an internationally used behavioral software program specifically designed for the analysis, presentation and management of observational data (Noldus et al., 2000). After coding the video, the two coders discussed their results to come to an agreed, detailed and standardized behavior pattern. When differences existed between the coders the video fragment was reexamined based on the coding scheme. The software provides us with a reliability analysis, the level of agreement between pairs of data files (Noldus et al., 2000). The average inter-rater agreement was 97.8% (Kappa=.98), which can be interpreted as an “almost perfect” agreement (Landis & Koch, 1977).

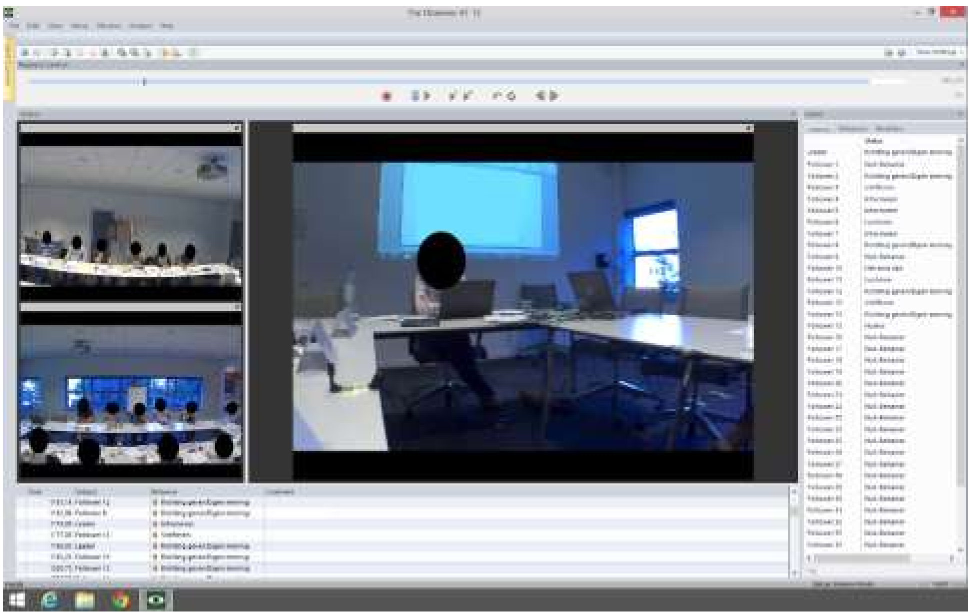


Figure 2: Video observation software ‘the Observer XT’ as used in this study (anonymized)

Skin conductance wristband measurement

In this research, a wristband is used that measures the skin conductance at the inside of the wrist, marketed by Empatica (see figure 3). It is an exosomatic, direct current device, measuring skin conductance four times per second.

Figure 3: Empatica wristband sensor

This type of sensor originates from research into a wearable wristband sensor. Westerink, Ouwerkerk, de Vries and de Waele (2009) designed a wristwatch skin conductance sensor in their so-called ‘Emotion Measurement Platform’, where one wears an electrocardiogram chest band and a skin conductance wristwatch that communicate with a smartphone. They were only able to compare this to participant questionnaires and not to a scientifically approved system, such as on the fingers. The first to present a full wristwatch sensor were Poh, Swenson, Picard (2010), who tested a “novel, unobtrusive, non-stigmatizing, wrist-worn integrated sensor”. They tested this sensor against an approved skin conductance measurement system on 26 participants and found that their results were highly accurate, strongly correlated with the approved system and that the wrist is a viable skin conductance recording site (Poh et al., 2010). Van Dooren, de Vries and Janssen (2012) presented a comparison of 16 locations that showed correlations between the finger as golden standard and the wrist, and noted that the vertical wrist can be convenient in ambulatory monitoring. Though, outcomes should still be used with caution, as the use of non-standard electrode sites as the wrist is still lacking comparisons with standard sites (Boucsein, 2012, p. 109).

Fletcher, Dobson, Goodwin, Eydgahi, Wilder-Smith, Fernholz, Kuboyama, Hedman, Poh and Picard (2010) presented the iCalm, a "low-cost, comfortable, robust, small and low power sensor module that provided the necessary set of measurements needed for affective sensing" and tested their wristband solution on 12 participants to an approved system on the fingertips, where they found that the device reproduced were lower on the wrist, but reproduced all skin conductance data features. This wearable sensor was continued by the spin-off Affectiva to the Q-Sensor, which in turn was improved into the Empatica (Picard, n.d.). Also Affectiva states that since skin conductance evaluated based on relative changes, either measurement method is equally valid (Affectiva, 2014).

This measurement method is chosen, because of the unobtrusiveness of the measurement. The Empatica E4 is the only fully ambulatory, unnoticeable skin conductance measurement device available. Therefore, the meeting will be a better reflection of a normal situation as it does not interfere with normal activities and other observations will not be disturbed. The generalizability of laboratory situation research to real-life situations can be questioned, so one need unobtrusive measurements that don't interfere with activities but still provide reliable data (van Dooren et al., 2012). During the meetings, the leader is asked to wear the sensor on the non-dominant hand. It is less likely to have cuts or calluses and it leaves the dominant hand free to perform a manual task (Dawson et al., 2007, p. 163), increasing unobtrusiveness.

Skin conductance analysis

To analyze the raw skin conductance data that come from the Empatica sensor and to couple them with the video observation data, a VBA macro (Walkenbach, 2013) has been written that automatically processes the data from the Empatica wristband and the data from Noldus 'the Observer', named the "Empatica – Observer Excel File Maker", as shown in appendix B. The Empatica wristband measures the skin conductance, but does not provide information about skin conductance level or responses. Both tonic measures, the skin conductance level and nonspecific skin conductance responses, are incorporated in the analysis. As opposed to brief discrete stimuli after a specific stimulus, chronic long-lasting stimuli or situations are best be thought of as increases and decreases in tonic arousal and are therefore the most useful skin conductance measures in the context of continuous stimuli (Dawson et al., 2007, p. 171). Several calculations are carried out on the skin conductance data, by the VBA macro in Excel, as shown in figure 4.

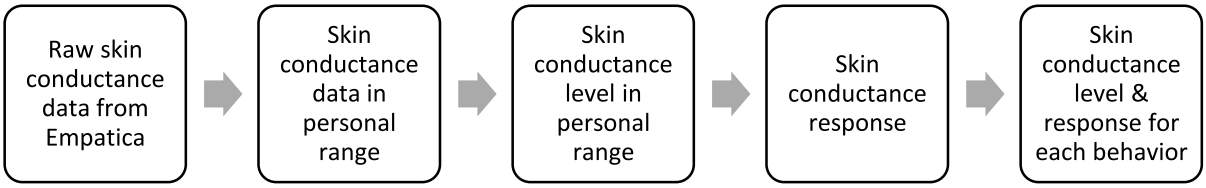


Figure 4: Calculation steps of skin conductance analysis

First, the skin conductance data are first corrected for variance. Skin conductance can vary widely between different subjects and between different psychological states (Dawson et al., 2007, p. 164). Many psychological variables cause an inter-individual variability of skin conductance (Lykken, Rose, Butler, & Maley, 1966). Sources of variance include ambient temperature (Boucsein, 2012, p. 190; Dawson et al., 2007, p. 164; Venables & Martin, 1967; Venables & Christie, 1980, p. 43), skin temperature (Venables & Martin, 1967; Venables & Christie, 1980, p. 45), humidity (Dawson et al., 2007, p. 164; Boucsein, 2012, p. 192), skin temperature and blood flow (Boucsein, 2012, p. 194), skin moisture (Boucsein, 2012, p. 197), age, gender and ethnicity (Dawson et al, 2007, p. 165), other demographics (Boucsein, 2012, p. 198), and time of day (Dawson et al., 2007, p. 164).

One can establish a baseline, the average skin conductance level over some time prior to the time when the actual research data are gathered (Potter & Balls, 2012, p1. 121) and compare the value at a specific moment with the baseline, either as absolute or relative measurement (Cacioppo & Petty, 1983) to correct for variance. However, due to the field setting, there was not enough time before the start of our meetings to collect such baseline. Therefore, a correction is done by calculating a range from the 5th to the 95th percentile as thresholds (Lykken, 1971; Lykken & Venables, 1971; Ben-Shakhar, 1985; Westerink et al., 2009). Correcting by computing a possible range for each individual subject and then expressing the subject's momentary value in terms of this range is often used for correcting individual differences (Lykken et al, 1966; Dawson et al., 2007, p. 166; Potter & Balls 2012, p. 121). In this research, the 5th percentile is called "0", the 95th percentile is called "1" and all other values are calculated within this range. This results in skin conductance data within the personal range, as an example is shown in figure 5 as the blue line.

Figure 5: Part of a skin conductance graph (25 seconds) with the skin conductance data (blue), the calculated skin conductance level (orange) and the responses (peaks in blue, marked by a grey peak).

Then, a moving average of the skin conductance data is calculated to indicate a skin conductance level at a specific moment, every ¼ second. Analyzing the skin conductance level involves averaging the skin conductance data over a determined period of time (Potter & Balls, 2012, p. 120). The skin conductance level can be formed by an average skin conductance level of all artefact-free data points within a sufficient interval, although this will overestimate in states of high arousal (Boucsein, 2012, p. 173). The time period over which skin conductance data are averaged is up to the researcher to determine. One might want to average across two to five seconds (Potter & Balls, 2012, p. 121). For this research is decided to average the skin conductance data from two seconds before until two seconds after each specific moment, 4 moments per second, to approach the skin conductance level and filter out the skin conductance responses, as shown as the orange line in figure 5.

After the skin conductance level, the skin conductance responses are determined by comparing the skin conductance data with the calculated skin conductance level. The most widely used measure is the frequency per minute, which is typically between 1 and 3 per minute at rest (Dawson et al., 200 p. 164). Skin conductance response analysis involves assessing the frequency of nonspecific skin conductance responses (Potter & Balls, 2012; p. 111). One must decide on a minimum amplitude change in conductance to count as a skin conductance response. As a system will be able to evaluate very small changes that look like responses but are artefacts in fact, minimum values of 0.05 or 0.01 µS are generally used (Dawson et al., 2007, p. 164; Boucsein, 2012, p. 138, 157; Potter & Balls, 2012, p. 121). For this analysis, a 0.03 deviation (in the personal range of 0 to 1) of the momentary skin conductance from the skin conductance level, is seen as a skin conductance response. This is generally within the range of 0.01 – 0.05 µS, but as skin conductance level varies from leader to leader, so does the skin conductance response. Because of that, this deviation is also chosen in the personal range and not as an absolute value. A peak is registered when the offset of 0.03 is met, and the skin conductance data has a local maximum at that certain moment (i.e., it is the real peak). This results in all skin conductance responses, as shown as grey peaks in figure 5.

When the skin conductance level and skin conductance responses are calculated from the skin conductance data for every ¼ second, skin conductance data and behavioral data are combined. Skin conductance and behavioral data are synchronized by setting a 'tag' with the wristband on video, which gives the possibility to combine these data, as shown in figure 6. This 'tag' is recorded by the Empatica wristband, and can be found on the video, and thus the data can be matched. The accuracy of this synchronization is based on the exact video frame (0.04s) and Empatica time (0.01s).

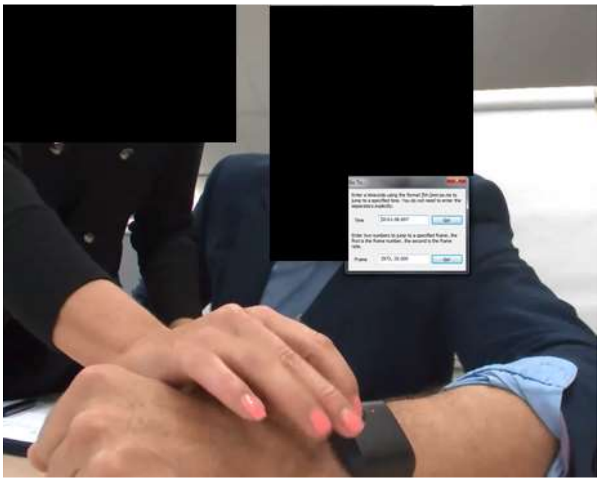


Figure 6: Synchronization of the skin conductance recording with video-recorded behaviors

The skin conductance data are not instantly reactive to variations of conditions, so changes must be considered after 3 seconds (Dawson et al., 2007, p. 168) or even between 10 and 30 seconds afterwards (Boucsein, 2012, p. 173). The skin conductance level normally decreases at rest and rapidly increases after a new stimulus (Dawson et al., 2007, p. 164). For each occurrence of a behavior, the skin conductance data are therefore taken from 3 seconds after every start to 1 second after every end of each occurrence of this behavior. A graphical representation can be found in figure 7. The black boxes in the top row are behaviors, resulting in the colored boxes of analyzed time frames for the skin conductance data. Note that all time frames from 1 second until 3 seconds after the start of a behavior are excluded. They cannot be allocated to either the current or the previous behavior.

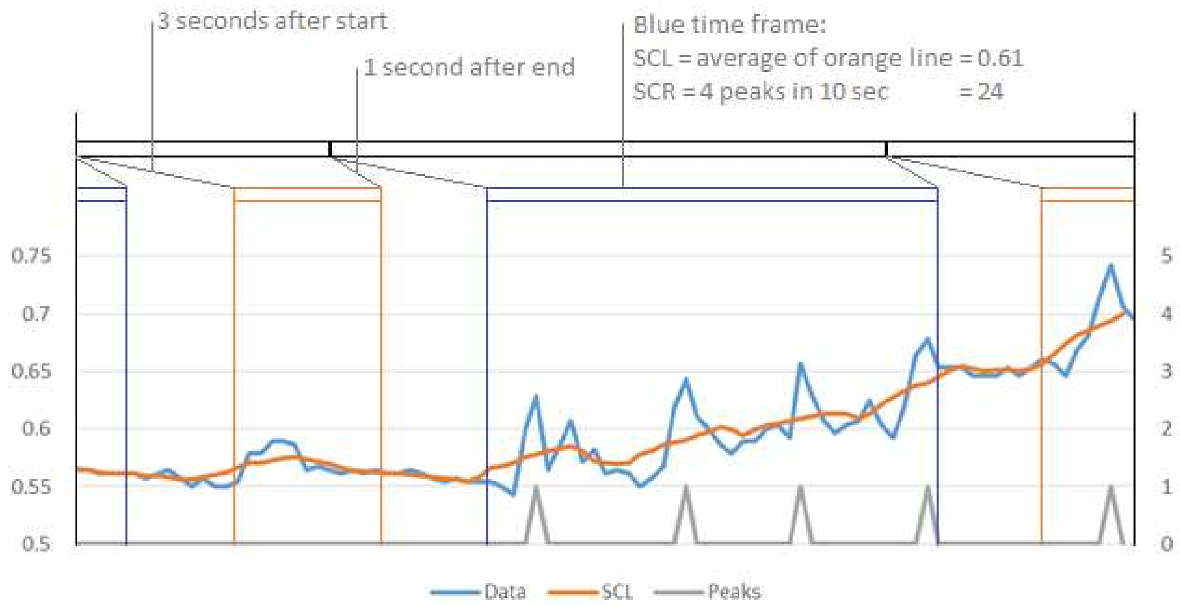


Figure 7: Explanation of the combination of skin conductance data and behavioral data

The skin conductance level is then averaged over all time frames that are assigned to a specific behavior (e.g. all boxes that are related to 'informing'). This analysis results in an average skin conductance level during this specific behavior in the meeting, which is expressed in the personal range of 0 to 1. The skin conductance responses are summed over the same time frames, and then divided by the total duration of these time frames. This analysis results in an average skin conductance response during this specific behavior in the meeting, expressed in peaks per minute. These average skin conductance levels, and average skin conductance responses per minute, for every behavior and for every leader, are used for statistical analysis.

Measures

Arousal during transactional behavior. As described, arousal is measured as an average skin conductance level and the skin conductance responses per minute. For transactional behavior, arousal during all task-oriented behaviors were combined, being ‘providing negative feedback’, ‘correcting’, ‘delegating’, ‘task monitoring’, ‘structuring’, and ‘informing’, see appendix A. The skin conductance level during transactional behavior, expressed in the personal range, was on average 0.55 (SD=0.16; [0.25, 0.90]). The skin conductance response during transactional behavior, expressed in peaks per minute, was on average 2.78 (SD=2.59; [0.13, 9.62]).

Arousal during transformational behavior. For transformational behavior, arousal during ‘agreeing’, ‘providing positive feedback’, ‘individualized consideration’, ‘humor’, and ‘informing personally’, are combined, see appendix A. The skin conductance level during transformational behavior was on average 0.55 (SD=0.21; [0.22, 0.95]). The skin conductance response during transformational behavior was on average 4.19 (SD=4.12; [0.00, 17.83]).

Arousal during listening. Furthermore, the arousal during the inactive behavior ‘listening’ is used. The skin conductance level during ‘listening’ was on average 0.44 (SD=0.12; [0.20, 0.74]). The skin conductance response during ‘listening’ was 1.75 (SD=1.63; [0.00, 4.89]).

Arousal during all behaviors. Lastly, the arousal during all behaviors, except ‘listening’, was included. The skin conductance level during all behaviors was on average 0.54 (SD=0.16; [0.25, 0.92]). The skin conductance response during all behaviors was on average 2.99 (SD=2.69; [0.12, 9.80]), resembling normal values (Dawson et al., 200 p. 164) but having a very high standard deviation.

Transformational behavior. Followers and the leader rated the style of the leader by 16 transformational leadership items of the MLQ-5X-Short, comprising ‘idealized influence’, ‘inspirational motivation’, and ‘individualized consideration’ (e.g. spending time teaching and coaching). The response categories ranged from 1 – totally disagree – to 7 – totally agree as a 7-point Likert scale. The Cronbach alpha for this construct is 0.92. The items have a mean between 4.76 and 6.02, with a standard deviation of 0.84 to 1.35. The ICC1 was 0.14 ($p<.01$) and the ICC2 was 0.80 ($p<0.01$). Based on the high alpha, the ICC1 > 0.05 and ICC2 > 0.70, the data are combined and aggregated into a single transformational behavior measure per leader (LeBreton & Senter, 2008).

Transactional behavior. Followers and the leader rated the style of the leader by the 8 transactional leadership items of the MLQ-5X-Short, comprising ‘contingent reward’, and ‘active management by exception’ (e.g. directing attention toward failures to meet standards) on a 7-point Likert scale. The Cronbach alpha for this construct is 0.89. The items have a mean between 4.96 and 5.55, with a standard deviation of 0.96 to 1.11. The ICC1 was 0.14 ($p<.01$) and the ICC2 was 0.80 ($p<0.01$).

Leadership effectiveness. Followers and the leader rated the performance of the leader by the 4 leadership effectiveness items of the MLQ-5X-Short (e.g. being effective in meeting others’ job-related needs) on a 7-point Likert scale. The Cronbach alpha for this construct is 0.88. The four items have a mean between 5.27 and 5.45, with a standard deviation of 0.91 to 1.13. The ICC1 was 0.14 ($p<.01$) and the ICC2 was 0.80 ($p<0.01$).

Follower extra effort. Followers and the leader also rated the performance of the leader by the 3 extra effort effectiveness items of the MLQ-5X-Short on a 7-point Likert scale (e.g. getting others to do more than they expected to do). The Cronbach alpha for this construct is 0.88. The three items have a mean ranging from 4.85 to 4.94 and a standard deviation between 1.06 and 1.13. The ICC1 was 0.14 ($p<.01$) and the ICC2 was 0.80 ($p<.01$).

Leader satisfaction. Followers and the leader rated the performance of the leader is by the 2 satisfaction with leader items of the MLQ-5X-short on a 7-point Likert scale (e.g. using methods of leadership that are satisfying). The Cronbach alpha for this construct is 0.79. Means are 5.41 and 5.30 with a respective standard deviation of 1.10 and 1.03. The ICC1 was 0.14 ($p<.01$) and the ICC2 was 0.80 ($p<.01$).

Control variables. As control variables, gender and age of the leader are chosen. Several studies not only demonstrated that these variables might affect effectiveness (Hoogeboom & Wilderom, 2015a), they are also related to the skin conductance as personal difference (Dawson et al., 2007).

Data analysis

For this research, data analysis is carried out in SPSS statistical software. Two tests have been used. First, paired samples T-tests are applied. The paired samples t-test is used because for multiple tests there are two experimental conditions (e.g. arousal during active behaviors and arousal during listening), and the same participants took part in both conditions (i.e. the values for the same leader are compared with each other) (Field, 2013). Second, linear regression ANOVA's are carried out. Multiple regression is used because there are several independent variables for each dependent variable (Field, 2013).

As not all variables were normally distributed, a bootstrap has been applied. A test that is robust to violations of assumptions is by far the best option if you have non-normally distributed data, better than trimming or transforming the data (Field, 2013). Bootstrapping offers a flexible and general alternative that makes less standard distributional assumptions than the traditional approaches (Wright, London, & Field, 2011). Bootstrapping takes the data as a population from which smaller bootstrap samples are taken. This process is repeated multiple times, resulting in just as much parameter estimates. The SPSS default is 1000, which is also used in this research, as no more bootstrap samples are needed (Field, 2013).

From these 1000 bootstrap samples, the standard error, the 95% confidence intervals and the significance are calculated and used as estimates of the parameters of the population (Wright et al., 2011). Though, bootstrapping has some difficulties as well. Because it is based on random samples, the estimates will be slightly different every time (Field, 2013). Furthermore, our sample with *n = 27* is relatively small. Therefore, it is even more important to have a sample that is truly representative of the population, but this should be the case with traditional methods as well (Wright et al., 2011).

RESULTS

Appendix C presents the means, standard deviations, and bivariate correlations of the key variables in this study. The correlations show that arousal during transformational behaviors and during transactional behaviors are significantly related to leader effectiveness and satisfaction with leader. Furthermore, transformational leadership and transactional leadership are significantly related to leader effectiveness, extra effort, and satisfaction with leader. In the following paragraphs, these relationships is elaborated upon.

Proposition testing

Proposition 1. For proposition 1, a test is carried out to see whether arousal is higher during active behaviors, then during listening. First, the skin conductance level is taken as a measure of arousal. A paired samples, 1000 samples bootstrapped, T-test is applied for this test. On average, leaders who were active (M=0.54; SE=0.03), were more aroused than those who were listening (M=0.44; SE=0.02). This difference, 0.11, BCa 95% CI [0.05, 0.15], was significant t(26)=3.68, p<0.01. If skin conductance response is taken as measure, leaders who were active (M=2.99; SE=0.49), were more aroused than those who were listening (M=1.75; SE = 0.30). This difference, 1.25, BCa 95% CI [0.61, 1.95], was significant as well t(26) = 3.85, p<0.01. As expected, it is found that leaders who are active are more aroused than those who are listening, and thus support is found for proposition 1.

Proposition 2. For proposition 2, it is tested whether arousal during transactional behavior leads to leader effectiveness, follower extra effort, and satisfaction with the leader. First, the skin conductance level is used as a measure of arousal. Three linear regression ANOVA's with 1000 bootstrap samples are carried out for this test. The linear regression of all three dependent variables, with arousal during transactional behaviors, transactional leadership, and control variables age and gender as independent variables, can be found in appendix D. For leader effectiveness, a positive effect is found of both transactional leadership and arousal during transactional behaviors. Leaders who are more aroused during transactional behaviors, are more effective, which means that proposition 2a can be accepted. For follower extra effort, only a positive effect is found of transactional leadership. Since no relationship between arousal during transactional behaviors and follower extra effort is found, proposition 2b is rejected. For satisfaction with leader, there is a positive effect of both transactional leadership and arousal during transactional behaviors. The followers of leaders who are more aroused during transactional behaviors, are more satisfied with their leader, which means that proposition 2c can be accepted. Second, the skin conductance responses are used as a measure of arousal. However, with this measure, no significant relationships were found between arousal during transactional behaviors and leader effectiveness, follower extra effort, or satisfaction with leader.

Proposition 3. For proposition 3, it is tested whether arousal during transformational behavior leads to leader effectiveness, follower extra effort, and satisfaction with the leader. Again, the skin conductance level is used as a measure of arousal first. Three linear regression ANOVA's with 1000 bootstrap samples are carried out for this test. The linear regression results of all three dependent variables, with arousal during transformational behaviors, transformational leadership, and control variables age and gender as independent variables, can be found in appendix D. For leader effectiveness, a positive effect is found of both transformational leadership and arousal during transformational behaviors. Leaders who are more aroused during transformational behaviors, are more effective, which means that proposition 3a can be accepted.

For follower extra effort, only a positive effect is found of transformational leadership. As no relationship between arousal during transformational behaviors and follower extra effort is found, proposition 3b is rejected. For satisfaction with leader, there is a positive effect of both transformational leadership and arousal during transformational behaviors. The followers of leaders who are more aroused during transformational behaviors, are more satisfied with their leader, which means that proposition 3c can be accepted. Second, the skin conductance responses are used as measure of arousal during transformational leadership. However, with this measure, no significant relationships were found between arousal during transformational behaviors and leader effectiveness, follower extra effort, or satisfaction with leader.

Proposition 4. First, a test is carried out whether there is a difference between the arousal during transactional behaviors, and during transformational behaviors. First, the skin conductance level is taken as a measure of arousal. A paired samples, 1000 samples bootstrapped, T-test is applied for this test. On average, leaders were evenly aroused during transformational behaviors ($M=0.55$, $SE=0.21$) than during transactional behaviors ($M=0.55$, $SE=0.16$). There was no difference, 0.00, BCa 95% CI [-0.06, 0.05], $t(26)=-0.08$, $p=0.94$. However, if skin conductance response is taken as measure, leaders were more aroused during transformational behaviors (M 4.19, $SE=4.1$) than during transactional behaviors ($M=2.78$, $SE=2.59$). This difference, 1.41, BCA 95% CI [0.64, 2.17], was significant $t(26)=3.07$, $p<0.01$.

Then, the relative influence of arousal during transformational behavior and transactional behavior, on leader effectiveness, follower extra effort, and satisfaction with the leader are tested. Still, the skin conductance level is used as a measure of arousal first. Three linear regression ANOVA's with 1000 bootstrap samples are carried out for this test. The linear regression of all three dependent variables, with arousal during transformational behaviors, during transactional behaviors, and during listening, together with control variables age and gender as independent variables, can be found in appendix D. For leadership effectiveness, it is shown that only arousal during transformational behaviors remains having a significant influence on leadership effectiveness.

Furthermore, the arousal during listening, although only close to significance (p=0.06) might have a very strong negative influence on leadership effectiveness. Arousal during transactional behavior does not have a significant influence on leadership effectiveness any more. For extra effort, no significant model was obtained. This was expected, as arousal during neither transactional behavior, nor transformational behavior, had a significant influence on follower extra effort. For satisfaction with leader, it is also shown that only arousal during transformational behaviors remains having a significant influence. Arousal during listening has a significant negative influence on satisfaction with the leader, as was the case with leadership effectiveness. Arousal during transactional behavior does not have a significant influence on satisfaction with leader any more. Second, the skin conductance responses are taken as measure of arousal, but with this measure, no significant relationships were found between arousal and leader effectiveness, follower extra effort, or satisfaction with leader.

DISCUSSION

Discussion of results

In this study, arousal is added to the toolbox of leadership research. By employing an organizational neuroscience method combined with coded actual leader behavior, and not relying only on questionnaires or behavioral data, more insight in the working of transactional and transformational behavior is provided. It is found that a leader who is more aroused during transactional behavior and, more importantly, during transformational behavior, is more effective and his followers are more satisfied with him. Both goals for this study are discussed respectively: developing a research method that combines arousal at a specific point in time with simultaneously observed behaviors, and presenting results of the influence of arousal on leader performance by using this method.

Skin conductance measurement as an organizational neuroscience method is introduced to the field of leadership behavioral research in a careful and rational way (Becker & Cropanzano, 2010), which has not been combined before. The developed approach is discussed by looking at the possible critiques of a neuroscientific method. Although the sample size of 27 was lower than expected when starting the study, there was no lack of statistical possibilities present when using the skin conductance level measurement (Lindebaum & Jordan, 2014; Ashkanasy et al., 2014). All statistical relations were tested at $p<0.05$ and consistent results were found between the independent and dependent variables, which shows that it is possible to employ a research design that results in statistically sound results. The method has been described in detail (Lindebaum & Jordan, 2014). The sensor is commercially available and the "Empatica – Observer Excel File Maker" has been designed to be used in follow-up research in such a way that all interested scholars are able to do so. An adequate scientific incentive has been described in the introduction (Butler et al., 2015; Lindebaum & Jordan, 2014; Ashkanasy et al., 2014). A deliberate choice to combine the organizational behavioral level with the neuroscientific level overcame the criticism that research should not look at brain systems in isolation (Butler et al., 2015; Ashkanasy et al., 2014). With this innovative and comprehensive research design, insight is given into the possibilities of combining leadership and neuroscientific fields, and behavioral and skin conductance measurements. This exploratory research and development can be seen as a beneficial contribution for the neuroscientific and leadership research.

The study showed that leaders who are more aroused during both transactional and transformational behaviors in meetings, are more effective. This is in line with what was expected and proposed. This adds another dimension to the full-range model of leadership. Leadership styles are often described as *what* leaders do, but there is less emphasis on *how* they perform these behaviors. Arousal could be seen as a measure of the intensity of behaviors (Lowe et al., 1996). Another proposition showed that being more aroused during transformational behaviors is more important than during transactional behavior, in relation to leadership effectiveness.

In a regression analysis with arousal during transactional behaviors, transformational behaviors and listening, it is found that arousal during transformational behaviors is the strongest. As transformational leadership is described with terms as excitement, enthusiasm and energizing (see table 2), the findings support the descriptions of the dimensions of transformational leadership. A leader is more effective when he is less aroused during listening. So, being relaxed during active behaviors of others increases leader effectiveness. In conclusion, leadership effectiveness increases with a higher arousal during transformational behavior. A higher arousal during transactional behavior and a lower arousal during listening also increases leadership effectiveness.

In contrast with the propositions, were the results of the influence of arousal on extra effort. No statistical relationship was found between arousal of the leader and follower extra effort. That is not in line with the expectations, as it was measured exactly the same as leader effectiveness and satisfaction with leader. This means that the arousal of the leader does not significantly increase nor decrease the extra effort a leader provokes from his followers. As arousal is a measure of the current emotional processing of the leader (Potter & Balls, 2012), it could be that only arousal at the time where this effort is necessary, outside the recorded meeting, influences followers' extra effort.

In addition, the study showed that when leaders are more aroused during transactional and transformational behaviors in meetings, followers are more satisfied with them. Another proposition showed that being more aroused during transformational behaviors is more important than during transactional behavior, in relation to followers' satisfaction with their leader. In a regression analysis with arousal during transactional behaviors, transformational behaviors and listening, it is found that arousal during transformational behaviors is the strongest. This is consistent with the description of the dimensions of transformational leadership (table 2), in terms of inspiring and energizing followers and supporting and respecting the individual. Followers are more satisfied with their leader when he is less aroused during listening. In total, followers' satisfaction with their leader increases with a higher arousal during transformational behavior, consistent with the definition. A higher arousal during transactional behavior and a lower arousal during listening also enhances satisfaction.

Thus, this research was able to strengthen the definitions of table 2 by objectively measuring the arousal of the leader. An overview of all propositions that are accepted and rejected can be found in table 3. In dark green, the most important relationships are depicted.

	AROUSAL DURING LISTENING	AROUSAL DURING TRANSACT. BEH.	AROUSAL DURING TRANSFOR. BEH.
AROUSAL	P1: A leader is significantly more aroused during active behaviors		
LEADER EFFECTIVENESS	P4a: almost significant (negative correlation)	P2a: significant P4a: insignificant	P3a: significant P4a: significant
FOLLOWER EXTRA EFFORT	P4b: insignificant	P2b: insignificant P4b: insignificant	P3b: insignificant P4b: insignificant
SATISFACTION WITH LEADER	P4c: significant (negative correlation)	P2c: significant P4c: insignificant	P3c: significant P4c: significant

Table 3: Overview of propositions, where "P" is an abbreviation of proposition.

In contrast to the skin conductance level measures of arousal, the skin conductance response measures were found uncorrelated with the outcome variables 'leadership effectiveness', 'follower extra effort', and 'satisfaction with leader'. It was expected to yield roughly the same results as the skin conductance level measures of arousal as the same situations result in a high level and frequent responses (Dawson et al., 2007; Boucsein, 2012), which was not found in practice. The author argues that this is the case because many behaviors had zero skin conductance responses in certain meetings, i.e. no peak has fallen within the time frames of a certain behavior. This can be seen from e.g. the histogram of the skin conductance responses of transformational behaviors (figure 8), and from the fact that the minimal values of responses during transformational behavior, transactional behavior, and listening were respectively 0.00, 0.13, and 0.00. That does not reflect a real life situation, where 1 – 3 responses per minute are expected (Dawson et al., 2007). As this is the first research to combine behavioral data and synchronous skin conductance in short time frames as such, it was unknown what this combination would yield.

If certain behaviors (e.g. ‘agreeing’) appear a couple of times for a short duration of time, it is very probable that no peak falls exactly in its time frames. When no peaks are observed, skin conductance response is 0.00 per minute. For these null-responses, there is no difference between more effective leaders and less effective leaders and no conclusions can be drawn. Although no effects on leadership performance can be presented, it is shown that this analysis works for skin conductance levels, but was not able to provide interesting data about the skin conductance responses. Using another types of analysis, as described in the future research section, might improve response analysis.

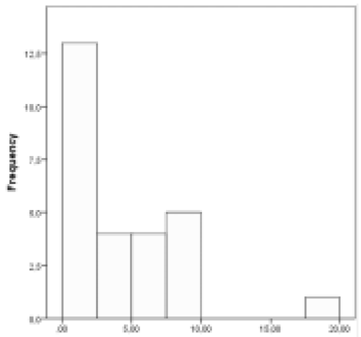


Figure 8: Histogram of the skin conductance responses of transformational behaviors[1]

So, to get closer to an answer to the question of Balthazard et al. (2012), “Is there a neurological pattern associated with transformational leadership?”, another piece to the puzzle is added. Although there are no neurological patterns examined directly in this research, it can be stated from neuroscientific research that leaders who are more aroused during meetings, especially during transformational behaviors but also during transaction behaviors, perform better. They are found to be more effective, and their followers are more satisfied with them.

[1] The right-hand outlier has been checked for possible exclusion, but the skin conductance graph of this meeting was not found to have a clearly irregular pattern. Furthermore, the analysis problem of this graph is the high bar of 0.00, not the outlier.

Practical implications

The first goal of this study was the contribution of adding an organizational neuroscience method to the toolbox of leadership research: skin conductance measurement in combination with video-taped coded leader behavior. However, it is very important to have a practical incentive as well (Butler et al., 2015; Lindebaum & Jordan, 2014; Ashkanasy et al., 2014). The results show that it is important for a leader to be actively involved during the meeting. This is because, as shown by our findings, if during transformational and transactional behaviors leaders are more aroused, they are more effective and followers are more satisfied with their leaders. It is most important to be actively involved during transformational behavior. It is clear that one cannot directly influence our arousal as such and thus, it makes no sense to advise that one should have a higher arousal. But, being more actively involved during active behaviors (Dawson et al., 2007, p. 173) – e.g. 'providing positive feedback' by heart and not as a habit (Becker & Menges, 2013) and showing more emotions (Akinola, 2010; Potter & Balls, 2012) – e.g. 'informing personally' emotionally, could lead to higher arousal, which is shown to lead to higher effectiveness.

Limitations, future research and conclusion

The results of this study provide a vast range of new opportunities for research of effective leader behavior. The combination of skin conductance with video-observed behaviors gives new insights that could possibly go far beyond the results that are presented in the current study. Most criticism that has been described in the literature has been taken into account for this study.

However, despite the strengths of this study, there are some limitations. These limitations can be imputed to the exploratory nature of our study, but are nonetheless important to improve the research design for future research. The first limitation of our study is the relatively small sample size (Lindebaum & Jordan, 2014; Ashkanasy et al., 2014). This can be solved in two ways. The first possibility is to enlarge the video-taping sample, which is planned in the near future.

The second possibility is to improve the skin conductance recording during the meetings, to reduce the 41% of the meetings where no valid skin conductance was recorded. The wristband was new for the recorders and is far from a responsive device, having only one multi-colored LED and one button (Picard, n.d.). Also, the sensor was sometimes not turned on in sight of the camera, even though a detailed, step-wise guidebook was used by the recorders. Hence, in these instances it was not possible to synchronize behavioral data with the skin conductance data. There is no reason to assume that these inefficiencies have influenced the results of the present study, as failed recordings were excluded. The included meeting’s recordings were of good quality and were very precisely synchronized.

Another limitation is the fact that for each leader, only one meeting is recorded. Although the results of the questionnaire show that meetings were highly representative, there are always variations between meetings. This not only applies to this skin conductance research, but to the video-coding research in general. Overall, a longitudinal design will exclude specific meeting artefacts such as the themes that are discussed and a more generally applicable conclusion can be drawn on the differences between leaders. Recording more meetings removes influences from the meeting type, such as discussing a certain topic, serving as a weekly motivating start, or informing about future plans. For the skin conductance research, this will further exclude artefacts such as temperature and time (Boucsein, 2012; Dawson et al., 2007, Potter & Balls, 2012).

Two possible options for future research are given. First, it would be interesting to use another skin conductance data analysis method. For example, a specific skin conductance response analysis (‘specific’ denoted as the opposite of ‘nonspecific’ skin conductance responses) could give new insights. Analyzing all skin conductance responses from the start until 3 seconds after the end of a behavior could be seen as a search for responses that could possibly be related to this behavior. When this would be analyzed for specific short-duration behaviors such as ‘defending one’s own position’, ‘providing negative feedback’ or ‘interrupting’, it could be seen as a specific skin conductance response (Boucsein, 2007). As this would result in a time frame that is 3 seconds longer then a behavior (from begin to 3 seconds after the end), instead of 2 seconds shorter (3 seconds after begin until 1 second after the end) in the present study, possibly more results would come from the skin conductance responses. Another possibility would be to start the analysis from the recorded skin conductance responses, and see which behaviors were present in e.g. 3-5 seconds before their occurrence. This could be seen as a search for behaviors that induce unexpected, significant stimuli (Dawson et al., 2007). These possibilities could overcome the limitation of our study, that no results were found using the skin conductance response measures.

Second, it could be possible to relate other leadership variables to the study of arousal and behaviors, especially the influence of the setting and atmosphere. One possible study could be on the effect of voice climate. Group voice climate can be conceptualized as a shared belief about whether speaking up is safe versus dangerous and about whether group members are able to use their voice effectively (Wolfe Morisson, Wheeler-Smith, & Kamdar, 2012). Another possible study could include affect and emotion. Positive affect (PA) reflects the extent to which a person feels enthusiastic, active, and alert. High PA is a state of high energy, full concentration, and pleasurable engagement, whereas low PA is characterized by sadness and lethargy. In contrast, negative affect (NA) is a general dimension of subjective distress and unpleasable engagement that subsumes a variety of aversive mood states, including anger, contempt, disgust, guilt, fear, and nervousness, with low NA being a state of calmness and serenity (Watson, Clark, & Tellegen, 1988). These definitions resemble the definition of arousal as a state of activation, attention, and stimulus intensity (Dawson et al., 2007). Arousal also is used in the circumplex model that tests the group mood and emotions, as based on arousal and pleasance or valence (Russell, 1980; D'Hondt et al., 2010; Lehmann-Willenbrock et al., 2011). The challenge for this research would be to overcome the presentation of only a correlation between arousal and affect, but show the scientific and practical implication of combining these two measures. One could be able to distinguish arousal originating from PA or NA, but as unpleasant and pleasant emotions induce the same arousal this might be difficult (D'Hondt et al., 2010). Else, one could be able to relate specific behaviors to this and thereby be beneficial.

In conclusion, the present study adds arousal to the traditional measures being used in leadership research and developed a systematic to enable scholars to use this possibility. Due to the exploratory nature of this study, there are ample opportunities of follow-up research questions which could be answered by combining the presented results with other variables from leadership literature, or by using other combinations between the behaviors and simultaneous arousal measurement. The conclusion of this study is that leaders who are actively and emotionally involved in a meeting, especially during transformational behaviors, are more effective and greater follower satisfaction with the leader is shown. A large portion of the variance in leader effectiveness can be explained by highly aroused transformational leader behavior. The fact that this can be concluded from objectively video-coded behavior and directly measured arousal is a great improvement for the future of leadership research.

REFERENCES

Affectiva (2014). How does measurement on the wrist compare to the fingers? Retrieved from: http://qsensor-support.affectiva.com/customer/en/portal/articles/1539334-how-does-measurement-on-the-wrist-compare-to-the-fingers-

Akinola, M. (2010). Measuring the pulse of an organization: Integrating physiological measures into the organizational scholar's toolbox. Research in Organizational Behavior 30, p. 203-223

Antonakis, J., Avolio, B.J., & Sivasubramaniam, N. (2003). Context and leadership: an examination of the nine-factor full-range leadership theory using the Multifactor Leadership Questionnaire. The Leadership Quarterly 14, p. 261-295.

Arvey, R.D., Wang, N., Song, Z., & Li, W. (2013). The Biology of Leadership. In Day, D. (ed.), Oxford Handbook of Leadership and Organizations, p. 75-92, Publisher: Oxford University

Ashkanasy, N.M., Becker, W.J., & Waldman, D.A. (2014). Neuroscience and organizational behavior: Avoiding both neuro-euphoria and neuro-phobia. Journal of Organizational Behavior 35, p. 909-919.

Avolio, B.J., & Bass, B.M. (1995). Individual consideration viewed at multiple levels of analysis: a multi-level Framework for examining the diffusion of transformational leadership. Leadership Quarterly 6(2), p. 199-218.

Avolio, B. J., & Bass, B. M. (2004). Multifactor leadership questionnaire: Third edition manual and sampler set. Redwood City, CA: Mind Garden.

Avolio, B.J., Bass, B.M., & Jung D.I. (1999). Re-examining the components of transformational and transactional leadership using the Multifactor Leadership Questionnaire. Journal of Occupational and Organizational Psychology 72, p. 441-462.

Balthazard, P.A., Waldman, D.A., Thatcher, R.W., & Hannah, S.T. (2012). Differentiating transformational and non-transformational leaders on the basis of neurological imaging. The Leadership Quarterly 23, p. 244-258.

Bass, B.M. (1985). Leadership and performance beyond expectations. New York: Free Press.

Bass, B.M. (1990). From transactional to transformational leadership: Learning to the vision. Organizational Dynamics 18(3), p. 19-31.

Bass, B.M., Avolio, B.J., Jung, D.I., & Berson, Y. (2003). Predicting Unit Performance by Assessing Transformational and Transactional Leadership. Journal of Applied Psychology 88(2), p. 207-218.

Becker, W.J., & Cropanzano, R. (2010). Organizational neuroscience: The promise and prospects of an emerging discipline. Journal of Organizational Behavior 31, p. 1055-1059.

Becker, W.J., Cropanzano, R., & Sanfey, A.G. (2011). Organizational neuroscience: Taking Organizational Theory inside the Neuro Black Box. Journal of Management 37(4), p. 933-961.

Becker, W.J., & Menges, J.I. (2013). Biological implicit measures in HRM and OB: A question of how not if. Human Resource Management Review 23, p. 219-228.

Ben-Shakhar, G. (1985). Standardization within individuals: A simple method to neutralize individual differences in Skin Conductance. Psychophysiology 22(3), p. 292-299.

Boucsein, W. (2012). Electrodermal activity. New York: Springer.

Boucsein, W., Fowles, D.C., Grimnes, S., Ben-Shakhar, G., Roth, W.T., Dawson, M.E., & Filion, D.L. (2012). Committee report: Publication recommendations for electrodermal measurements. Psychophysiology 49, p. 1017-1034.

Burns, J.M. (1978). Leadership. New York: Harper & Row.

Butler, M.J.R., O’Broin, H.L.R., Lee, N. & Senior, C. (2015). How Organizational Cognitive Neuroscience Can Deepen Understanding of Managerial Decision-making: A Review of the Recent Literature and Future Directions. International Journal of Management Reviews.

Butler, M.J.R., & Senior, C. (2007). Toward an Organizational Cognitive Neuroscience. Annals of New York Academy of Sciences 1118, p. 1-17.

Bycio, P., Hackett, R.D., & Allen, J.S. (1995). Further Assessments of Bass’s (1985) conceptualization of Transactional and Transformational Leadership. Journal of Applied Psychology 80(4), p. 468-478.

Cacioppo, J. T., & Petty, R. E. (1983). Foundations of social psychophysiology. In J. T. Cacioppo & R. E. Petty (Eds.), Social Psychophysiology: A sourcebook, p. 3-36. New York: Guilford Press.

Dawson, M.E., Schell, A.M., & Courtney, C.G. (2011). The Skin Conductance Response, Anticipation, and Decision-Making. Journal of Neuroscience, Psychology, and Economics 4(2), p. 111-116.

Dawson, M.E., Schell, A.M., & Filion, D.L. (2007). The Electrodermal System. In Cacioppo, J.T., Tassinary, L.G., & Berntson, G. (Eds.), Handbook of Psychophysiology (p. 157-181). Cambridge: Cambridge University Press.

Dinh J.E., Lord, R.G., Gardner, W.L., Meuser, J.D., Liden, R.C., & Hu, J. (2014). Leadership theory and research in the new millennium: current theoretical trends and changing perspectives. Leadership Quarterly 25, p. 36-62.

Van Dooren, M., de Vries, J.J.G., & Janssen, J.H. (2012). Emotional sweating across the body: Comparing 16 different skin conductance measurement locations. Physiology & Behavior 106, p. 298-304.

Field, A.P. (2013). Discovering statistics using IBM SPSS Statistics: and sex and drugs and rock ‘n’ roll (fourth edition). London: Sage publications.

Fletcher, R.R., Dobson, K., Goodwin, M.S., Eydgahi, H., Wilder-Smith, o. Fernholz, D., Kuboyama, Y., Hedman, E.B., Poh, M.Z., & Picard, R.W. (2010). iCalm: Wearable Sensor and Network Architecture for Wirelessly Communicating and Logging Autonomic Activity. IEEE Transactions on Information Technology in Biomedicine 14(2), p. 215-223.

Gupta, K.X., Wilderom, C.P.M., & van Hilligersberg, J. (2009). Exploring the Behavior of Highly Effective CIOs using Video Analysis. Proceedings of the Fifteenth Americas Conference on Information Systems.

Den Hartog, D.N., Van Muijen, J.J., & Koopman, P.L. (1997). Transactional versus transformational leadership: An analysis of the MLQ. Journal of Occupational and Organizational Psychology 70, p. 19-34.

Hater, J.J., & Bass, B.M. (1988). Superiors’ Evaluations and Subordinates’ Perceptions of Transformational and Transactional Leadership. Journal of Applied Psychology 73(4), p. 695-702.

D’Hondt, F., Lassonde, M., Collignon, O., Dubarry, A-S., Robert, M., Rigoulot, S., Honoré, J., Lepore, F., & Sequeira, H. (2010). Early brain-body impact of emotional arousal. Frontiers in Human Neuroscience 4(33).

Hoogeboom, A.M.G.M., & Wilderom, C.P.M. (2015a). Integrating Two Classic leadership Models: Augmentation Effects with Initiating Structure. Manuscript submitted for publication.

Hoogeboom, A.M.G.M., & Wilderom, C.P.M. (2015b). Refining the augmentation thesis of transformational leadership: a triangulated, video-based field study. Manuscript submitted for publication.

Howell, J.M., & Avolio, B.J. (1993). Transformational Leadership, Transactional Leadership, Locus of Control, and Support for Innovation: Key Predictors of Consolidated-Business-Unit Performance. Journal of Applied Psychology 78(6), p. 891-902.

Huettel, S.A., & Payne, J.W. (2009). Integrating Neural and Decision Sciences: Convergence and Constraints. Journal of Marketing Research 46, p.14-24.

Hunter, S. T., Bedell-Avers, K. E., & Mumford, M. D. (2007). The typical leadership study: Assumptions, implications, and potential remedies. The Leadership Quarterly 18, p. 435–446.

Johnson, L.C., & Lubin, A. (1966). Spontaneous electrodermal activity during waking and sleeping. Psychophysiology 3(1), p. 8-17.

Judge, T.A., & Piccolo, R.F. (2004). Transformational and transactional Leadership: A Meta-Analytic Test of Their Relative Validity. Journal of Applied Psychology 89(5), p. 755-768.

Kauffeld, S., & Lehmann-Willenbrock, N. (2012). Meetings Matters: Effects of Team Meetings on Team and Organizational Success. Small Group Research 43(2), p. 130-158.

Landis, J.R., & Koch, G.G. (1977). The Measurement of Observer Agreement for Categorical Data. Biometrics 33(1), p. 159-174.

Lehmann-Willenbrock, N., Meyers, R.A., Kauffeld, S., Neininger, A., & Henschel, A. (2011). Verbal Interaction Sequences and Group Mood; Exploring the Role of Team Planning Communication. Small Group Research 42(6), p. 639-668.

Lee, N. & Chamberlain, L. (2007). Neuroimaging and Psychophysiological Measurement in Organizational Research: An Agenda for Research in Organizational Cognitive Neuroscience. Annals of New York Academy of Sciences 1118, p. 1-17.

Lee, N., Senior, C., & Butler, M. (2011). Leadership research and cognitive neuroscience: The state of this union. Leadership Quarterly 23(2), p. 213-218.

Lee, N., Senior, C, & Butler, M.J.R. (2012). The Domain of Organizational Cognitive Neuroscience: Theoretical and Empirical Challenges. Journal of Management 38(4), p. 921-931.

Lindebaum, D., & Jordan, P.J. (2014). A critique on neuroscientific methodologies in organizational behavior and management studies. Journal of Organizational Behavior 35, p. 898-908.

Lowe, K.B., Galen Kroeck, K., & Sivasubramaniam, N. (1996). Effectiveness correlates of transformational and transactional leadership: a meta-analytic review of the MLQ literature. Leadership Quarterly 7(3), p. 385-425.

Lupton, D. (2013). Quantifying the body: monitoring and measuring health in the age of mhealth technologies. Critical Public Health 23(4), p. 393-403.

Lykken, D.T. (1962). Range correction applied to heart rate and to GSR data. Psychophysiology 9, p. 373-379.

Lykken, D.T., Rose, R., Butler, B., & Maley, M. (1966). Correcting psychophysiological measures for individual differences in range. Psychological Bulletin 66, p. 481-484.

Lykken, D.T., & Venables, P.H. (1971). Direct measurement of skin conductance: A proposal for standardization. Psychophysiology 8(5), p. 656-672.

Marci, C.D., Ham, J., Moran, E., & Orr, S.P. (2007). Physiologic Correlates of Perceived Therapist Empathy and Social-Emotional Process during Psychotherapy. The Journal of Nervous and Mental Disease 195(2), p. 103-111.

Meyer, J.P., Stanley, D.J., Herscovitch, L., & Topolnytsky, L. (2002). Affective, Continuance, and Normative Commitment to the Organization: A Meta-analysis of Antecedents, Correlates, and Consequences. Journal of Vocational Behavior 61, p. 20-52.

Michel, J.W., Lyons, B.D., & Cho, J. (2010). Is the Full-Range Model of Leadership Really a Full-Range Model of Effective Leader Behavior? Journal of Leadership & Organizational Studies 18(4), p. 493-507.

Noldus, L.P.J.J. (1991). The Observer: A software system for collection and analysis of observational data. Behavior Research Methods, Instruments, & Computers 23(3), p. 415-429.

Noldus, L.P.J.J., Trienes, R.J.H., Hendriksen, A.H.M., Jansen, H., & Jansen, R.G. (2000). The Observer Video-Pro: New software for the collection, management, and presentation of time-structured data from videotapes and digital media files. Behavioral Research Methods, Instruments, & Computers 32(1), p. 197-206.

O'Shea, P.G., Foti, R.J., Hauenstein, N.M.A., & Bycio, P. (2009). Are the Best Leaders Both Transformational and Transactional? A Pattern-oriented Analysis. Leadership 5(2), p. 237-259.

Picard, R.W. (n.d.). Toward a wearable autonomic sensor. Retrieved from http://affect.media.mit.edu/projectpages/iCalm/iCalm-2-Q.html

Picard, R.W., & Wolf, G. (2015). Sensor Informatics and Quantified Self. IEEE Journal of Biomedical and Health Informatics 19(5), p. 1531

Poh, M.Z., Swenson, N.C., & Picard, R.W. (2010). A Wearable Sensor for Unobtrusive, Long-Term Assessment of Electrodermal Activity. IEEE Transactions on biomedical engineering 57(5), p. 1243-1252.

Potter, R.F., & Balls, P.D. (2012). Psychophysiological Measurement and Meaning: Cognitive and emotional processing of media. New York: Routledge.

Quantified Self (n.d.). About the Quantified Self. Retrieved from http://quantifiedself.com/about/

Russell, J.A. (1980). A Circumplex Model of Affect. Journal of Personality and Social Psychology 39(6), p. 1161-1178.

Schaufeli, W.B., Bakker, A.B., & Salanova M. (2006). The Measurement of Work Engagement with a Short Questionnaire. Educational and Psychological Measurement 66(4), p. 701-716.

Scherbaum, C.A., & Meade, A.W. (2013). New Directions for Measurement in Management Research. International Journal of Management Reviews 15, p. 132-148.

Senior, C., Lee, N.J., & Butler, M.J.R. (2011). Organizational Cognitive Neuroscience. Organization Science 22(3), p. 804-815.

Smarr, L. (2012). Quantifying your body: A how-to guide from a systems biology perspective. Biotechnology Journal 7, p. 980-991.

Spector, P.E. (2014). Point/counterpoint introduction: Two views of organizational neuroscience. Journal of Organizational Behavior 35, p. 897.

Swan, M. (2009). Emerging Patient-Driven Health Care Models: An Examination of Health Social Networks, Consumer Personalized Medicine and Quantified Self-Tracking. International Journal of Environmental Research and public Health 6, p. 492-525.

Venables, P.H., & Christie, M.J. (1980). Electrodermal activity. In Martin, I., & Venables, P.H., Techniques in Psychophysiology. Chichester: John Wiley & Sons.

Venables, P.H., & Martin. I. (1967). Skin resistance and skin potential. In Venables, P.H., & Martin, I. (Eds.), a manual of psychophysiological methods. Amsterdam: Noord-Holland, p. 53-102.

Waldman, D.A., Balthazard, P.A., & Peterson, S.J. (2011a). Social cognitive neuroscience and leadership. The Leadership Quarterly 22, p. 1092-1106.

Waldman, D.A., Balthazard, P.A., & Peterson, S.J. (2011b). Leadership and Neuroscience: Can We Revolutionize the Way That Inspirational Leaders Are Identified and Developed? Academy of Management Perspectives 25(1), p. 60-74.

Walkenbach, J. (2013). Excel 2013 Power Programming with VBA. Chichester: John Wiley.

Wang, G., Oh, I., Courtright, S.H., & Colbert, A.E. (2011). Transformational Leadership and Performance across Criteria and Levels: A Meta-Analytic Review of 25 Years of Research. Group & Organization Management 36(2), p. 223-270.

Watson, D., Clark, L.A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. Journal of Personality and Social Psychology 54(6), p. 1063-1070.

Van der Weide, J.G. (2007). Een exploratieve video-observatiestudie naar het gedrag van effectieve middenmanagers [An explorative video-study of the behaviors of effective middle managers]. Unpublished doctoral dissertation, University of Tilburg, the Netherlands.

Van der Weide, J.G., & Wilderom, C.P.M. (2006). Gedrag van effectieve middenmanagers in grote Nederlandse organisaties [Behavior of effective middle managers in big Dutch organizations. M&O 2006 (5), p. 35-54.

Westerink, J., Ouwerkerk, M., de Vries, G.J., & de Waele, S. (2009). Emotion measurement platform for daily life situations. 3rd International Conference on Affective Computing and Intelligent Interaction and Workshops.

Wolfe Morisson, E., Wheeler-Smith, S.L., & Kamdar, D. (2011). Speaking Up In Groups: A Cross-level Study of Group Voice Climate and Voice. Journal of Applied Psychology 91(1), p. 183-191.

Wright, T.A., Cropanzano, R., Bonett, D.G., & Diamond, W.J. (2009). The role of employee psychological well-being in cardiovascular health: when the twain shall meet. Journal of Organizational Behavior 30, p. 193-208.

Wright, D.B., London, K., & Field, A.P. (2011). Using Bootstrap Estimation and the Plug-in Principle for Clinical Psychology Data. Journal of Experimental Psychopathology 2(2), p. 252-270.

Zimmerman, P.H., Bolhuis, J.E., Willemsen, A., Meyer, E.S., & Noldus, L.P.J.J. (2009). The Observer XT, A tool for integration and synchronization of multimodal signals. Behavior Research Methods 41(3), p. 731-735.

APPENDIX A: DESCRIPTIONS AND EXAMPLES OF VIDEO-BASED CODED BAHAVIORS BEHAVIORS

	BEHAVIOR	DESCRIPTION	EXAMPLE	LABEL[2]	TOTAL TIME[3]
1.	Showing disinterest	Not taking any action when expected; not having any attention for the meeting	Talking to others while someone else is talking	-	16
2.	Defending one's own position	Emphasizing one's position and self-importance	"I am the manager within this organization"	-	691
3.	Providing negative feedback	Criticizing the behavior of others; focusing on irregularities or mistakes	"I am not happy with the way you did this"	TA	87
4.	Disagreeing	Objecting followers or opposing to them	"I don't agree with you"	-	80
5.	Agreeing	Agreeing, accepting and or assenting with someone	"That's true"	TF	371
6.	Directing / correcting	Imposing someone to conform to norms, values and common procedures	"That's not how we do that in here"	TA	144
7.	Directing / delegating	Explicitly assigning a task to one or more others	"John, I'd like you to take care of that"	TA	652

[2] Label refers to the behaviors used in the analysis for transformational (TF) and transactional (TA) leadership.

[3] The total time is the sum of all time frames where the arousal is analyzed. In other words, from three seconds after the start of each occurrence of a certain behavior to one second after the end of that behavior. These time frames are summed over all meetings. The total time is shown in seconds.

8.	Directing / interrupting	Shortly interrupting someone	Start talking when someone else is talking	-	70
9.	Task monitoring	Checking upon the task progress or current situation	"Have you done this yet?"	TA	1689
10.	Structuring	Organizing the meeting and discussed topics	"We will end this meeting at 2pm"	TA	4540
11.	Informing	Giving factual information	"The budget for this project is…"	TA	24372
12.	Visioning / giving one's own opinion	Stating the direction one would like to follow or what is important	"I think we should…"	-	9609
13.	Visioning / giving one's own long term view	Stating one's own opinion on the long term mission of the organization	"We should really try to reach…"	-	1890
14.	Visioning / giving one's own opinion on organization and strategy	Stating one's own opinion on the current pursuits in the organization	"I think we are doing it wrong now"	-	403
15.	Providing positive feedback	Complementing and rewarding the behavior of others	"You did great"	TF	346
16.	Intellectual stimulation	Positively stimulating and professionally challenging others	"What actions should be taken, according to you?"	-	1687

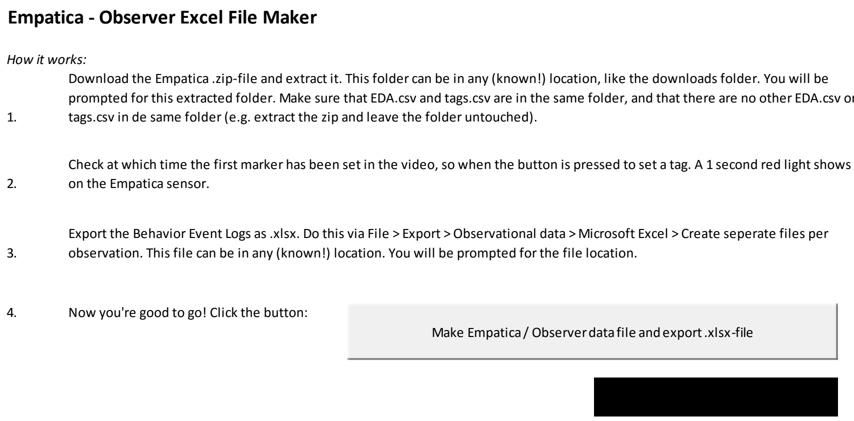
17.	Individualized consideration	Showing an interest in one others feelings or situation; showing empathy	"I am sorry to hear that, how are things now?"	TF	792
18.	Humor	Making friendly or funny jokes	"Let's just invest a billion"	TF	515
19.	Informing personally	Giving information on home situation	"My vacation was great"	TF	117
20.	Listening	Being actively involved in understanding what is said	Nodding head	-	66025

APPENDIX B: EMPATICA – OBSERVER EXCEL FILE MAKER

For this master thesis, a VBA macro has been written that automatically processes the data from the Empatica wristband and the Noldus ‘the Observer XT’ behavioral data, called the “Empatica – Observer Excel File Maker”. In this Appendix, we show the Excel sheet, the use of the macro, and the output of the process. The underlying rationale is explained in the paper itself.

Using the Empatica – Observer Excel File Maker

The File Maker is essentially an Excel ‘.xlsm’ file, including an invisible code, as shown in figure a.


Empatica - Observer Excel File Maker

How it works:

1. Download the Empatica .zip-file and extract it. This folder can be in any (known!) location, like the downloads folder. You will be prompted for this extracted folder. Make sure that EDA.csv and tags.csv are in the same folder, and that there are no other EDA.csv or tags.csv in de same folder (e.g. extract the zip and leave the folder untouched).
2. Check at which time the first marker has been set in the video, so when the button is pressed to set a tag. A 1 second red light shows on the Empatica sensor.
3. Export the Behavior Event Logs as .xlsx. Do this via File > Export > Observational data > Microsoft Excel > Create seperate files per observation. This file can be in any (known!) location. You will be prompted for the file location.
4. Now you're good to go! Click the button: Make Empatica / Observer data file and export .xlsx-file

[redacted]

Figure a: Empatica – Observer Excel File Maker

It shows a short description on how to use the macro.

1. *Download the Empatica .zip-file and extract it. This folder can be in any (known!) location, like the downloads folder. You will be prompted for this extracted folder. Make sure that EDA.csv and tags.csv are in the same folder, and that there are no other EDA.csv or tags.csv in de same folder (e.g. extract the zip and leave the folder untouched).*

The website of Empatica has the possibility to download the recorded data to a compressed .zip-file of a specific recording, including several .csv-data files and an info.txt description file. The user selects the right recording based on date, time, and wristband used, and downloads the corresponding .zip-file. The user doesn’t have to bother about the included files, but only extract it to a known folder (e.g. right click > Extract All…). There is one remark: every recording should have its own folder, so no two EDA.csv or tags.csv files are in the specified folder.

2. *Check at which time the first tag has been set in the video, so when the button is pressed to set a tag. A 1 second red light shows on the Empatica sensor.*

Use 'the Observer' or some other video software to check at which time the button is pressed. In the protocol, written for this master thesis as well, one is asked to first put the device on, wait for a minute, and then press the button shortly in sight of the camera. This so-called 'tag' is recorded by the device. This File Maker automatically uses the first tag that is recorded by the device, which is then used to synchronize behavioral and recorded data with use of the entered video time.

3. *Export the Behavior Event Logs as .xlsx. Do this via File > Export > Observational data > Microsoft Excel > Create separate files per observation. This file can be in any (known!) location. You will be prompted for the file location.*

As a third necessary information source, the Behavior Event Logs should be exported from Noldus 'the Observer XT'.

4. *Now you're good to go! Click the button:*

The user can now run the macro.

A new Excel worksheet opens, and the user is prompted to give the name of the leader, as shown in figure b. The user can, if preferred, also choose to enter the team number or some other recognition.

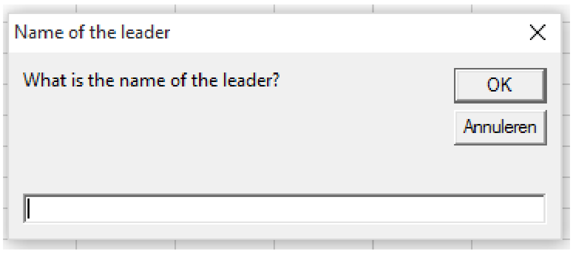


Figure b: Name of the leader

After that, the user is asked to select the folder path where the 'Empatica' data are extracted to in step 1, as shown in figure c.

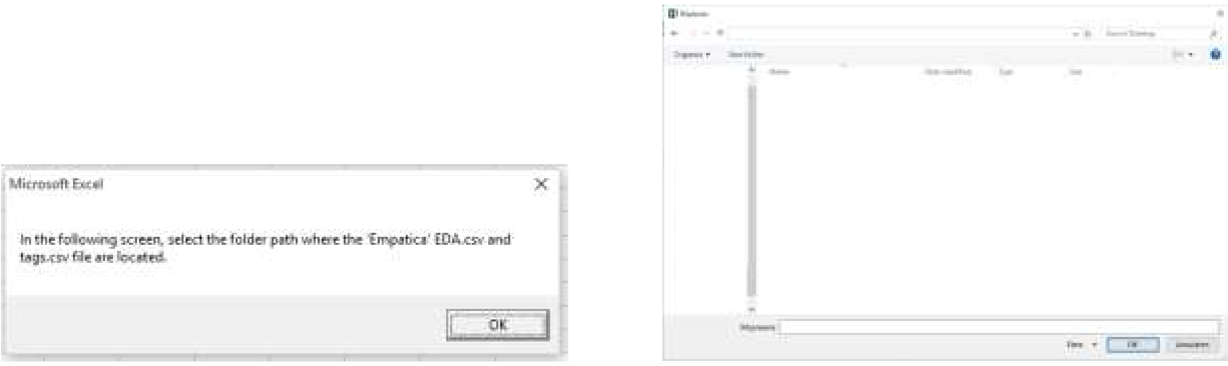


Figure c: Empatica path

If the folder path is chosen, the user is asked to insert the time the first tag is set in the video, as found in step 2 and shown in figure d. This input box is followed by another File Dialog. The user is now asked for the location where the 'the Observer XT' file can be found, as exported in step 3, see figure e.

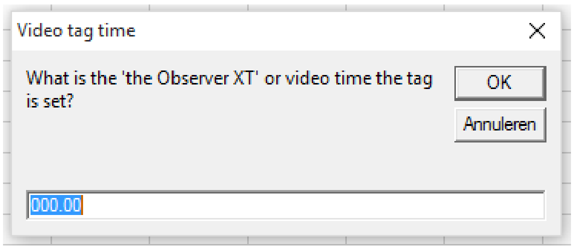


Figure d: Video tag time

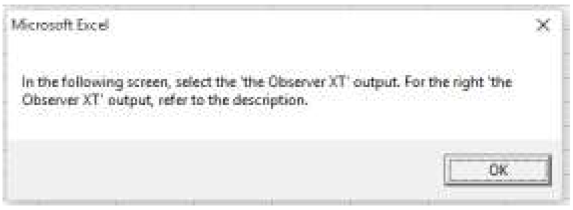


Figure e: 'the Observer XT' output location

If you select a file, the macro will start calculating all necessary information. Wait until Excel shows the screen shown in figure f.

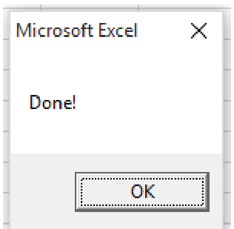


Figure f: Done!

Output of the Empatica – Observer Excel File Maker

The exported Excel has three worksheets, see figure h. The ‘Information’ worksheet shows all information. The Observer data can be referred to for specific ‘the Observer XT’ information, Empatica data shows the skin conductance data from the wristband.

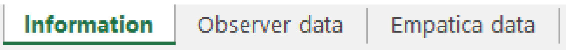


Figure h: Worksheets

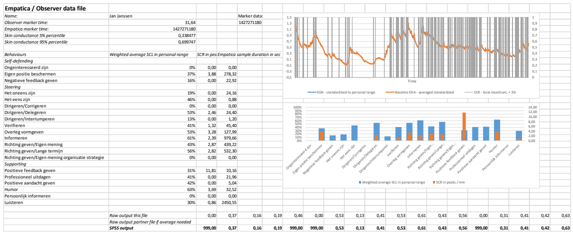


Figure i: Information worksheet

The information worksheet, as shown in figure i, shows in the left upper corner the name and marker time that have been entered by the user, the Empatica tag time and the skin conductance 5% and 95% percentiles from the file, as shown in figure j. Then, the output of the File Maker is shown: the weighted average skin conductance level in personal range, the skin conductance response in peaks per minute, and the total sample duration in seconds, for the meeting that is analyzed.

Name:	Jan Janssen
Observer tag time:	31,64
Empatica tag time:	1427271180
Skin conductance 5% percentile	0,338477
Skin conductance 95% percentile	0,699747

Figure j: General information

Behaviours	*Weighted av*	*SCR in peaks*	*Empatica sar*
Self-defending			
Ongeinteresseerd zijn	0%	0,00	0,00
Eigen positie beschermen	37%	3,88	278,32
Negatieve feedback geven	16%	0,00	22,92
Steering			
Het oneens zijn	19%	0,00	24,16
Het eens zijn	46%	0,00	0,88
Dirigeren/Corrigeren	0%	0,00	0,00
Dirigeren/Delegeren	53%	2,46	24,40
Dirigeren/Interrumperen	13%	0,00	1,20
Verifieren	41%	1,32	45,40
Overleg vormgeven	53%	3,28	127,99
Informeren	61%	2,39	979,66
Richting geven/Eigen mening	43%	2,87	439,22
Richting geven/Lange termijn	56%	2,82	532,30
Richting geven/Eigen mening organisatie strategie	0%	0,00	0,00
Supporting			
Positieve feedback geven	31%	11,81	10,16
Professioneel uitdagen	41%	0,00	21,96
Positieve aandacht geven	42%	0,00	5,04
Humor	63%	3,69	32,52
Persoonlijk informeren	0%	0,00	0,00
Luisteren	30%	0,86	2450,55

Figure k: File Maker output

On the right hand side, two graphs are shown. The top one shows the skin conductance graph from the exact beginning of the meeting to the end of the meeting. The bottom graph shows a visualization of the data shown on the left.

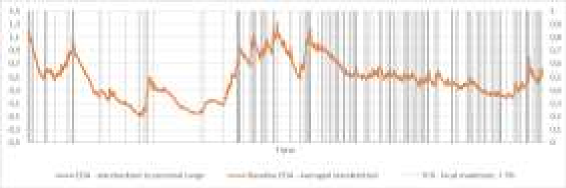


Figure l: Skin conductance graph

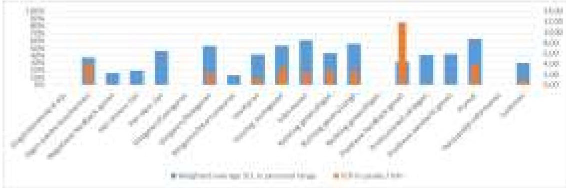


Figure m: File Maker output visualization

The bottom of the file shows a copyable SPSS output. If necessary, the user can repeat all steps with the ‘the Observer XT’-output of another coder, and copy the raw output of that file into this file. The third row shows the SPSS output for this leader, based on both coders.

Raw output this file	0,00	0,37	0,16	0,19	0,46	0,00
Raw output partner file if average needed						
SPSS output	**999,00**	**0,37**	**0,16**	**0,19**	**999,00**	**999,00**

File n: SPSS output

The other worksheets can be referred to if the user is looking for specific information, but are by no means necessary for use of the File Maker.

APPENDIX C: CORRELATION BETWEEN ALL VARIABLES[4]

	M	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CONTROL VARIABLES																	
1. LEADER GENDER[5]	1.3	0.5	-														
2. LEADER AGE	48.0	7.5	-.40*	-													
AROUSAL[6]																	
3. SCL – LISTENING	.43	.12	-.15	.09	-												
4. SCR – LISTENING	1.75	1.63	.07	.19	.30	-											
5. SCL – ALL ACTIVE BEH.	0.54	0.2	-.01	.20	.48*	.20	-										
6. SCR – ALL ACTIVE BEH.	2.99	2.7	-.02	.24	.26	.81**	.37	-									
7. SCL – TRANSFORM. BEH.	0.55	0.2	-.02	.15	.36	.16	.67**	.40*	-								
8. SCR – TRANSFORM. BEH.	4.19	4.2	.15	.04	.26	.71**	.37	.88**	.44*	-							
9. SCL – TRANSACT. BEH.	0.55	0.6	.08	.11	.40*	.18	.97**	.31	.64**	.38	-						
10. SCR – TRANSACT. BEH.	2.78	2.6	-.06	.21	.25	.81**	.29	.97**	.38	.84**	.23	-					
LEADERSHIP[7]																	
11. TRANSFORM. LEADERSHIP	5.34	0.4	.25	.00	-.18	.15	.25	.22	.30	.20	.33	.23	-				
12. TRANSACT. LEADERSHIP	5.23	0.4	.32	-.06	-.16	.12	.09	.17	.10	.15	.15	.21	.74**	-			
LEADERSHIP PERFORMANCE[8]																	
13. LEADER EFFECTIVENESS	5.42	0.5	.25	0.02	**-.11**	**.08**	**.39***	**.20**	**.49****	**.16**	**.46***	**.21**	.82**	.67**	-		
14. EXTRA EFFORT	4.98	0.4	.05	.18	**-.21**	**.14**	**.18**	**.13**	**.20**	**.02**	**.19**	**.15**	.73**	.71**	.64**	-	
15. SATISFACTION WITH LEADER	5.44	0.5	.31	.05	**-.20**	**.03**	**.36**	**.23**	**.50****	**.30**	**.44***	**.20**	.84**	.61**	.87**	.64**	-

[4] * correlations are significant at the 0.05 level (2-tailed), ** correlations are significant at the 0.01 level (2-tailed).

[5] Gender was coded "1" for male and "2" for female.

[6] Refer to text for the units of measurement of arousal. SCL refers to 'skin conductance level', SCR to 'skin conductance responses'.

[7] MLQ Questionnaire data.

[8] MLQ Questionnaire data.

APPENDIX D: LINEAR REGRESSION RESULTS OF MLQ AND SKIN CONDUCTANCE

Linear regression results with 95% BCa CI reported in parentheses. CI, SE and p are based on 1000 bootstrap samples. SCL is an abbreviation for 'skin conductance level' as measure of the leader's arousal.

Transactional behavior

Leadership effectiveness. R^2 = 0.59, p<0.01.

VARIABLE	B	SE B	BETA	P
CONSTANT	0.70 (-1.90; 2.90)	1.03		0.45
GENDER	0.04 (-0.22; 0.44)	0.12	0.04	0.72
AGE	0.00 (-0.01; 0.03)	0.01	0.03	0.77
TRANSACT. LEADERSHIP	0.75 (0.38; 1.01)	0.20	0.61	<0.01
SCL – TRANSACT. BEH.	1.11 (0.47; 2.01)	0.42	0.36	0.02

Extra effort. R^2 = 0.57, p<0.01.

VARIABLE	B	SE B	BETA	P
CONSTANT	0.16 (-2.04; 2.20)	0.85		0.87
GENDER	-0.11 (-0.33; 0.06)	0.13	-0.12	0.38
AGE	0.01 (-0.01; 0.03)	0.01	0.17	0.39
TRANSACT. LEADERSHIP	0.84 (0.54; 1.17)	0.19	0.75	<0.01
SCL – TRANSACT. BEH.	0.21 (-0.81; 0.90)	0.40	0.07	0.60

Satisfaction with leader. R^2 = 0.52, p<0.01.

VARIABLE	B	SE B	BETA	P
CONSTANT	0.71 (-1.62; 3.63)	1.21		0.52
GENDER	0.17 (-0.19; 0.61)	0.17	0.16	0.32
AGE	0.01 (-0.02; 0.04)	0.01	0.10	0.55
TRANSACT. LEADERSHIP	0.68 (0.23; 1.05)	0.25	0.51	0.01
SCL – TRANSACT. BEH.	1.12 (0.22; 2.12)	0.48	0.34	0.03

Transformational behavior

Leadership effectiveness. $R^2 = 0.75$, $p<0.01$.

VARIABLE	B	SE B	BETA	P
CONSTANT	-0.37 (-1.83; 0,95)	0.85		0.62
GENDER	0.08 (-0.15; 0.34)	0.14	0.08	0.60
AGE	0.00 (-0.02; 0.02)	0.01	0.01	0.93
TRANSFORM. LEADERSHIP	0.99 (0.55; 1.39)	0.17	0.72	<0.01
SCL – TRANSFORM. BEH.	0.63 (0.07; 1.35)	0.29	0.28	0.03

Extra effort. $R^2 = 0.58$, $p<0.01$.

VARIABLE	B	SE B	BETA	P
CONSTANT	-0.44 (-3.04; 1.70)	1.01		0.62
GENDER	-0.07 (-0.34; 0.19)	0.14	-0.08	0.60
AGE	0.01 (-0.01; 0.04)	0.01	0.16	0.38
TRANSFORM. LEADERSHIP	0.96 (0.59; 1.33)	0.22	0.77	<0.01
SCL – TRANSFORM. BEH.	-0.11 (-0.83; 0.66)	0.33	-0.05	0.72

Satisfaction with leader. $R^2 = 0.79$, $p<0.01$.

VARIABLE	B	SE B	BETA	P
CONSTANT	-1.01 (-2.76; 0.16)	0.81		0.17
GENDER	0.18 (-0.06; 0.42)	0.11	0.16	0.11
AGE	0.01 (-0.01; 0.03)	0.00	0.07	0.60
TRANSFORM. LEADERSHIP	1.05 (0.74; 1.43)	0.17	0.71	<0.01
SCL – TRANSFORM. BEH.	0.68 (0.14; 1.15)	0.26	0.28	0.02

Relative influence of arousal during different behaviors

Leadership effectiveness. $R^2 = 0.44$, p=0.03.

VARIABLE	B	SE B	BETA	P
CONSTANT	4.62 (2.78; 6.30)	0.91		<0.01
GENDER	0.19 (-0.20; 0.49)	0.19	0.19	0.30
AGE	0.00 (-0.03; 0.03)	0.01	0.03	0.85
SCL – LISTENING	-1.42 (-2.92; -0.27)	0.74	-0.36	0.06
SCL – TRANSFORM. BEH.	0.95 (0.03; 2.11)	0.46	0.42	0.03
SCL – TRANSACT. BEH.	0.98 (-0.31; 3.06)	0.70	0.32	0.16

Extra effort. $R^2 = 0.19$, p=0.45.

VARIABLE	B	SE B	BETA	P
CONSTANT				
GENDER		Model not significant		
AGE				
SCL – LISTENING				
SCL – TRANSFORM. BEH.				
SCL – TRANSACT. BEH.				

Satisfaction with leader. $R^2 = 0.54$, p<0.01.

VARIABLE	B	SE B	BETA	P
CONSTANT	4.47 (2.72; 5.91)	0.93		<0.01
GENDER	0.28 (-0.17; 0.64)	0.18	0.26	0.14
AGE	0.00 (-0.02; 0.04)	0.01	0.09	0.61
SCL – LISTENING	-1.95 (-3.97; 0.23)	0.82	-0.46	0.03
SCL – TRANSFORM. BEH.	1.14 (0.18; 2.05)	0.42	0.47	<0.01
SCL – TRANSACT. BEH.	0.97 (-0.41; 2.56)	0.65	0.30	0.12