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# Cooperative leadership in hyperscanning. Brain and body synchrony during manager-employee interactions

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Abstract

*Recent advances in neurosciences permitted to extend the knowledge about brain functioning to the organizational field with a specific interest to leadership, with the extent to explore more proficient ways of managing. In the present research, through a hyperscanning paradigm, EEG and autonomic synchrony was explored during performance reviews to investigate if different leadership styles (partecipative vs. authoritative), could be associated with different dyadic engagement. Analysis involved coherence computation assessing the strenght of inter-brain and body synchrony, which revealed the presence of a higher emotional synchronization for both neural and bodily reactions mainly for partecipative style.*

*Keywords: neuromanagement; leadership style; EEG; autonomic measures; coherence*

## 1. Introduction

Recent advances in the neuroscience field permitted to extend and improve the knowledge about brain functioning in different social life situations, giving space to the development of a new research field, that is social cognitive neurosciences (Camerer, Loewenstein, & Prelec, 2004). This specific branch applies scientific disciplines such as psychology, physiology and neuroscience to the empirical study of interpersonal social dynamics (Blakemore, Winston, & Frith, 2004). Thus, it is possible to observe interesting social processes by an interdisciplinary perspective (Ochsner & Lieberman, 2001). Accordingly, this new direction allows observing, through the use of neuroscientific tools and neuropsychology (Lieberman, 2007), different social phenomena such as empathy, emotions, cognition, agency, and interactive behavior.

In the last few years, in particular, this approach has been applied also to the organizational field, with a specific interest in relational and communication issues. One of the most important focus at this regard was devoted to leadership and its different features, such as transformational (Ashkanasy, 2013), inspirational leadership (Waldman, Balthazard, & Peterson, 2009), and generative leadership (Balconi, Fronda, Natale, & Rimoldi, 2017b). For example it was found that transformational leader behavior, to be effective, has to combine emotional balance and self control, emotional understanding by the leader of the followers' needs, foresight and insight, communication skills (Balthazard, Waldman, Thatcher, & Hannah, 2012).

This interest is due to the extent to explore new ways of managing, which consider more supportive and interpersonal exchange (Ashkanasy, 2013; Balthazard et al., 2012; Waldman et al., 2009). For example, the results of previous research showed how cooperative leadership has positive effects not only within the individual performance, but also within work group and organization (Judge & Piccolo, 2004; Lowe, Kroeck, & Sivasubramaniam, 1996). In particular, it has been observed that a more cooperative style of leadership encourages interactions between colleagues, thus bringing a greater performance of the individual and its commitment toword the company (Bass & Bass, 2009).

Previous neuroscience studies about cooperative leadership processes tried to detect the markers of a generative style of leadership, finding the activation of some brain areas that seem involved in the interaction processes. For example, the frontal lobes appear to be good predictors of functional leadership behaviors (Balthazard et al., 2012). This area, in fact, appears to be involved in executive functioning and monitoring, such as self-regulation, planning and organization of behaviors (Lewis, 1997). Furthermore, the frontal cortex integrates external and internal sensory information, organizing it temporally and transforming it into complex behavioral response patterns, which are the basis of the leadership processes (Case, 1992; Fuster, 1999). In fact, leaders need a great ability to regulate and monitor others' and their own behavior (Zaccaro, Foti, & Kenny, 1991). Indeed, prefrontal cortex supports behavioral, affective, social and cognitive components during interpersonal exchange

(Levitan, Hasey, & Sloman, 2000). Moreover, the recruitment of such regions was previously identified in cooperative social tasks during significant joint performance (Balconi, Crivelli, & Vanutelli, 2017a; Balconi, Pezard, Nandrino, & Vanutelli, 2017c). The involvement of these regions in social interactions highlights the use of top-down control mechanisms for particular emotional responses related to social events (Marsh, Blair, Jones, Soliman, & Blair, 2009).

Moreover, within the frontal lobe, some specific processes could be ascribed to the left and the right hemisphere (hemispherical asymmetries) because of the differences in the way information is processed (Hellige, 1990). Some studies highlighted how a greater activity of the left hemisphere presides over an analytical and rational information processing during decision making, thus indicating a better ability to discriminate the details and explore the possibilities of action (Hellige, 1990). On the contrary, greater activity of the right hemisphere can be associated with holistic processes of information processing indicating a contribution of emotional processes (Craig & Craig, 2009; Jones, Field, & Davalos, 2000). Consequently, a dysfunction of the right front of the brain results to be related to an inability or difficulty in understanding interpersonal relationships (Salloway, Malloy, & Duffy, 2001) or in balancing emotions in conditions of uncertainty (Naqvi, Shiv, & Bechara, 2006). The observation of hemispheric lateralization can therefore provide more information on skills and styles of leadership (Thatcher, North, & Biver, 2008).

Besides localization, some other neural markers could be used to understand emotional and cognitive processes, that is electroencepalographyc activity and specifically the frequency brain oscillations. In fact, the so-called cortical bands are measures of a brain area activation, given by the extraction of specific frequencies from the EEG trace. A prevalent delta band activity in the frontal area, for example, results to be correlated to the affective salience and to the importance attributed to a particular event (Balconi & Lucchiari, 2006). Moreover, Knyazev (Knyazev, 2007) showed that it is involved in motivational systems and during salience detection of a certain stimulus. In addition, both delta and theta modulations were found to be related to arousing power of stimuli (Balconi, Brambilla, & Falbo, 2009a; Balconi & Pozzoli, 2009), as well as to motivational and attentional significance of relevant emotional cues (Balconi, Brambilla, & Falbo, 2009b; Balconi & Pozzoli, 2009; Başar, 1999). Higher frequencies, instead, such as beta band, proved to be more sensitive to attentive processes. In fact, beta waves are usually related to an alert state of mind, active thinking and attention (Güntekin, Emek-Savaş, Kurt, Yener, & Başar, 2013).

In addition to neural markers, other emotional and cognitive cues could be acquired from the peripheral system and autonomic body activity, and specifically from electrodermal (EDA) and cardiovascular activity recording (Heart Rate: HR). These indices can easily measure some reactions during interpersonal processes, like empathy (Levenson & Ruef, 1992) and affective behaviors (Adolphs, 2003; Levenson & Gottman, 1983; Vanutelli, Gatti, Angioletti, & Balconi, 2017). EDA is composed by

SCL and SCR. SCL reflects a general arousal activation (Malmo, 1959), while SCR can be interpreted as an index of emotional processing and attention (Damasio, 1994; Frith & Allen, 1983; Öhman & Soares, 1994; Soares & Öhman, 1993) towards a specific stimulus. HR usually reflects the emotional valence (Bradley & Lang, 2000; Sequeira, Hot, Silvert, & Delplanque, 2009), with a significant acceleration especially in response to aversive situations (Balconi et al., 2009b; Nagai, Critchley, Featherstone, Trimble, & Dolan, 2004; Solbakk, Reinvang, Svebak, Nielsen, & Sundet, 2005).

However, the use of autonomic and peripheral indices is still rarely applied to neuromanagement, despite of their usefulness in an ecological setting. Naming one of them, a recent pilot study on leader-employee relationship (Balconi, 2017; Venturella, Gatti, Vanutelli, & Balconi, 2017) explored a manager-employee interaction with the aim to find neurophysiological markers of emotional and cognitive responses, comparing authoritative and participative styles.

Central (EEG) and peripheral measures can be considered individually for each subject comparing different experimental conditions or belonging to different groups, but can be also used to perform more sophisticated analyses which consider the two activities jointly to assess their mutual modifications. This paradigm has been called "hyperscanning" (Balconi et al., 2017c; Dumas, Nadel, Soussignan, Martinerie, & Garnero, 2010; Montague, 2002) by considering brain-to-brain coupling. In fact, it has been shown that observing the actions, emotions or feelings of others can elicit the same cortical representations, a mechanism defined as vicarious activation (Balconi & Vanutelli, 2017a; Hasson, Ghazanfar, Galantucci, Garrod, & Keysers, 2012; Keysers & Gazzola, 2009).

Synchrony of neuro and psychophysiological responses has been found across a broad range of contexts and can be used to assess the strenght of the coupling of the two signals (for a review see Balconi & Vanutelli, 2017). Considering EEG activity, increased coherence was found during rhythm, music and motor synchronization (Kawasaki, Yamada, Ushiku, Miyauchi, & Yamaguchi, 2013; Konvalinka et al., 2014; Sänger, Müller, & Lindenberger, 2012), but also during cooperative activity with evidence from the Game Theory (Astolfi et al., 2012), or using computer-based paradigms in lab settings (Balconi & Vanutelli, 2016). For what concerns autonomic activity, hyperscanning was also applied, founding heart rate synchrony between spouses engaged in conversation (Gottman & Levenson, 1986), in dyads connected by touching (Chatel-Goldman, Congedo, Jutten, & Schwartz, 2014), in mother-infants dyads (Feldman, Magori-Cohen, Galili, Singer, & Louzoun, 2011), during trust-based social interactions (Mitkidis, McGraw, Roepstorff, & Wallot, 2015), and group cohesion and team trust (Strang, Funke, Russell, Dukes, & Middendorf, 2014).

In the present research, by using a hyperscanning paradigm, we explored EEG (coherence) and peripheral autonomic synchrony during performance evaluation condition as a tipical manager-employee interaction. In particular, we were interested in detecting different responses inside the leader-employee dyad characterized by different style of leadership (partecipative vs. authoritative style) during a sensitive managerial process. Leadership style was stressed during a role-played interaction by the use of a different communication style: responsive and partecipative vs. unidirectional and authoritative one, that we thought would affect the conversation trend. Furthermore, based on our hypotheses we expected a significant increased synchronicity within the dyad in the case of a more partecipative leadership style. Indeed we supposed an increased coherence measures for both central (EEG frequency band modulation) and autonomic (peripheral markers) components. Specifically, these higher synchronicity (higher coherence measure) was expected for some frequency bands which were found to be more directly responsive to the emotional significance of the interactions, that is the low-frequency bands such as delta and theta. In addition the cortical prefrontal site (and the DLPFC) was attended to reveal the most significant coherence increasing for the two-brains in the case of partecipative leadership condition, based on the brain-to-brain coupling hypothesis and to the social significance of these frontal areas.

## 2. Method

### *2.1 Participants*

11 leaders and 11 employees have been recruited for the present experiment (22 subjects; M=43,55, SD=8,33; 86% male) and then randomly coupled in leader-employee dyads. Participants were recruited from three different companies. All participants voluntarily submitted to the experiment after giving their written informed consent which reported the research aims.

### *2.2 Procedure*

Each dyad was composed of a leader and an employee, who was subjected to evaluation. Indeed participants were required to role-play a performance review based on specific scenarios about the employees' productivity. Leaders were previously instructed to represent a particular type of leadership style following a progress report to be followed during the interview. 5 leaders had to use an empathetic and partecipative communication and leadership, while 6 leaders had to use a more authoritative leadership style, characterized by an unidirectional communication. The two members of the dyads were positioned closed and next to each other, in order to promote face-to-face interaction. No time limits were set in a way that each dyad could be free to manage its time. The sessions were continuosly video-recorded, together with electrophysiological and autonomic measures acquisitions. Also, a 120s baseline was set before beginning the interviews (fig 1).

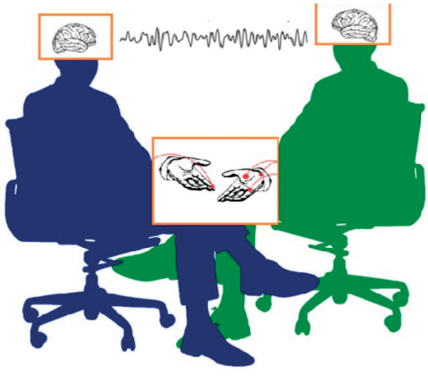

*Figure 1. Experimental hyperscanning setup*

### *2.3 EEG recording and coherence analysis*

EEG acquisitions were conducted with two 16-channel portable EEG-System (V-AMP: Brain Products, München. Truscan: Deymed Diagnostic, Hronov). Two ElectroCaps with Ag/AgCl electrodes referred to the earlobes (10/5 system of electrode placement; Oostenveld & Praamstra, 2001) have been applied. About the frontal sites, electrodes were placed over Fp1, Fp2, F3, F4 for both leader and employee. Data were acquired using a sampling rate of 1000 Hz, with a frequency band of 0.01-40 Hz. The impedance of the recording electrodes was monitored for each subject prior to data collection and was always below 5 kΩ. To prevent artifacts related to signal-to-noise ratio, an off-line common average reference was used (Ludwig et al., 2009). Moreover, one EOG electrode was positioned on the outer canthi of the eye to acquire eye movements. For the successive analyses, only artifacts-free epochs were considered thanks to EOG correction and visual inspection (rejected epochs, 2%) to increase specificity. Ocular artefacts, including eye movements and blinks, were adjusted by using a correction algorithm that applies a regression analysis together with artefact averaging (Sapolsky, 2004). Digital EEG data (from all 12 active channels) were band-pass filtered in the following frequency bands: Delta (0.5-3.5Hz), Theta (4-7.5Hz), Alpha (8-12.5Hz), Beta (13-30Hz). During data reduction a bandpass filter was applied in the 0.01-50 Hz frequency band. For the statistical analysis specific frontal areas were considered.

For what concerns signal processing, a set of analysis was applied to obtain inter-brain connectivity (inter-sybjective coherence) by calculating the partial correlation coefficient $\Pi_{ij}$ for each pair of channels and for each dyad, applied to each frequency band. They were obtained by normalizing the inverse of the covariance matrix $\Gamma = \Sigma^{-1}$.

$$\Gamma = (\Gamma_{ij}) = \Sigma^{-1} \text{ inverse of the covariance matrix}$$

$$\Pi ij = \frac{-\Gamma ij}{\sqrt{\Gamma ii \Gamma jj}} \text{ partial correlation matrix}$$

It quantifies the relationship between two signals (i, j) irrespective of the other (Wheland et al., 2012)

*2.4 Autonomic measures recording and synchrony analysis*

For each dyad component's autonomic measures recording two different devices were used. Biopac MP 150 system (Biopac Systems Inc., USA) continuously recorded ECG in lead1 from two electrodes positioned on the lower wrist, with the positive pole on the left arm and the negative pole on the right one. The ECG signal was sampled at 1000 Hz with the Biopac Acknowledge 3.7.1 software (Biopac Systems Inc., USA) and was converted to heart rate (HR, beats per minute, bpm). The signal was lowpass filtered at 35 Hz and highpass filtered at 0.05 Hz. The electrodes for SCR and SCL (electrodermal activity or the electrical conductance of the skin expressed in μS) were placed on the palm of the non-dominant hand according to a bipolar montage. The signal was sampled at 1000 Hz and lowpass filtered at 10 Hz.

Then, inter-subjects Pearson's correlational indices were calculated to compute the synchronization values within each dyad.

## 3. Results

Two orders of analyses were performed: a first step included a general analysis (repeated measure ANOVA) about the modulation of the neurophysiological dependent variables throughout the task (both electrophysiological and autonomic measures) considering the different leadership style (partecipative vs authoritative) and organizational position (leader vs. employee).

A second step included the application of ANOVAs on synchrony indices as dependent variables (coherence indices for EEG and Pearson's values for HR, SCL and SCR). For all the ANOVA tests, the degrees of freedom have been corrected using Greenhouse–Geisser epsilon where appropriate. Post-hoc comparisons (contrast analyses) were applied to the data. Simple effects for significant interactions were further checked via pair-wise comparisons, and Bonferroni correction was used to reduce multiple comparisons potential biases. Furthermore, the normality of the data distribution was preliminary assessed by checking kurtosis and asymmetry indices.

### *3.1 General analysis - EEG measure*

The first set of analysis (mixed model ANOVA) applied to EEG included three independent factors: leadership style (2), organizational position (2) and electrode site (7).

As shown by ANOVA about delta band, interaction effect style x electrode showed significant differences ($F[6, 40]= 8.18$, $p \leq .001$, $\eta^2 = .40$). Indeed post-hoc paired comparisons revealed increased frontal (F3 and F4) activation more for partecipative than authoritative style (respectively $F[1, 40]= 7.40$, $p \leq .001$, $\eta^2 = .37$; $F[1, 40]= 7.77$, $p \leq .001$, $\eta^2 = .37$) (fig 2a).

About theta band, interaction effect style x electrode showed significant differences ($F[6, 40]= 8.45$, $p \leq .001$, $\eta^2 = .41$). Post-hoc paired comparisons revealed increased frontal (F3 and F4) activation more for partecipative than authoritative style (respectively $F[1, 40]= 7.87$, $p \leq .001$, $\eta^2 = .38$; $F[1, 40]= 7.51$, $p \leq .001$, $\eta^2 = .35$) (fig 2b).

Finally, about beta band, style x electrode showed significant interaction effect ($F[6, 40]= 8.02$, $p \leq .001$, $\eta^2 = .39$). Post-hoc paired comparisons revealed showed F3, FP1 and FP2 activation more for partecipative than authoritative style (respectively $F[1, 40]= 7.12$, $p \leq .001$, $\eta^2 = .36$; $F[1, 40]= 7.03$, $p \leq .001$, $\eta^2 = .35$; $F[1, 40]= 7.43$, $p \leq .001$, $\eta^2 = .37$) (fig 2c). No other effect was statistically significant.

### *3.2 General analysis – Autonomic measures*

For SCR, style main effect was significant ($F[1, 140]= 8.43$, $p \leq .001$, $\eta^2 = .38$). As shown, significant increased SCR was found in both leader and employee in the case of partecipative style more than authoritative. About SCL significant effect was found for style ($F[1, 40]= 9.02$, $p \leq .001$, $\eta^2 = .43$), with higher SCL value for partecipative more than authoritative style (fig. 3a-b). No other effect was statistically significant.

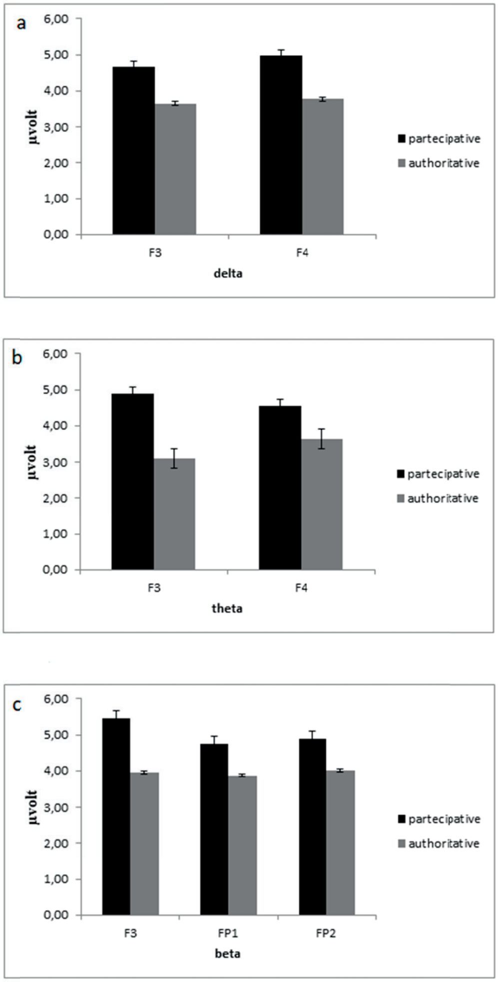


*Figure 2. Significant Style*Electrode effect for delta (a), theta (b), and beta (c)*

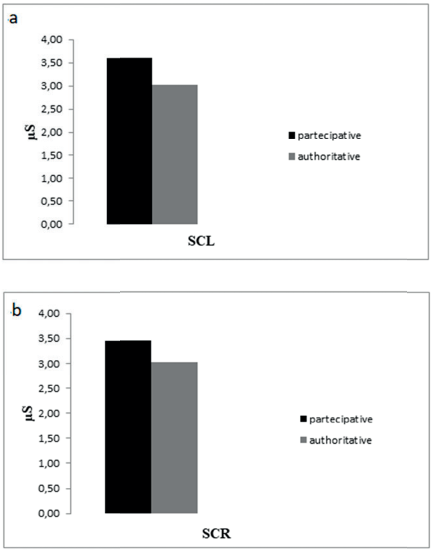


*Figure 3. SCR and SCL modulation for Style effect. Results showed higher responses in the participative condition*

### *3.3 Coherence analysis – EEG measures*

The ANOVA applied to inter-brain indices for the dyads revealed significant effects. Indeed about delta band, interaction effect style x electrode showed significant differences ($F[6, 40]= 8.18$, $p \leq .001$, $\eta^2 = .40$). Post-hoc paired comparisons revealed increased frontal coherence within the dyads for F3, F4, FP1, more for partecipative than authoritative style (respectively $F[1, 40]= 7.59$, $p \leq .001$, $\eta^2 = .37$; $F[1, 40]= 7.02$, $p \leq .001$, $\eta^2 = .35$; $F[1, 40]= 7.80$, $p \leq .001$, $\eta^2 = .38$) (fig 4a).

About theta band, interaction effect style x electrode showed significant differences ($F[6, 40]= 8.02$, $p \leq .001$, $\eta^2 = .40$). Post-hoc paired comparisons revealed increased frontal coherence within the dyads for F3, F4, FP1, more for partecipative than authoritative style (respectively $F[1, 40]= 7.23$, $p \leq .001$, $\eta^2 = .36$; $F[1, 40]= 7.55$, $p \leq .001$, $\eta^2 = .35$; $F[1, 40]= 8.43$, $p \leq .001$, $\eta^2 = .39$) (fig 4b). No other effect was statistically significant.

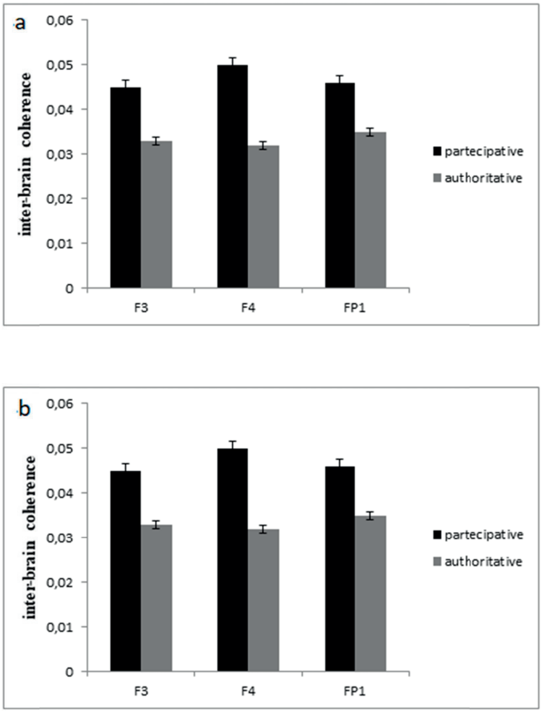


*Figure 4. Significant Style*Electrode effect for Delta (a) and theta (b) coherence*

### *3.4 Coherence analysis – Autonomic measures*

For SCR, Pearson's correlational indices within each dyad revealed significant style main effect ($r^2$ = .513, $p \leq .001$). As shown, significant positive relationship was found within the dyad for partecipative style. About SCL, significant effect was found for style ($r^2$ = .557, $p \leq .001$) with significant positive relationship within the dyad in the case of partecipative style (fig. 5a-b). No other effect was statistically significant.

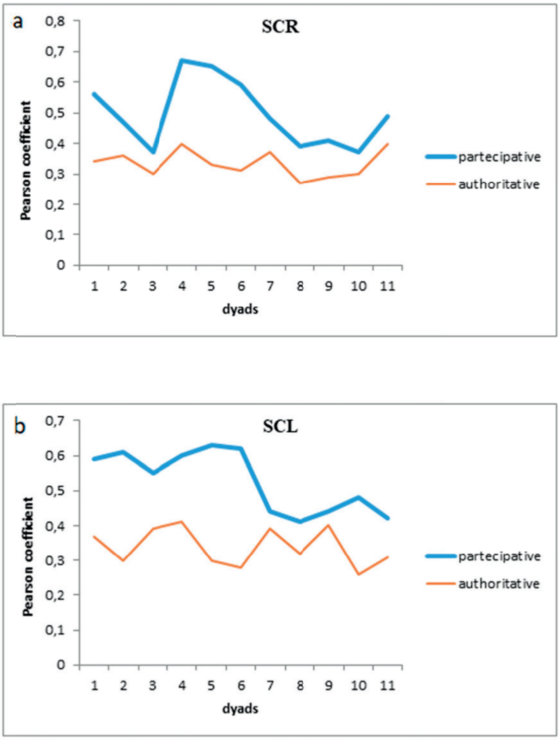


*Figure 5. Significant Style effect for (a) SCR and (b)SCL correlational indices*

## 4. Discussion

The aim of the present work was to investigate and assess the neuro and psychophysiological response of managers and employees during a performance review conducted with different leadership styles: authoritative vs partecipative. A neuroscientific approach was applied to allow the recording of responses with respect to central (electrocortical) and autonomic activity (peripheral), within a multimethod perspective. The specific organizational role was also included as a variable of interest. Such signals were analyzed with two different sets of analyses, where the first included a general investigation of the neural response to the different conditions, roles, and brain areas, while the second one involved coherence analyses assessing the strenght of inter-brain and inter-body synchrony.

For what concerns the first set of analyses, EEG results revealed an increased delta and theta band activity over F3 and F4 for the partecipative group. Regarding beta, instead, besides F3 activity, more anterior regions were involved, that is Fp1 and Fp2. Low-frequency EEG bands have often be associated with some kinds of emotion processing. In particular, theta band was associated with orienting functions to salient emotional cues, and typically emerges with increasing attentional demands and/or task difficulty (Başar, 1999). Thus, it is possible to assume that the modulation of this frequency band may be responsive to the arousal effect on emotional cues' comprehension. For what concerns delta, previous research found that it is involved in salience detection and it is associated with motivational factors (Knyazev, 2007). Interestingly, both frequencies have been found in both hemisphere, regardless of emotional valence. Therefore, we could hypothesized that theta and delta modulations appeared in response to motivational and attentional meaning of significant emotional cues per se (Balconi, Grippa, & Vanutelli, 2015; Balconi & Pozzoli, 2009). In the context of the annual review, such bilateral activation could thus reflect an emotional and attentional engagement during a situation perceived as higly significant, that is a partecipative social exchange. Regarding the specific localization, F3 and F4 correspond to the dorsolateral prefrontal cortex (DLPFC) (Koessler et al., 2009). This area was previously associated with social cognition, and in particular with theory of mind (Kalbe et al., 2010) and the commitment in significant relationships (Petrican & Schimmack, 2008), which is compatible with the social nature of the simulation. Moreover, the bilateral activation of such area is compatible with the recruitment of both cognitive and emotional processes within the social interaction (Craig & Craig, 2009; Hellige, 1990; Jones et al., 2000) involving motivation and affect and, possibly, intentionality of the communicative act.

Considering beta band, instead, it is described as a neural marker of attention and cognitive processing (Başar, Başar-Eroglu, Karakaş, & Schürmann, 2001) and an alert state of mind. Although beta waves emerged also over the left DLPFC, the effect was prevalent over frontopolar regions, corresponding to the superior frontal gyrus. This area was previously related to higher cognitive functions and particularly to working memory (WM) (Du Boisgueheneuc et al., 2006). Therefore, it is possible to assume that both emotional and cognitive components were recruited during the interpersonal social dynamic in the form of specific localization and functional oscillations. Thus, we could interpret the partecipative leadership style as a good way to establish a significant bond between managers and employees. In fact, such effect was present for both roles, included within an empathic framework based on support and understanding.

Considering autonomic indices, instead, both SCR and SCL were higher in the partecipative dyads. Electrodermal Activity (EDA) recording identifies modifications in skin conductivity deriving from sweat emission that can be considered an indicator of emotional arousal (Sohn, Sokhadze, & Watanuki, 2001). Thus, according to our hypotheses, the partecipative leadership could be associated with a higher rewarding effect (Kätsyri, Hari, Ravaja, & Nummenmaa, 2013). Indeed, previous research underlined a similar increased autonomic responsivity during, for example, gambling conditions (Sharpe, 2004). Interestingly, such effect was still present in both roles, thus revealing a reciprocal gratifying situation.

Analyzing the coherence effect, the ANOVA applied to inter-brain indices revealed increased connectivity between F3, F4, FP1 when considering low frequency bands (delta and theta) during partecipative interpersonal exchange. Both the localization, mainly over the DLPFC, and the functional role of EEG oscillation within low-frequency ranges, suggest how coherence measures attest an emotional attuning of the two participants within the dyad, as already revealed by previous research on cooperation and bond construction (Balconi et al., 2017a, 2017c). Moreover, previous studies by Balconi and colleagues (Balconi et al., 2017c; Balconi & Vanutelli, 2017b, 2017c) implemented an innovative experimental paradigm through which it is possible to manipulate the emotional dyadic strength by administering specific social feedback. The various experimental scenarios demonstrated that this area was especially recruited during the most significant emotional and social exchange. Similarly, the increased coherence in the present situation can reveal higher synchrony in the partecipative group.

In this case, beta band did not show any significant coherence effect, in favor of higher connectivity within low-frequency ranges. This result is in line with the functional meaning of theta and delta band and their emergence during emotional scenarios, thus revealing increased connectedness.

Also, with respect to single-brain analyses, a new area emerged as highly connected, that is the left frontopolar cortex (Fp1). The activation of this region was previously associated with higher-order emotional processes, such as emotional control over automatic associations (Volman, Roelofs, Koch, Verhagen, & Toni, 2011), social control and the regulation of social conduct (Moll, Eslinger, & Oliveira-Souza, 2001), including moral behavior and moral learning (Moll & de Oliveira-Souza, 2007). Thus, we could hypothesize that the brain activity during the task was supported by different emotional networks: when observing the evoked task-related activity in single brains, dorsolateral regions' activation emerged in support of motivational and engagment components of the dyadic process. When considering the connections (coherence) between brain areas of the two members, instead, more anterior regions were involved, thus suggesting the need for social-regulating mechanisms.

At the same time, a positive mutual ongoing variation of autonomic responses (both SCL and SCR) was found within partecipative dyads. Since the presence of a co-evolution of electrodermal responses has been associated to the quality of social interactions (Guastello, Pincus, & Gunderson, 2006; Vanutelli et al., 2017), both the central and the peripheral coherence seem to contribute to underline the presence of a joint effect. This result is of particular interest if we consider the mutual influence between mental processes and the physiological state of the body. Previous research (Sequeira et al., 2009) proposed that the autonomic activity could be seen as a body-brain interface supporting complex behaviors, such as emotional reactions and social exchange. Moreover, according to the

Somatic Marker Hypothesis, peripheral reactivity can be considered as a mediator of social experiences (Damasio, Everitt, & Bishop, 1996), in interplay with higher-order prefrontal areas devoted to emotional control and monitoring. Thus, the involvement of affective mechanisms appears consistent for both brain and body reactions.

The present findings provide new insights into the application of original and innovative neuroscientific paradigms such as hyperscanning to explore the presence of cognitive and emotional synchrony of different actors within the organizational framework that could be applied to different interpersonal situations. Future studies could proceed exploring these issues by considering, for example, individual, motivational and personaliy factors, together with different demographic variables such as gender and age, in a way to better select the most proficient dyadic, group and organizational settings.

## *Conflict of interest*

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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