

When brains dialogue by synchronized or unsynchronized languages. Hyperscanning applications to neuromanagement

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ABSTRACT

Neuromanagement deals with neuroscience methodological approaches to the management. A management construct is leadership, but objective psychophysiological data in support of it are still missing. The present pilot study aimed to apply the hyperscanning paradigm during a role-played employees' evaluation. Our purpose was to identify lexical and neuro/psychophysiological markers of leader-employee interactions. The sample consisted in paired manager-collaborator couples. Managers were required to use two different communication styles: authoritative vs. cooperative. A conversational analysis permitted to identify main topics to interpret data. Results showed that the interview was more arousing for the employee than the manager. Greater Delta and Theta EEG bands could denote positive valence of personal interactions and company mission topics. Autonomic measures (Skin Conductance Response, SCR and Heart Rate, HR) showed important information related to different leadership style. Results highlight the importance of applying neurosciences to organizational contexts exploring processes related to manager-employee dynamics and communicative style.

Keywords: Management; Hyperscanning technique; Leadership; Communicative style

1. INTRODUCTION

Cognitive neurosciences have recently been applied to the management studies, alongside other disciplines, to investigate the physiological responses and cerebral indices when people are faced with typical problems of economics and management (Balconi & Venturella, 2015).

Springing up as an innovative discipline, neuromanagement deals with the application of cognitive neuroscience models and methodological approaches to the management and its component and features, so as to encourage new research horizons.

1.1 Neuromangement topics: neuroleadership

A well-known and investigated management construct is leadership and its features. The study conducted by Lewin and White (1939) represents the most significant contribution in the description of the different style of leadership. The main styles described by the authors refer to different form of communication. In particular three types of leadership have been described: autocratic, democratic and laissez-faire. Considering an autocratic style, communications are centralized. This leadership style allows to obtain, in general, good productivity, but inevitably entails a heavy reliance on leaders, forms of aggression among group members who feel poorly motivated. Democratic style requires that the most important decisions are taken with the participation of the group. This way of doing favours the participation of all in decision-making; the group, therefore, feels more involved in choices and is more motivated. Through this style of leadership, the leader expresses confidence in group's members and supports them in their activities, but still remains ultimately responsible for the choices. In particular, the authors hypothesized that the leader's function was to create a certain "social climate" in the group, and that, this climate, influenced the mood of the group members including its performance. The study showed that a democratic style (or transformational) has a good balance between productivity and satisfaction among group members (Bass, 1985). This type of study has encouraged the interest in finding effective leadership models.

Some theories have shown that the effectiveness of a leadership style may have biological basis. Finkelstein and Hambrick (1996) noticed how

individuals with dominant left hemisphere are less effective manager than those with dominant right hemisphere, as the latter is responsible for imagination, creativity, emotional response, characteristics needed to become a good manager. The emotion, as well as communication, is an aspect of great importance in the study of leadership, so many researchers have focused their attention on this topic without forgetting the importance of communication related to leadership styles (Conger & Kanungo, 1998). Different researchers suggested that leader emotional displays may influence followers either by motivating them because they convey positivity, or because they are contagious and engender positive emotions in followers that guide their behaviour (Balconi & Venturella, 2015).

It is also important to make decisions about how to use emotions to inspire others to express a higher level of emotional intelligence (Goleman, Boyatzis & McKee, 2002). This implies that leaders with higher emotional intelligence can also empathize more effectively with the emotion of employees and express emotions more appropriately during interaction (Mayer & Salovey, 2008) and accordingly establish a better bond (Humphrey, Kellert, Sleeth & Hartman, 2008). A charismatic and transformational leadership is also associated with low level staff's stress; on the contrary the authoritarian leadership is associated with high levels of stress (De Hoogh & Den Hartog, 2008).

The neuromanagement uses neuroscience's instruments to investigate how communication affects the parties involved, taking into account manager's leadership style. Therefore we can consider the Management Neuroscience as the science of how the resources are allocated by individuals to control their behavior in social contexts, where the psychology and neuropsychology of individual behavior should underline and inform the management domain, as physics informs chemistry or neuroscience informs cognitive psychology.

1.2 Neuromanagement instruments and methods

The purpose of this section is to provide an overview of the major instruments and methods of neuromanagement research, in particular electroencephalographic (EEG) method, autonomic measures and their application to leadership research (Javor, Koller, Lee, Chamberlain & Ransmayr, 2013).

EEG can be used to measure both tonic activity (for example, conditions of rest or baseline) and phasic activity (in response to an handling status). When compared with other neuroimaging methods, electroencephalogram is a suitable detection instrument and it turns out to have an excellent temporal resolution, since it measure the electrical activations with high accuracy

(Harmon-Jones, Peterson & Peterson, 2009). In previous studies also psychophysiological autonomic measures (skin conductance, heart rate, blood pressure, and so on) were used taking into account the modulation in arousal. In fact arousal is considered a fundamental feature of behavior and it is defined as the neurophysiological basis underlying all the processes in the human organism, with specific role for emotional behavior. In particular, electrodermal activity (EDA) is considered a valid and sensitive indicator responding to the smallest variation in phasic arousal, that is the behavioral response to specific stimulus emotional valence (Groepel-Klein, 2005).

1.3 Hyperscanning technique

Thus, neuroscience offers an ample range of techniques and paradigms to be applied to management research. Simultaneous EEG recordings of several brains have recently opened a new field, called Hyperscanning. Hyperscanning is a recent paradigm in neuroscience which consists in the simultaneous recording of the cerebral activity of two or more subjects involved in interactive tasks (Balconi & Vanutelli, 2016). This measure allows exploring inter-personal brain mechanisms generated by social interactions: previous studies showed that the mutual adaptation of two interactive brains results in brain synchrony, and cooperative tasks are one of the best examples of possible applications of such technique. Accordingly, these mechanisms cannot be captured by conventional single-subject recordings (Vanutelli, Crivelli & Balconi, 2015). Taking into account these methodological considerations, hyperscanning technique could be useful to highlight the neural synchronization of two interactive participants during joint activities like communication.

1.4 The pilot study: hyperscanning in leaders' communication

Starting by the distinction of transformational and cooperative vs. authoritative leadership style, the present study aimed to apply the hyperscanning paradigm during a crucial phase of management conduction: employees' evaluation. The main interest in communication process between leader and employee makes hyperscanning the best technique applicable to this topic. Thanks to EEG and Biofeedback simultaneous recording, our purpose was to identify lexical and neuro/psychophysiological markers of leader-employee interactions. In particular we wanted to investigate neural synchronization patterns related to leadership style, to role played in the company, the relevant topics emerged by the employee evaluation interview. The main aim was that findings would help to identify to more functioning and effective leadership styles.

2.METHOD

2.1 *Sample*

The pilot sample was constituted by some couples of people, each one composed by a leader and an employee who had to be evaluated. Participants gave their written informed consent for participating in the study.

2.2 *Procedure*

Participants were asked to enrol an interview, through a role-playing, in which the leader had to evaluate an employee on his work performance. Participants were previously instructed to embody a particular type of leadership style: some couples had to use a responsive and participative communication and leadership style: some couples had to use a more traditional and authoritative leadership style with a more unidirectional communication. A progress report with a fictitious scenario was gave to the leader, who had to follow it during the role-playing. Every couple was free to manage its time to conduce the interview. Video-recording was performed during the entire session. Autonomic indices and electrophysiological measures were recorded during the whole session and 120s previous for baseline values.

2.3 *EEG recording and reduction*

EEG activity was recorded by means of 16-channels portable EEG-System (V-AMP: Brain Products, München. Truscan: Deymed Diagnostic, Hronov). An ElectroCap with Ag/AgCl electrodes was used to record EEG from active scalp sites referred to the earlobes (10/20 system of electrode placement; Oostenveld & Praamstra, 2001). Electrodes were placed at Fpz, Fp1, Fp2, Fz, F7, 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. An off-line common average reference was successively computed to limit the problems associated with the signal-to-noise ratio (Nunez et al., 1997). One EOG electrode was placed on the outer canthi to detect eye movements. The impedance of the recording electrodes was monitored for each subject prior to data collection and was always below 5 k Ω . The signal was visually scored, and portion of the data that contained artefacts were removed to increase specificity. Blinks were also visually monitored. Ocular artefacts (eye movements and blinks) were corrected using an eye-movement correction algorithm that employs a regression analysis in combination with artefact averaging (Joyce, Gorodnitsky & Kutas, 2004). After performing EOG correction and visual inspection, only artefact-free trials

were considered. Only significant time blocks derived from semantic-conversational analysis were considered for segmentation (epochs length: 1000ms). 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 regions of interest (ROI) were calculated as follow: Left Frontal from Fp1 and F3 and Right Frontal from Fp2 and F4.

2.4 Autonomic measures recording

Two device for autonomic measures recording were used, one for each couple component. One was Biopac MP 150 system (Biopac Systems Inc., USA) and was used to record the leader's autonomic activity. ECG was recorded continuously in lead1 from two electrodes attached to 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) according to the manufacturer guidelines. ECG was converted to heart rate (HR) in number of beats per minute. The signal was lowpass filtered at 35 Hz and highpass filtered at 0.05 Hz for motor and ocular artefacts. For SCR (electrodermal activity or the electrical conductance of the skin) measure, before attaching the electrodes, the skin was cleaned with alcohol and slightly abraded. The electrodes for SCR were attached to the distal phalanges of the first and second finger of the left hand. SCL was recorded using two Ag/AgCl electrodes and an isotonic gel. The signal was sampled at 1000 Hz and lowpass filtered at 10 Hz for motor, ocular and biological artefacts. Trials with artefacts were excluded from analysis. SCR elicited by each stimulus was registered continuously with a constant voltage. It was defined as the largest increase in conductance during emotional image presentation, with a cut-off of at least 0.4 IS in amplitude with respect to baseline (pre-stimulus) mean values.

A Biofeedback 2000x-pert system with radio module MULTI (Schuhfried GmbH, Mödling, Austria), instead, was used to record employee's autonomic activity, which is capable of measuring skin conductance level and response (SCL, SCR) in μS and heart rate (HR) in beats per minute (bpm). SCL was recorded with an EDA gold electrode using current-voltage measurement at a sampling rate of 2 kHz. The use of alternating voltage prevents polarization. The measurement resolution for the SCL measurement is 1 μS . SCR was recorded with a sampling rate of 40 Hz. HR was measured by infrared absorption principle with a sampling rate of 500 Hz. Measurement resolution is .004 bpm. Moreover, the mobility of the non-dominant hand was monitored

with an accelerometer in m/s² integrated into the sender unit to ensure that recordings were not compromised by hand movements. All sensors were combined in one unit which was attached to the volar surface of the middle section of the forefinger of the non-dominant hand.

Baseline values were scored during 120s prior to task beginning and was used to create a ratio *activity index* = *block mean activity* / *baseline activity* minimizing possible differences caused by the use of two devices.

3. RESULTS

3.1 *Conversational semantic mapping*

A conversational semantic mapping was made to create categories based on salience for the speakers. Categories will be used to form time block on recorded EEG trace to be analysed. Conversational semantic mapping was performed by three independent referees, which had detected frequent topics and key-words semantically-related to these topics. The referees proceeded with the semantic units repetition count. The following categories were made up: team work by employee point of view, team work by leader point of view, change by employee point of view, change by leader point of view and company mission.

As a pilot study this paper considers electrophysiological and autonomic activity means by a morphological and descriptive analysis point of view.

3.2 *EEG measures*

Cortical bands activity was analysed considering two separated independent variables: the topics emerging from semantic conversational analysis and the role (leader vs employee). Leadership and communication style were not considered for EEG analysis because of the thin difference between the two level of this variable, too small for limited number compared of couples by using cortical activity. Data showed a greater Delta (M=17.869)(Fig.1a) and Theta bands activity (M=2.023)(Fig.1b) in frontal areas during the block in which leaders talked about their personal change (cf. ChangeB in Fig.1a and Fig.1b below) and about company mission (Delta M=10.302, Theta M=1.517), compared to the employee activation when leader were talking of their own change (Delta M=6.648; Theta M=1.304)(Change A in Fig.1a and 1b) and of the company mission (Delta M=3.584, Theta M=0.464).

Another difference could be seen in the lateralization of Delta power (Fig.2a) in left frontal area: greater mean power was present during the block in which leaders talked about their personal change ($M=21.248$) and about company mission ($M=15.634$), compared to right frontal area (Change $M=14.491$; Company $M=4.9705$).

This difference in lateralisation is present also for Theta band (Fig.2b), but only for company mission discussing (Left Frontal $M=2.202$; Right Frontal $M=0.833$).

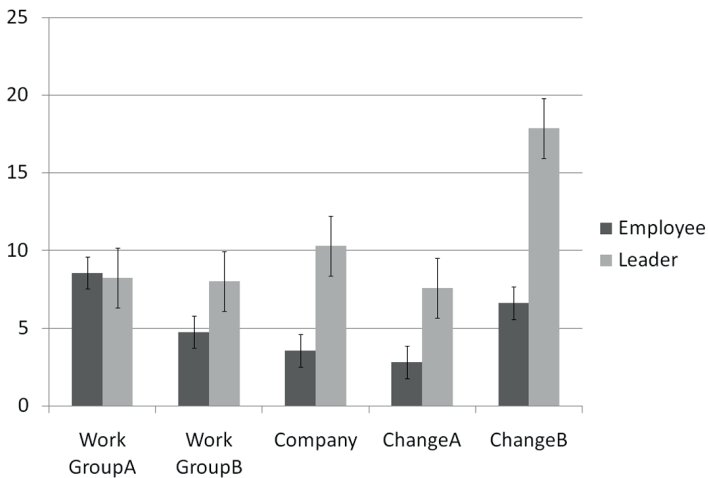


Figure 1a. Delta band values related to Frontal area during five topics emerged by semantic analysis: team work A (work group narrated by the employee), team work B (work group narrated by the leader), company (company mission) change A (employee's personal change), change B (leader's personal change)

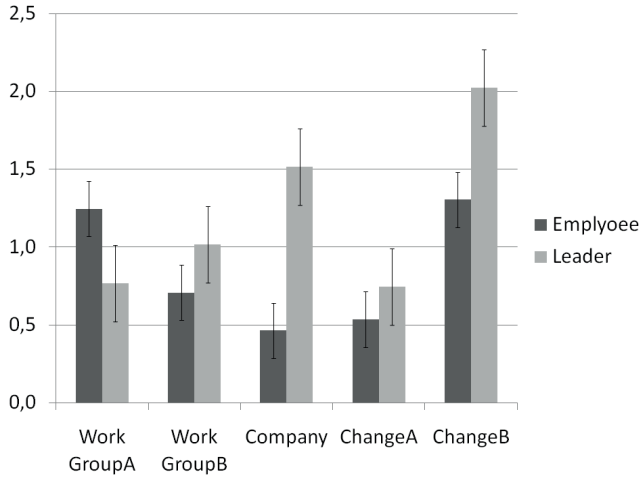


Figure 1b. Theta band values related to Frontal area during five topics emerged by semantic analysis: team work A (work group narrated by the employee), team work B (work group narrated by the leader), company (company mission) change A (employee's personal change), change B (leader's personal change)

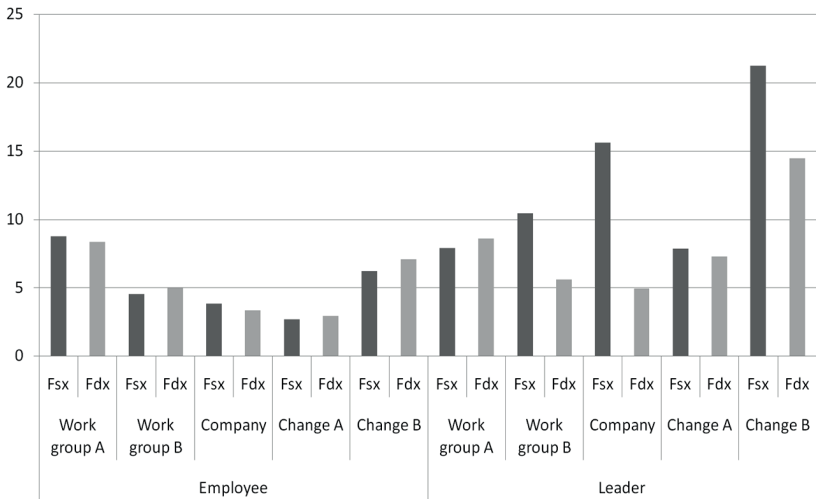


Figure 2a. Delta values related for left and right Frontal area during five topics emerged by semantic analysis

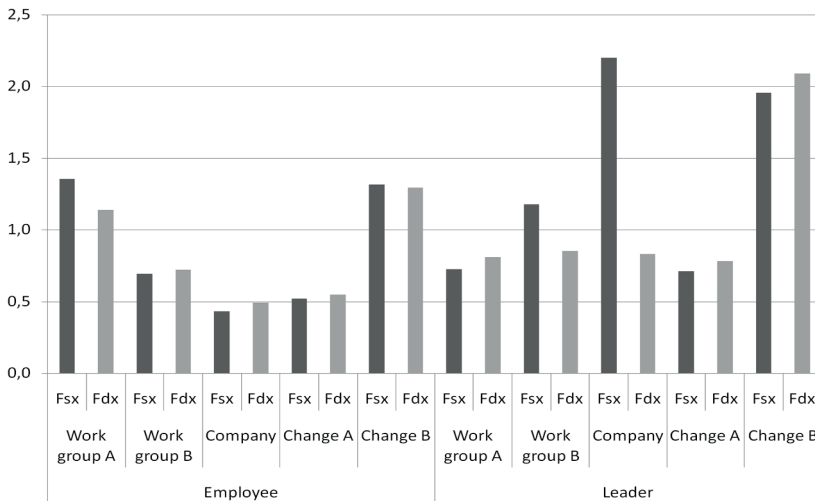


Figure 2b. Theta values related to left and right Frontal area during five topics emerged by semantic analysis

3.3 Autonomic measures

SCL and HR were analysed considering three separated independent variables: the topics emerging from semantic conversational analysis, the role (leader vs employee) and the leadership style (unidirectional and participative).

Regardless of the leadership and communication style played, SCL showed greater values for the employee compared to the leader (Fig.3a). The opposite trend was visible in company mission talking, when SCL values are greater for the leader. Considering leadership style, employee's SCR values were greater when he had to face an authoritative leader and his unidirectional communication style, especially when employee's personal change topic is treated (Fig.3b ChangeA, Employee1 M=1.655). Conversely, employee who had to face a more participative leader, showed greater SCR values (Fig.3b ChangeB Employee2 M=5.211) when the leader get involved in employee's change process. By manager point of view, HR values were greater when the authoritative manager had to face his personal change (Fig.3c ChangeB Leader1 M=1.066).

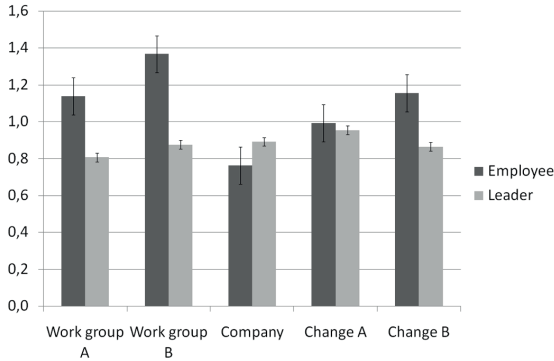


Figure 3a. SCL values during five topics emerged by semantic analysis related to different roles (employee vs. leader)

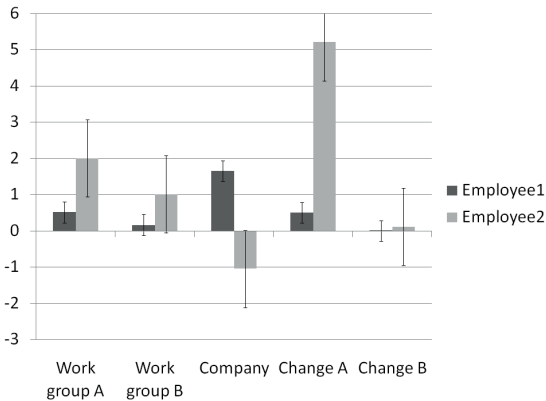


Figure 3b. SCR values during five topics emerged by semantic analysis related to leadership differences (authoritative vs. cooperative)

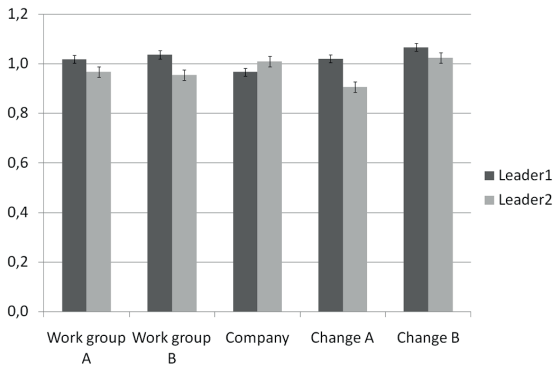


Figure 3c. HR values during five topics emerged by semantic analysis related to leadership differences (authoritative vs. cooperative)

4. DISCUSSION

The aims of this study were to investigate neural synchronisation patterns related to leadership style, to role played in the company, and the conversational mapping in term of topic emerged by the employee evaluation interview. Starting by EEG measures, leader and employee showed different activation to personal change and company mission topics, with a higher involvement of Delta and Theta band activity in Frontal areas. Managers seemed to be more involved in talking about their personal change, for the fact that this type of cortical response is usually related to salience and attributed importance to a particular situation or topic (Balconi & Lucchiari, 2006). A further consideration could be done in relation to differences between Delta and Theta activation linked to topics emerged as salient. While Theta band was greater only for company mission talking, highlighting the salience of this topic, Delta band was greater also for personal change, suggesting a deeper emotional processing. Moreover the left lateralisation of Delta and Theta activity could denote positive valence of the personal change and company mission topics. The Dual System Model (Balconi & Pozzoli, 2008; Davidson & Irwin, 1999; Balconi & Mazza, 2009; 2010), in fact, suggests a functional hemispheric specificity of prefrontal areas. This model supposes that cortical differences between the two hemispheres are to be reported to positive vs. negative valence of emotions (Silberman & Weingartner, 1986; Adolphs, Damasio, Tranel & Damasio, 1996; Borod et al., 1998; Everhart, Carpenter, Carmona, Ethridge & Demaree, 2003). Thus, based on this model, the left hemisphere would be specialized for positive emotions and could represent a positive vision for a positive leader figure, which is motivated and ready to action. Moreover, the approach-withdrawal model of emotion states that asymmetrical activity of the brain areas are associated with emotional behaviours (Davidson, 1995). Frontal EEG asymmetry has been hypothesized to relate to appetitive and aversive motivation and emotion, with more frequent approach tendencies reflected in left-frontal activity and more frequent withdrawal tendencies reflected in relative right-frontal activity (Davidson, 1992; Balconi & Lucchiari, 2006). According to this model, the greater activation for personal change and company mission may reflects a relevant attitude to action, approaching eventual problems and proposing solution based on his personal involvement. An higher activation for the company topic may suggests an identification of the manager with his company and the positive imagination related to it.

At the moment, leadership and communication style were not considered for EEG analysis because of the thin difference between the two level of this variable, too small for limited number compared of couples by using cortical

activity. Despite of this, autonomic measures showed important information related to the different style of leadership. HR values showed us a greater activation for the authoritative leader that had to face his personal change topic, highlighting some difficulties in managing a situation in which he is personally involved for his company improvement. According to literature, an increased heart rate is characteristic of a state of arousal (Appelhans & Luecken, 2006) and by the other hand, we can see a cooperative leader more quiet and with lower HR values. We know that leaders with higher emotional intelligence can also empathize more effectively with the emotion of employees and express more emotionally appropriate interactions and reactions (Mayer et al., 2008).

In addition to differences among leaders and their communication style, we can see the influence of leadership style on employees' reaction. In general, a stronger emotional activation was showed by the employees, with the increasing of SCL values, independently from the leadership style of the manager, maybe it being due to the evaluating situation. Nevertheless, SCR showed an increased arousal when employee had to face an authoritative leader and his unidirectional communication style, especially when employee's personal change topic is treated. Conversely, employee that had to face a more participative leader, showed greater SCR values when the leader get involved in employee's change process. The leader, get himself involved, succeeds in involving the employee activating in him a genuine response; this type of reaction could be based on the fact that it can not be mystified by adjustment due to display rules. In this way it becomes possible that leader transmits his readiness to action to the employee, encouraging his positive change and, finally, the company well-being. Finally, sustained long-term levels of arousal lead to a physiological and psychological distress, which contributes to feed the physiological one, in a loop. A charismatic and transformational leadership is also associated with low level staff's stress, on the contrary the authoritarian leadership is associated with high levels of stress (De Hoogh & Den Hartog, 2008).

5. CONCLUSIONS

These first preliminary results show the importance of applying a neuroscientific approach to organizational contexts for exploring, and eventually modifying, some important processes related to the employment status, to the manager-employee behavioural dynamics and to their communication style. All of that considering that neurosciences are able to enter into the "black-box", analyzing the hidden and unaware sides of human behavior.

Neurosciences offer a new way to comprehend how people deal with work

or react to everyday job's situations: on one hand, meetings with active participation, situations of functional cooperation; on the other hand, the anxiety of having to complete an important task or the colleague with whom it's difficult to interact are common experiences that the neuroscientific approach help us to understand in a deeper and more truthful way. In fact, this approach is starting to shed light on which are the mechanisms at the base of a more, or less, efficient management thanks to our brain and body reactions.

The ability to tune with each other inside a dynamic of interactive exchange is certainly one of the crucial factors for a the employment relation's building based on a constructive, and consequently profitable, relationship (Balconi, Bortolotti & Gonzaga, 2011; Balconi & Canavesio, 2013). Therefore the next step of the research will be dedicated to the study of neuro and physiological counterpart for these tuning processes: in fact, current literature tells us that one relational exchange based on empathy and comprehension for the other also brings, on the long term, to asynchronisation of the involved actors' brain and body parameters.

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