

EXPLORING THE RELATIONSHIPS BETWEEN EXECUTIVE FUNCTIONS AND PERSONALITY DIMENSIONS IN THE LIGHT OF “EMBODIED COGNITION” THEORY: A STUDY ON A SAMPLE OF 130 SUBJECTS

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ABSTRACT

The Executive Functions and the dimensions of the personality seem to have numerous points of convergence both on the psychological and neurobiological sides. Current studies interpret this relationship as a linear concatenation that starts from a damage of the prefrontal cortical areas, produces a deficit of the executive functions and finally evolves towards the development of pathological character traits. In an “enacted cognition” perspective, the relationship between executive functions and personality should be interpreted according to a circular causality model that appears ecologically more realistic and adequate to empirical data.

The present study evaluates executive functions and personality dimensions in a sample of 130 subjects using the Frontal Assessment Battery, the Temperament and Character Inventory, respectively.

The results show that subjects with low empathic and emotional propensities, detected through 9 items of Temperament and Character Inventory, while not presenting any kind of disturbances, show Executive Functions that are not efficient or even inadequate.

These data are not easily explained according to the classic linear model and seem to confirm the circular perspective proposed by the “embodied cognition” theory. However, an expansion of the sample is essential to obtain confirmation of the data that emerged.

Keywords: Executive Functions, personality, prefrontal cortical areas.

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Introduction

In the last 10 years, personality theories and neuropsychological models of Executive Functions are evolving along converging lines⁽¹⁻²⁾.

In the current theorizations of these two constructs, the Executive Functions (EF) and the neural network that underlie them appear closely connected to the psychological dimensions and to the neurobiological structures that organize the personality⁽³⁻⁸⁾.

However, the study of the relationship between EF and personality traits is currently still limited to trying to explain some pathological traits of the character as the ultimate consequence of damage to the frontal areas⁹⁻¹⁰. Recent research has confirmed the classical linear model that starts from the presence of pre-frontal cortex lesions that cause a deficit of the executive functions that, in turn, are at the origin of the development of pathological personality traits⁽¹¹⁻¹³⁾.

Without denying the clinical value of these studies that link neuronal damage to executive deficits and pathological personality traits, it is necessary to integrate this classical perspective with explanatory models with circular causality that best fit the empirical evidence⁽¹⁴⁻¹⁸⁾.

The convergent elements of the “personality” and “EF” constructs⁽¹⁹⁾ will be described below to clarify the importance of a research program that explores the circular link between them⁽²⁰⁻²²⁾.

Personality and executive functions: two concepts in question

“Personality” is the term used to describe a set of creative functions that allow an individual to adapt to the environment and interact in social and relational contexts. These complex processes require the integration of perceptual phenomena and motor actions⁽²³⁻²⁵⁾. The personality, moreover, is characterized by sets of mental contents of a semantic nature (concepts) coherent for each style of personality, which serve to categorize the environment, to plan the action, to use the objects and to orient themselves in space and time. For example, a person with an avoidant style possesses, in relation to daily and ordinary activities, a series of concepts consistent with his relational modality marked by fear of judgment and self-representation characterized by low self-esteem⁽²⁶⁻²⁹⁾.

According to a defined approach “enacted cognition” concepts are mental entities generated by the relationship between the individual and his environment and reflect the structure of this relationship⁽³⁰⁻³⁴⁾.

They are not representations of objects (concrete or abstract) but something more similar to the reactivation of the networks of neurons that were formed during the interaction with these objects. For example, the concept of “automobile” is not a representation of the machine but rather corresponds to an intricate series of actions related to the car and the ways of interacting with it stored in our brain in the form of complex neuronal connections^(26,35-37).

From a neuroanatomical perspective, the personality can, therefore, be conceptualized as a cognitive-motor system involving the entire cerebral cortex and some subcortical structures such as the basal ganglia⁽³⁸⁻⁴⁰⁾.

Of great importance for the personality functions is the prefrontal cortex; its maturation is completed in the man after 20 years and the patterns of the neuronal connections of this area depend mainly

on the experience of the subject. This area has a controlling role during the execution of complex behaviors and a function of integration of the relational and environmental information within the motor behaviors⁽⁴¹⁻⁴⁴⁾.

Inside the frontal lobe, there is the cingulate cortex that belongs to the limbic system and is involved in the motivational and affective processes underlying the behavior⁽⁴⁵⁻⁴⁹⁾.

For their part, the EF can be described as a complex integrated system that regulates selective attention and sustained attention to the formulation and execution of behavioral programs aimed at addressing new situations⁽⁵⁰⁻⁵³⁾. Classically they are considered connected to the dorsal-lateral, ventromedial prefrontal cortex and to the anterior cingulate cortex^{3, (54-55)}. Recently it has been shown that through the area 6 of Brodmann (pre-motor area) the FE also involve the posterior parietal cortex and the striated body⁽⁵⁶⁻⁵⁹⁾.

These neural connections suggest that the executive system is a poly-modal network (sensory, motor and relational) dedicated to the production of complex and goal-oriented behaviors aimed at adaptation. Moreover, the cortical areas involved in the executive control are accessible to the conscious conscience and can evolve and change throughout life by integrating new sensory-motor and relational information and generating ever new projects, thoughts, and behaviors⁽⁶⁰⁻⁶³⁾.

Aims

The study explores the link between the construct of the EF the semantic mental contents characteristic of structures of healthy personalities. The goal is to understand if the link between these two constructs is attributable to a linear mechanism or if a circular causation process occurs that involves the subject’s experience as a primary factor.

This data is essential for the development of artificial neural networks capable of emulating human intelligence.

Methodology

The semantic contents of the mind, even the abstract ones, can be interpreted as the reactivation of the patterns of neuronal connections that have developed during interactions with the environment. In this perspective, the concepts are multi-modal (reactivate sensory, cognitive and motor neu-

ronal networks), referential (they are strictly connected to the interaction with certain concrete or abstract entities) and rooted in the environment (they evoke simulations of the experience made with an a specific object in a certain context). Whenever a situation requires making a choice, the decision-making process is managed by a frontoparietal cognitive motor network that is the biological correlate of the personality⁽⁶⁴⁻⁶⁶⁾.

The items of a personality questionnaire that require the subject to say whether or not it adheres to a certain behavior or thought, trigger the activation of the same neuronal network that is involved in the actual execution of the described behavior. The activation of this network gives rise to the formulation of a concept characterized by a certain level of abstraction but embodied in the ideomotor processes of the subject. In this sense, the individual item sofa personality questionnaire can be used to explore the mental contents typical of a personality style in amore ecological and effective way of personality dimensions⁽⁶⁷⁻⁶⁸⁾. Each of the 240 items of the TCI was analyzed with the Student's T test with respect to the efficiency of the FE assessed with the total FAB score (FABT). The FABT score obtained by the subjects who answered "true" to a specific item was compared to the score obtained by the subjects who answered "false" to the same items.

Items that showed a significant difference in the variances of the two subgroups were divided into two classes: in a first class the items (called positive items) were inserted for which the "true" answer was linked to a higher score at the FAB; in a second class the items (called negative items) were inserted for which the "true" answer was connected to a lower score to the FAB.

Finally, the summative effect of the items of each of the two classes on the efficiency of the FE, through the analysis of one-way variance (ANOVA).

Instruments

In a sample of healthy subjects, the Executive Functions were evaluated using the Frontal Assessment Battery (FAB)⁽⁶⁹⁻⁷⁰⁾ and the personality dimensions using the Temperament and Character Inventory (TCI)⁽⁷¹⁻⁷²⁾. FAB is a short diagnostic reagent that extensively evaluates the activity of the pre-frontal cortex. It consists of 6 sub-tests that explore the frontal lobes according to current EF theories.

The 6 sub-tests are: Conceptualization, mental flexibility, programming, interference sensitivity, inhibitory control, environmental autonomy. The FAB total score describes the overall efficiency of the EFs. The subjects that do not reach the threshold score of 13 present a deficit of the activities of the prefrontal areas. The TCI is a questionnaire of 240 items that assess the function in going the personality by organizing it into four dimensions of temperament and three of the character. The first version of the TCI was used in the study⁽⁷³⁾. The last version of the test called TCIR differs from the previous one for the answers to the items that are on a 5-point Likert scale and while in the first version the items have dichotomous answers (true/ false).

From a psychometric point of view, although the studies in the Italian population have been made a sample of not very numerous subjects, it is evident that the two instruments are substantially overlapping. Both versions of the test showed: the same epta factory structure provided by Cloninger, internal consistency values of the seven substantially equivalent dimensions and a good predictive validity with respect to personality disorders. However, the subjects of the study showed a significant preference for the tool with dichotomous responses that they consider easier to use and this fact has oriented the choice of the first version of the test⁽⁷³⁾. Finally, for the reasons indicated in the paragraph on the methodology, the seven personality factors were not used but the individual items of the test.

Materials

The sample consists of 130 subjects (54 males and 76 females) accessed from 2015 to 2016 at a mental health clinic for psychological counseling. The subjects have a mean age 33.91 years ($SD = 12.25$) with a minimum of 18 and a maximum of 66 years. 78 subjects completed upper middle studies and 29 subjects graduated. 83 subjects are single or unmarried and 50 are unemployed. The socio-demographic characteristic so the sample can be compared to those of the original population (Table 1).

The patients selected for the study did not present psychic or personality disturbances to the anamnesis or to the diagnostic evaluations carried out upon entry into treatment. In addition, subjects with a history of head trauma and psychic trauma or with cognitive deficits and neurodegenerative disorders were excluded from the study.

All subjects were informed and accepted that the data collected for the clinical evaluations would be used in scientific studies according to the legislation regarding the respect of anonymity and confidentiality of sensitive information and the assurance that use of the data would not modify the treatment prescribed (Table 1).

Socio demographic status	Frequency
Degree of study	
Elementary	3
Average	20
Diploma	78
Graduation	29
Status civil	
Bachelors/spinsters	83
Married	38
Separated/divorced	6
Widowers	3
Working activity	
Unemployed	50
Occupied	80

Tab. 1: Socio-demographic status of the sample subjects.

Results

As shown in Table 2, 4 items were identified, defined as “negative items”, for which the “true” answer is associated with a significantly lower total FAB score.

N° ITEM	Negative Items - for which the "true" answer was tied to a total score at significantly lower or loss-related FAB	Item's answer	Number subjects	Average FAB TOT	S.D.	T.
1	If I am embarrassed or humiliated I overcome it quickly	False	71	14.33	2.5	4.98
		True	59	12.97	3.17	P<.01
2	I think sad songs and movies are a bit boring	False	97	14.23	2.41	3.69
		True	33	12.19	3.51	P<.01
3	I hate to change the way I do something even when many people tell me that there is a new and better one	False	65	14.32	2.55	2.4
		True	65	13.13	3.09	P<.05
4	I spent moments of great joy in which I suddenly had a clear and deep sense of uniqueness with all that exists.	False	71	14.27	2.65	2.41
		True	59	13.05	3.05	P<.05

Tab. 1: Total score obtained at FAB. Comparison between the subjects that have selected "false" vs the subjects that have selected "true" in the reply to the TCI items.

N° ITEM	Positive items – for which the "true" was tied to a significantly higher FAB total score	Item's answer	Number subjects	Total score at FAB M (SD)	T.
1	I often get deeply moved by a good speech or a poem	False	45	12.74 (3.32)	-2.93
		True	85	14.25 (2.5)	p < .01
2	I prefer to keep for myself and my problems	False	74	13.23 (2.91)	-2.25
		True	56	14.35 (2.77)	p < .05
3	I do not want to be richer than any other person	False	55	12.94 (2.9)	-2.3
		True	75	14.3 (2.75)	p < .01
4	It gives me pleasure to help others even if they treated me badly	False	7	10.38 (2.83)	-3.23
		True	123	13.9 (2.79)	p < .05
5	Most of the people I know are concerned only with themselves, they do not care if someone else forgives us	False	60	13.07 (3. 12)	-2.35
		True	70	14.26 (2.58)	p < .05

Tab. 3: Total score obtained at FAB. Comparison between the subjects that have selected “false” vs the subjects that have selected “true” in the reply to the TCI items N ° ITEM Positive items - for which the "true" answer was linked to a significantly higher FAB total score the Item Number subjects Total score at FAB M (SD) T of Student.

The first and second of these items describe the tendency to escape unpleasant emotions; the subjects that have selected “true” have total FAB scores not only on average more bases than those who have selected “false” but also below the threshold score of 13 and therefore indicative of a deficit of the executive functions.

The third and fourth items respectively express the difficulty in question is one's way of doing things and the tendency to experience ecstatic feelings. The subjects that have selected “true” to these items have non-deficient scores but on average lower than those who have selected “false”.

Table 3 shows 5 items, called “positive items”, for which the “true” answer has been selected by subjects who have overall FAB scores on average higher than those who have selected “false”. All in the table I express a high empathic ability of the subjects that select “true” as an answer. Furthermore, subjects who have selected “false” as a response to items 1, 3 and 4 have average FAB scores that are indicative of the reduced efficiency of the Executive Functions (Table 3).

Tables 4 and 5 describe the summative effect of negative items and positive items on FE efficiency. Subjects who have never selected the “true” answer to the “negative items” obtain the FAB total scores significantly high-

er than the subjects who have chosen “true” to at least three 3 negative items showing a higher efficiency of the FE (Table 4).

NUMBER OF NEGATIVE ITEMS SELECTED BY EVERY SUBJECT	Name of the Group	N of the subjects in the Group	Total score at FAB M (SD)
Group that answered yes to 0 NEGATIVE ITEMS	A1	16	14.99 (2.28)
Group that answered yes to 1 NEGATIVE ITEM	A2	51	14.52 (2.38)
Group that answered yes to 2 NEGATIVE ITEMS	A3	31	13.97 (2.48)
Group that answered yes to 3 NEGATIVE ITEMS	A4*	26	11.96 (3.0)
Group that answered yes to 4 NEGATIVE ITEMS	A5*	6	9.88 (3.86)

Tab. 4: Total FAB score obtained by the subjects according to the number of selected negative items. Anova Univariate: $F 8.52 - p < .01$ - Contrast tests - reference category A1: * groups with average FAB score Totally lower than A1.

Subjects who chose the “true” answer to at least 5 Items in the “positive” class have FAB Total scores that are significantly higher than those who have chosen “true” at no more than 2 items in this class. Moreover, these last subjects have deficit deficits (Table 5).

NUMBER OF POSITIVE ITEMS SELECTED BY EVERY SUBJECT	Name of the Group	N of the subjects in the Group	Total score at FAB M (SD)
Group that answered yes to 1 POSITIVE ITEM	B1*	11	10.64 (2.80)
Group that answered yes to 2 POSITIVE ITEMS	B2*	24	12.92 (2.59)
Group that answered yes to 3 POSITIVE ITEMS	B3	43	13.8 (2.69)
Group that answered yes to 4 POSITIVE ITEMS	B4	37	14.86 (2.22)
Group that answered yes to 5 POSITIVE ITEMS	B5	15	14.78 (3.02)

Tab. 5: Total FAB score obtained by the subjects according to the number of positive items selected. Anova Univariate: $F 7.78 - p < .01$ - Contrast tests - reference category B5 : * groups with average FAB score Totally lower than B5.

Discussion

The TCI items that are statistically significant in relation to the Total score at the FAB and therefore to the efficiency of the EF, describe behaviors, emotions, and cognitions that are not symptoms of pathologies but expressions of adaptive personality styles.

Their relationship with a poor efficiency of executive functions cannot be explained simply, as a consequence of a deficit of the frontal areas but appears as evidence of a circular causative mode⁽⁷⁴⁻⁷⁶⁾. In the framework of the model defined “embodied cognition”, the presence of emotional, empathic and altruistic thoughts produces a continuous exercise of the ideomotor network that involves the secondary motor cortex, the prefrontal cortex and the posterior parietal cortex and the striated body.

These areas are the neurobiological substratum of both the dimensions of the personality and the executive processes and their exercise, understandably enhancing the executive activity, while their inhibition, typical of a self is hand avoiding character style, reduces their efficiency⁽⁷⁷⁻⁹⁰⁾. On the other hand, efficient EFs favor the ability of subjects to engage in empathic and emotionally strong relationships, while weak EFs reduce this relational inclination and this type of self-representation.

Conclusions

FE and personality dimensions appear as the two poles of a highly plastic circular process. Neuropsychological functions and personalities influence each other in the sense that the habits and the relational modes determined by the character, enhance the executive functions and the latter reinforced, stabilize the character traits; the condition reached remains unstable equilibrium until the environmental pressure, requiring new habits and relational modalities, moves the EF and the personality on a new point of equilibrium.

The dynamics emerged from the study is consistent with a vision defined “embodied cognition” in which both the thoughts and the decisional and planning processes are interpreted as multimodal (reactivate sensory, cognitive and motor neuronal networks), referential (they are closely related to 'interaction with certain concrete or abstract entities) and rooted in the environment (evoke simulations of the experience made with a given object in a given context).

From a character logical point of view, item urges that the altruistic, empathic and emotionally active modalities are related to a greater efficiency of cognitive functions. Conversely, opposite character attitudes are, on average, coupled with less efficient cognitive functions. This evidence is consistent with the most recent studies on empathy and learning processes and personality disorders⁽⁸¹⁻⁹³⁾.

The present work is a pilot study that requires an expansion of the sample size to obtain confirmation of the relationships detected and their statistical validity. Furthermore, it is necessary to analyze in detail the individual executive functions in relation to the character descriptions for an analytical understanding of the structure of the involved neuronal network.

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