A CONCEPTUAL FRAMEWORK FOR PERSONALITY MODELING IN CORRELATION WITH EEG-BASED AFFECT

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ABSTRACT: *It is well known that people are naturally different and behave differently even in the given similar situations. Each individual has unique characteristic patterns of personality traits that derive and control his/her behavior. However, someone's behavior can be predicted by assessment his/her personality. Therefore, personality tests have become increasingly popular in business, education, and medicine as well. The traditional way for measuring someone's personality has been through interviews or self-reported questionnaires. Such measurements depend on human behavior and can be affected by factors such as environment, subjectivity, and cultural biasness. Therefore, this paper introduces a conceptual framework for measuring personality from brain waves which are independent of the intended human behavior. Some studies have reported that behavior is highly influenced by emotions and emotions play a crucial role in causing it. On the other hand, psychologists have reported strong qualitative correlation between personality dimensions and affect dimensions specifically emotional valence and arousal. Studies have also reported that affect dimensions can be measured from brain signals by using emotion recognition systems. The main idea of this framework is to measure personality dimensions using personality test and to measure emotions from brain signals, then quantifying the correlation between personality dimensions and basic emotions primitives. The significant correlation can be then used for predicting personality factors.*

Keywords: Personality, Emotions, EEG, framework, Behavior

1. INTRODUCTION

For ages, human behavior has been studying in the fields of philosophy, psychology and business [1]. Studying human behavior helps understand what drives people and how people are individually different. The fact that people are naturally different and behave differently has motivated researchers to focus on finding ways to assess and predict behavioral habits of employees [1]. However, there is a wide agreement amongst academics and behaviorists that behavior is derived based on individual characteristic patterns of perception, which are defined as personality traits [2].

Since the human behavior differs from person to another, studies reported that the personality directly influences and controls the behavior [3, 4], and the personality has been suggested as an important determinant of human behavior [3, 4, 5]. Generally, the personality is defined as the unique way in which an individual thinks, feels, and behaves [6]. However, there is no one unique definition of the personality rather it has several definitions based on different theories. One theory of the personality is the trait theory which concerned with describing the personality in terms of person's trait and thereby predicting the behavior based on that description [6, 7]. According to the notion that the personality traits make the difference among individuals, the behavior of an individual can be predicted through personality assessment by measuring the extent to which the individual is engaged by those traits [8, 9].

Due to the important role of personality tests in predicting human behavior, they have become increasingly popular in many fields such as business, medicine and education. The most of business companies for instance, use personality assessment to aid in hiring new employees [10]. Personality assessment tools give scores for personality traits which can be used for selecting right people for right jobs. In this contest, people who are careless and lazy score low in the personality factor the Conscientious and they cannot be properly hired as managers. Similarly, people who score high in the personality factor the Neuroticism are usually depressed, anxious, and hostile and they cannot also be properly hired in such critical positions [11]. Personality assessment has also been interested by researchers in the field of computer science; particularly for modeling and supporting human-computer interaction [12].

Researchers have tried to objectively analyze and measure personality traits and they have developed several psychological instruments and tools that are used for personality assessment. The traditional way for measuring personality traits of individuals has been by using self-reported instruments that include interviews and questionnaires. Despite, self-reported instruments being widely used; the measurements of such tools can be affected by the environment, subjectivity and cultural biasness. Measurements can also be affected by individual's misremembering and lying. Thus, individuals under evaluation might give undesirable response [6, 13].

2. LITERATURE REVIEW

An overview

Personality is a branch of the field psychology which focuses on explanation of the human behavior. It concerns for individual differences among people in related to the mental and behavioral activities [14, 15]. However, personality does not have one agreeable definition rather it has different definitions based on different perspectives of study [6]. It is worth mentioning that, all definitions of personality confirm that personality is an internal stable (or relatively stable over time) process that guides the human behavior [6]. Personality has been studied from multiple perspectives and theories to explain how people are similar and different each to the other. The personality theories generally are the ways of describing individual characteristics and behavior. During the last century a number of different theories have been developed such as psychodynamic (Freudian) theory,

humanistic theory and trait theory which will be considered in this work.

Personality Trait theory

Psychologists have defined the personality traits as labels (terms) used for describing enduring characteristics (attributes) which influence someone's behavior across situations [16] and they assumed that traits denotes how much (quantitatively) of that characteristics the individual has [15]. Trait approach is considered as one of the most effective ways used for studying the personality as it makes three basic assumptions [7, 15]:

i. The traits are stable or relatively stable and therefore they can be predicted over time.
ii. The traits are stable or relatively stable across situations; which explains why people behave in predictable ways in several different situations.
iii. Personality traits make the difference among people in how much people possess of those traits.

Based on language dictionary, personality scientists have started this approach by collecting thousands of words they thought they are used by people for describing personality traits. In 1936 Allport with his colleague Odbert recorded about 18000 English words that refer to behavior characteristics. Sometime later, he noticed that some of these words are used interchangeably for describing the same thing. Therefore, the number was reduced to few thousands by eliminating the synonyms [6, 17].

Ten years later, Raymond Cattell used Allport's list and applied some statistical approaches to form the structure of the personality [18]. One tool was the factor analysis which was used to determine the relationships between sets of traits. Cattell has concluded his work with developing 16-trait personality model. The model structured by 16 bipolar graded dimensions; each trait at a one end of the dimension while the opposite trait at the other end. Cattell has also developed a self-reported questionnaire to measure the 16-trait dimension which is known as the Sixteen Personality Factor Questionnaire (or 16PF) [6, 15]. In further research, several groups of researchers have tried to reduce the number of trait dimensions to more suitable and manageable number and they have agreed almost on the same five trait dimensions. The five trait dimensions; Neuroticism, Extraversion, Openness to experience, Agreeableness, and Conscientiousness (usually abbreviated as NEOAC or OCEAN for better remembering) have been organized in a hierarchal structure of the personality traits known as the Five-big or interchangeably as the Five-Factor Model (FFM) [15, 19, 20, 21].

A number of studies have developed and reported psychological instruments and tools that can be used for assessing the personality based on the Five Factor Model. One of those instruments was the NEO Personality Inventory (NEO-PI) which was revised later as the Revised NEO Personality Inventory which abbreviated as the NEO PI-R. The NEO PI-R is a 240-item self-reported questionnaire that has a shortened form (60-item questionnaire) known as the NEO Five Factor Inventory or NEO-FFI [22].

3. EMOTIONS

Emotions play a significant role in our daily interactions and communications, and effectively influence our psychological and physiological activities. People have defined emotions in different ways and using different expressions, which denotes the complexity of understanding the emotions. However, there is no one fixed definition of emotions. Even though, emotions have been defined as complex mental states of feelings that cause physical and/or psychological changes which effect the though , memory, and behavior [23]. Emotions are subjective experience that has several characteristics:

i. Emotions are temporary experience that happens in relatively short and limited period of time.
ii. Emotions can be positive, negative, or even mixture experience.
iii. Emotions often alter the attention towards only a single event.
iv. Emotional experience triggers the motivation to behave in certain ways.
v. Emotions have been reported to interrupt thinking and behavior, but also to guide and control them [15].

From biological perspective, emotion can be observed in the mechanisms of the central nervous system CNS and it observed to be associated with changes of the emotional arousal. Several brain areas have been found related to emotion generation and to physiological emotional responses [15]. Emotional responses can be explicitly observed in facial expression [24], voice tension [25], and behavior [23], or implicitly in brain signals [12, 26]. Emotions experience, however, have been explained by two psychological approaches; the categorical and the dimensional [27].

Emotions Theories

Theories of emotion try to demonstrate what emotions are and how they are processed. Researchers, however, have studied and analyzed emotions from different perspectives and by different approaches. Psychology literature has reported using two major approaches for identifying and assessing human emotions; the first is categorical and the second is dimensional [23].

The categorical approach refers to earlier studies on using language words for describing human emotional experiences [23]. Categorical approach defines a discrete set of basic emotions while more complex emotions can be generated by a combination of the basic emotions [28]. For assessing person's emotion based on discrete approach, Studies reported that participant is given a list of emotional words and asked to self-report their emotions through three scales.

i. Nominal scale, by which participant selects the best terms describe his/her emotion.
ii. Ordinal scale; by which participant indicates on graded scale the extent to which he experienced the emotion by selecting 1, 2, or 3 for, a little, somewhat, or strong respectively.
iii. Interval scale; which used to indicate (in 1-100 scale) how much the participant experienced an emotion.

Despite the results from such approach are easily interpreted and acceptable, studies reported serious problems such as missing much data, the lack of standard set of basic emotions, and the difficulty of distinguishing the basic emotions from complex [23].

The dimensional approach has suggested a structural description for representing emotional states firstly in three-dimension; the valence (positive vs. negative), arousal (calm vs. excited), and tension (tense vs. relaxed) [27]. Due to difficulty of distinguishing the third dimension tension from the second the arousal, the modern approach has suggested representing emotional states in only two-dimensional affective space based on valence and arousal. The scientists following this approach have suggested also a circular structure models for representing emotional experiences. One widely used model is the Russell's two-dimension space affect model [29] which has been later used for emotion modeling and emotion recognition systems.

Emotion Modelling and Measurement

Studies have examined the polarity of emotion terms and enhanced the idea of bipolar multidimensional of affect [29]. Schlosberg introduced his idea about circular order of bipolar dimensions of effect in relation to two-dimensional space [30]. Based on the two-dimensional space model; eight emotion terms were allocated with their coordinates represented by angles [29]. The terms were pleasure at (0^o) relative to misery (unpleased) (180^o), excitement (45^o) relative to depression(225^o), arousal (90^o) relative to sleepiness (270^0), and distress(135^o) relative to contentment (relaxation) (315^o).

The findings from empirical work on circular order model of affect have encouraged scientists to more refine the model. Rossell in 1980 devised the Circumplex Model of Affect as shown by Fig. 1 below. The model is based on the idea of the two orthogonal dimensions. Instead of representing eight bipolar dimensions, the model divided the structure into 8 affective sectors, and allocated the feeling-related concepts in a circular order establishing on the affective bipolar dimensions proposed by Schlosberg [27]. This circumlex model, which interchangeably known also as Affective Space Model (ASM), suggested that emotions are represented by two-dimensional space, based on arousal and valence axes. Where the arousal represented by the vertical axis (y) and valence represented by the horizontal axis (x), while the neutral emotion represented by the center of the circle, so that emotional states can be represented at any time by giving values of valence and arousal [29, 31].

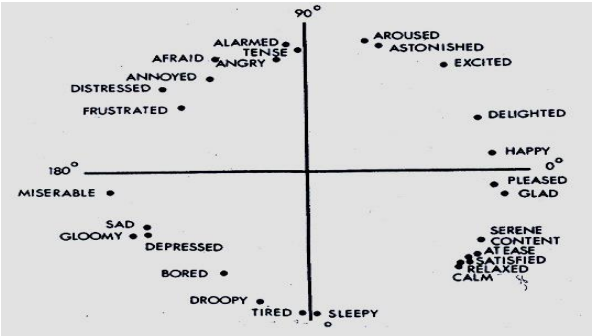

Fig. 1: Affective Space Model (Russell, 1980)

Meaguring Emotions from Brain Signals

Emotions can be observed explicitly by face expressions, changing in voice, or body language [32], and implicitly from physiological activities such as heart rate, skin conductance and brain signals [33]. Many studies have reported that emotions can be successfully measured from brain waves, where brain waves are naturally electrical signals that can be read by ElectroEncephaloGraphy (EEG) devices. Emotion measurements from EEG signals can be achieved using machine-learning algorithms [34]. The general system of emotion recognition as described by Fig. 2 consists mainly of signal preprocessing stage, features extraction stage, and classification stage. The output of emotion recognition system is a two-column array that represents the emotional primitives; valence and arousal. The values of valence and arousal can then be plotted on the two-dimensional affective space model (ASM) after they are normalized to range from -1 to +1 for identifying the emotion [34].

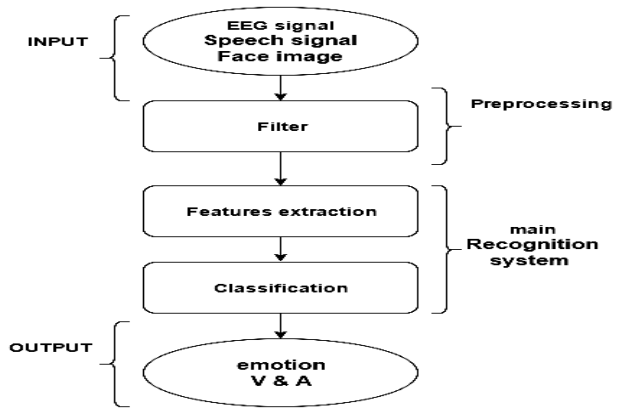

Fig.2: General Diagram for Emotion Recognition System [34].

However, Empirical studies have reported that some cognitive phenomena can be measured according to their inter-correlation with EEG-based emotions. Memory, for example has been measured in two studies according to its correlation with EEG-based emotional arousal [35, 36].

The Relationship between Personality and Affect

As mentioned earlier, personality trait theory has begun with finding words from spoken language that individuals can use to describe themselves [6]. The descriptors (words) have been classified based on their interrelationships. The most common taxonomic systems of personality traits include the subset of emotional descriptors, yielding thusly an overlap between the words used for describing personality traits and those used for describing emotions. This overlapping suggests an intimate relationship between personality traits and emotions [4]. Such relationship has encouraged researches to conduct empirical work to investigate how personality factors are related to emotion primitives. The findings from neuroscience studies have reported that the personality dimensions (factors) extroversion and neuroticism are associated with positive affect and negative affect respectively [4, 37]. On the other hand, neuroimaging studies have reported that extroversion was found to be correlated with low level of arousal [38] and correlated with positive valence, while

neuroticism was correlated with high level of arousal and to negative valence [39].

In addition, the big five personality factors have been reported to be correlated with some emotional traits. Neuroticism has been found to have positive correlation with depression and anxiety [40], and negative correlation with happiness [41]. Extroversion, openness and conscientiousness were found to have positive correlation with happiness and negative correlation with negative affect [4]. Agreeableness was found to be negatively correlated with negative affect such as anger and depression [42] and positively with positive affect [43].

4. PROPOSED CONCEPTUAL FRAMEWORK

Assumptions and Concluded Remarks

The review of the related work can be summarized in the following remarks and assumptions:

- Human behavior is derived and controlled by personality [44].
- Emotions play a crucial role in forming human behavior [4] and have been suggested to cause the behavior [45].
- There is an intimate relationship between personality and emotions [4].
- Personality has been suggested to controls emotions [4].
- Emotions can be measured from brain signals by using EEG-based emotion recognition system with ASM [34].
- Personality factors can be measured by using psychological instruments such as NEO-FFI [21].

Based on the assumptions and hypotheses mentioned above, we started with drawing the relationships between personality, behavior, and emotions. As shown by Fig. 3 personality derives and controls behavior and controls emotions as well. Emotions have great impact on behavior and even suggested to cause behavior. These relationships suggest strong relationship between emotions and personality. Personality can be measured by using personality tests such as NEO-FFI questionnaire which measures and reports personality by its five dimensions; Openness to experience, Conscientiousness, Extraversion, Agreeableness, and Neuroticism. Emotions which are a type of the affect and have the same dimensions of it can be measured from spontaneous brain signals by using EEG-based Emotion Recognition System (ERS) which produces a two-column array that includes values of emotion primitives; valence and arousal (V&A).

Based on the notion that personality has strong relationship with emotions, we suggest strong correlation between the results of the NEO-FFI personality test (N.E.O.A.C.) and the results of emotion recognition system (V&A).

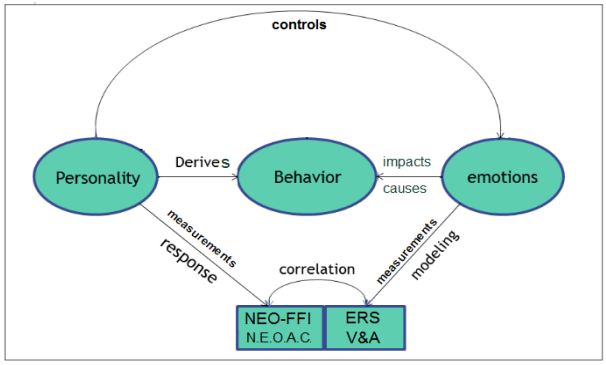

Fig. 3: Suggested Model for Personality Assessment in correlation with emotions

5. THE METHODOLOGY OF THE FRAMEWORK

Fig. 4 below demonstrates the methodological framework for design and implementation the personality model that used to assess personality based on the correlation between emotion primitives and personality factors. The framework consists of two parts; the upper part used for implementing a subject-independent EEG-based emotion recognition system to measure emotion primitives the subject while he/she is exposing to stimuli of four basic emotions that include happy, fear, sad, and calm. The primitives of theses emotions were abbreviated in the framework as the following; V_h=valence of happy, A_h= arousal of happy, V_f=valence of fear, A_f=arousal of fear, V_s=valence of sad, A_s=arousal of sad, V_c= valence of calm, and A_c=arousal of calm. The right part is to conduct NEO-FFI personality test to provide the five personality factors (N.E.O.A.C) of that subject. The model then can be implemented through statistical tools by calculating the correlation between personality factors and emotion primitives. Whenever the correlation is significant, regression analysis can be achieved for modeling the relationship and extracting the model equation. Based on the model equation, personality factors for an individual can be predicted by measuring his/her emotion primitives while he/she is exposed to the basic emotions that showed significant correlation with personality factors.

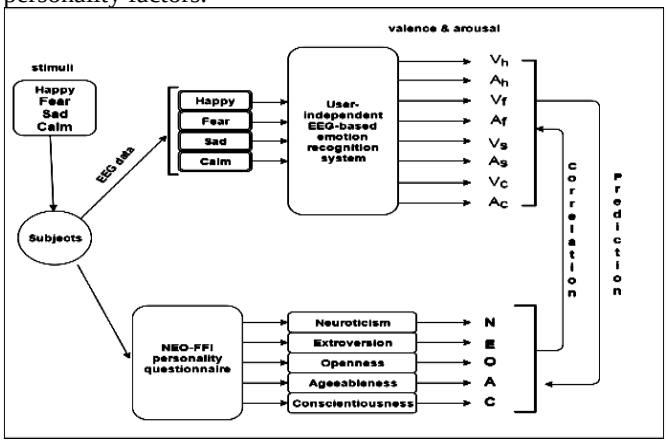

Fig. 4: the Framework for Measuring Personality Factors in Correlation with emotions

6. CONCLUSION AND FUTURE WORK

The main objective of this study is to find an approach by which personality traits can be measured independently of intended human behavior as the existing instruments depend on human responses and their measurements can be affected by several factors and their results can be falsified. To sum up, this paper has demonstrated the importance of the personality assessment in predicting human behavior and has investigated the relationship between personality and emotions and how can they influence behavior. The paper has also showed how emotions can be measured from brain signals and how personality can be assessed using psychological instruments. Finally, the paper introduced a conceptual framework by drawing the relationships of personality, behavior, and emotions. The suggested framework can be used for modeling the personality factors in correlation with dimensions of the EEG-based affect specifically emotions primitives; valence and arousal.

The future work will include an implementation of a subject-independent EEG-based emotion recognition system for measuring emotions primitives. Data from all subjects will be used for training and testing the system. The future work will also include designing a digital (softcopy) version of personality test; the NEO-FFI to achieve some goals such as flexibility, accuracy, and integrity. we suggest selecting the sample of participants from postgraduate students as they are belonging to one population, they are almost in the same age, and they are able to understand intended verbal context of the instruments' items (as the available original version is in English).

7. ACKNOWLEDGEMENT

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