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## Review Article

# Graphology: An Interface Between Biology, Psychology and Neuroscience

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### ABSTRACT

Handwriting analysis dates back to many centuries ago. Graphology is a discipline that investigates personality and intellect of the individual through writing, indeed handwriting of the human being is an expression of his or her essence. Graphology examines a writing in order to extract unfiltered information about innate temperament and subconscious nature of who has traced the letters. The present paper highlights the historical and methodological approaches of graphology and its usefulness in human knowledge in order to give a glimpse of the complexity of this discipline. We have gradually focused on the description of the various fields with which, over time until today, the graphologists have dealt according to experimental and epistemological methodologies along a spectrum that ranges from studies on the character, the neuronal and biological correlates, the use in the forensic field, until to the contributions to career counseling and personnel selection. This manuscript aims to provide a quantitative picture of the handwriting analysis trying to combine insights from different sources and exploring conditions, limits and possibilities of its subject matter and methods involved. Handwriting analysis draws reliable conclusions about the spirit personality of a writer. We suppose that graphology and psychology could complement each other, and in this perspective, we explore the hypothesis of the existence of a bidirectional relationship between psychology, graphology and neuroscience which allows to gain insight into ourselves and others.

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### Introduction

In the second half of the nineteenth century, between 1806 and 1881, in France, the Abbé Jean-Hippolyte Michon coined the term graphology catalogued as a series of recurrent graphic signs and empirically linked to specific aspects of the character. The term derives etymologically from the Greek, consisting of the word *graphè* meaning "to write" and *logos* signifying "word, study", therefore graphology is the study of writing. It is a discipline connoted by an experimental nature which seeks to outline the complexity of individual psycho-physical behaviour,

through the rigorous and meticulous analysis and interpretation of graphic signs detected in handwriting.

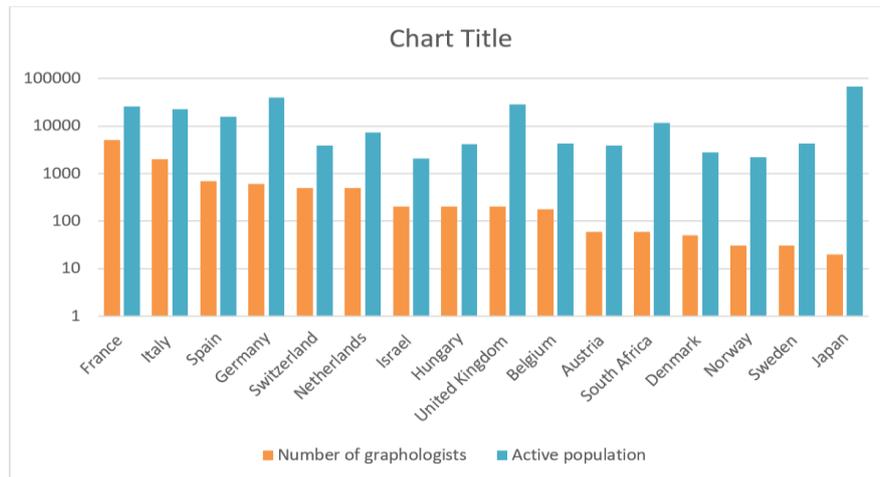
According to the ethical code adopted by the Société Française de Graphologie, graphology is described in terms of a "human science, technique of observation and interpretation" that "allows the study of personality through handwriting analysis". The medical dictionary defines graphology as "a technique of personality investigation that assigns to the manual handwriting a revelatory significance of the writer attitudes and behaviours" [1]. In addition, "the graphic aspects such as the pressure of writing on the paper, the size of the letters, the closure or

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not of the letter 'o', speed, etc. correspond pursuant to the graphologists to specific personality traits, cognitive styles and emotional states".

Trends in prevalence and incidence of graphology could provide important information about the development of this discipline over the time and in different countries across the world. The prevalence and

incidence data have not been somewhat easy to obtain since epidemiological studies are scarce. Although incidence and prevalence rates are difficult to establish, attention has been focused mostly on whether prevalence is increasing with time and on the relationship between the number of graphology and active working population (Figure 1) [2].



**Figure 1:** The estimated number of graphologists according to Bradley, set in descending order on the basis of the percentage of graphologists in the active population (millions).

The action of writing represents a spatial, temporal and symbolic activity which imprints on the leaf surface a track with rhythms, pressures and energy of its own. The act of writing, then, follows temporal dimensions related to the more or less rapid succession of letters, not apart from temporal conditions with different trends. This process takes into account the conventions that are learned and draw on the wealth of individual experience, in a link between past and present and oriented in a prospective manner through the becoming process. Not surprisingly, as it is commonly given to observe, the graphic elements proceed along more or less parallel stages to chronological and psychological evolution of the human being finalized to a communicative act. Ania Teillard affirmed that the style of writing speaks directly to the observer, not unlike a smile or the shape of a hand; the graphic trace reflects the most spontaneous and authentic aspects of a person configuring in terms of a creative process [3]. Through writing, valuable and "uncontaminated" information can be captured about the intelligence, emotions and lifestyles of an individual.

The act of writing draws on the energy and the creative tension inside a metaphorical representation of the inner world. In this regard, it is worth pointing out that graphological studies are independent of judgments about everything from the narrative style and content of a paper, concentrating exclusively on the characteristics of the graphic trace that the person inscribes on the leaf. The foundation lies in the possibility to build a bridge of connection to the psychic sphere, unveiling in this way, those shadow areas, unconscious and therefore less evident of the human soul.

### History of Graphology

The oldest interest towards graphology has been found in India and starting from the year 2000 B. C. it spreads in China, where the art of writing has been also carried out in order to understand the nature of man

[4]. Several centuries later, in Greece, philosophers like Aristotle and Dionysius of Halicarnassus devoted attention to the meaning of the scriptures. For Aristotle, in fact, it was important to capture the expressiveness of the writing gesture considering it as an element of revelation of the way in which the soul is conceived. In the period of Imperial Rome, Suetonius believed that to understand the character of Augustus it would have been useful to get information from the study of his handwriting. Even Confucius, in the year 500 A. D. made reference to the action of writing as moved by the spirit of man in the same way in which "a reed sways in the wind". After a long pause during the Middle Ages, graphological studies seemed to percolate since the seventeenth century, in particular in Bologna, a professor of logic and metaphysics, Camillo Baldi reported currently valid empirical and scientific observations, in the treatise entitled "How from a missive letter, one may know the nature and qualities of the writer".

In the following centuries the study of handwriting tried to establish methods more and more serious and reliable. In the second half of the eighteenth century, in effect, in France, Johann Kasper Lavater (1741-1801) edited a series of rules to be followed for the interpretation of the character through the study of handwriting and hereafter in the first half of the nineteenth century the first societies of graphology began to be born starting from France. The Abbé Jean-Hippolyte Michon devoted himself to the study of graphic signs cataloging and tracking down characteristic meanings of personality on empirical basis. Michon founded the first school of graphology and a journal "La Graphologie" that continues today to be published. The evaluation work undertaken by Michon about the graphological signs and their interpretation generated a certain fascination in Europe that justifies further investigations and assessments by his pupil Jules Crépieux-Jamin who carried on the work of his teacher integrating it with psychological elements.

The French graphologist selected 200 graphological signs that gathered in seven categories consisted of: size, shape, pressure, speed, direction, layout and continuity, all addressed in the *unicum* of a gestalt. Important characteristics of graphological studies are considered the harmony and disharmony levels of handwriting such as the reflection of the balance degree of the writer. In 1894, meanwhile, a French psychologist of the Sorbonne, professor of physiological psychology, Alfred Binet, dedicated himself to the study of handwriting to get the sex of the person who writes, in his essay “Les révélations de l’écriture d’après un contrôle scientifique”. In the rest of Europe, particularly in Germany, Ludwig Klages (1872-1956) a philosopher and a psychologist was the leading figure in the field of characterology and tried to perceive the level of “fullness of life” of the person from studies on handwriting. He showed interest particularly in handwriting movement and dynamism.

Fundamental element in the handwriting is the rhythm as an expression of the vital level; every graphological school recognizes in the rhythm a strongly indicative element of personality. Klages founded at Monaco an institute for the study of characterological psychology [5]. In England, the Czech-born Robert Saudek (1880-1935) became interested in experiments of comparison with stroboscopic movement cinema and movement measurement in handwriting, developing a rigorous and mechanized method to define scientifically the concept of speed coming to formulate graphic laws at the base of the graphomotor gesture. Max Pulver (1890-1953), in Switzerland, regarded carefully the investigation and the meaning of the symbolism in the handwriting conceiving an issue important and widespread in graphology throughout the world; in particular he noticed a certain importance in the three spatial dimensions of the graphic traces: vertically, horizontally and in depth, reporting the action of writing in human beings to something similar to a unaware design as asserted in “The symbolism of handwriting”: “the man who writes unconsciously draws its inner nature”, “the conscious writing is a unconscious drawing, sign and portrait of oneself” [6]. Pulver is considered one of the most important exponents of the science of graphology and spatial symbolism, even now an integral element of the evaluation system of handwriting.

In Italy, the founder of graphology in Ancona, is considered the Father Girolamo Moretti (1879-1963), who wrote under the pseudonym of Umberto Koch, the “manual of graphology” and the first of many editions of the “Treaty of graphology” which is still now used. He applied himself, among other things, to the study of the relationships between the handwriting and the physical features of the person conceiving a real system of measurement expressed in decimal classification. He started from the assumption of dynamic personality, with emphasis on the need to assess its continuing evolution. One of his famous treatise titled “Intelligence and feeling”. Between 1889 and 1978 the Estonian psychologist Ania Teillard before he dedicated herself to the study of Jung and later became a pupil of Klages and established contacts with Pulver, Saudek and Crépieux-Jamin. Through her contribution entitled “The soul and handwriting” new horizons have been opened for graphology combining in an original way the first and in particular the spatial symbolism of Pulver with the depth psychology and the Jung’s theory of psychological types.

Returning to Italy, between 1899 and 1991, Marco Marchesan stressed the importance of quantitative research and developed a methodology for designing a handwriting analysis system of 226 graphic signs and

3500 trends evaluated through a measurement scale expressed in centigrades, an extremely elaborate graphological system called “psychology of writing: signs and trends”, thus distancing a type of graphology that he considered to be without laws and a psychological system of reference.

### Theoretical Models Related to the Development of Graphology

In the course of the evolution of the studies on writing, the graphologists drew in parallel on the areas that were developing and expanding in psychological theories and practices, in particular important points of reference for them were Sigmund Freud and Carl Gustav Jung. These psychoanalysts starting to work together agreed on the existence of a hidden and inaccessible part of consciousness in the human soul: The Unconscious, however from a certain moment onwards their paths began to diverge.

As far as the first, he metapsychologically worked on a definition and a broad treatment of the three instances called Id, Ego and SuperEgo, which respectively constitute the sites of instinctual drives, where the Id pursues the pleasure principle, the Ego embodies the sense of reality and tends to defer the satisfaction of desire, when it is possible and the SuperEgo performs a normative and model function respect to which the Ego must mediate on the forces of the Id [7]. Freud distinguished four unconscious evolutionary phases of the psychic world as regards the maturing destiny of the drive energies, represented respectively by the oral, anal, phallic and genital phase [8].

In psychosexual development, the passages are described by Freud as critical moments that do not always travel naturally towards each other to the arrival of conflicting conditions or, to use a term introduced by him, for not overcoming the complex or the trauma or of the shock occurred. In this way, through studies and clinical practice, Freud traced in his patient the fixation conditions to one or the other phase. The persistence of one of these phases in the adult personality will determine its character. These elements are used by graphologists in handwriting assessments. In the accredited graphology courses, students learn to understand from the writing traits that are illustrated to them, the graphological characteristics based on the four phases theorized by Freud regarding the aspects of personality.

The four fundamental functions described by Jung regarding to the orientation of man in reality represented psychologic typologies detectable by handwriting analysis; the rational ones that include thought and feeling play an antagonistic action between them, the irrational ones are constituted by sensation and intuition, also like the other they are opposed and alternative [9].

In parallel, Carl Gustav Jung represented and still represents one of the points of reference for scholars of graphology. He devoted himself to the study of the Unconscious throughout his entire psychological research, referring to the personal Unconscious as a set of “all those things that have been forgotten and subliminally perceived and that do not reach consciousness to its inability to contain them all” [10]. His training depends on the personal history of the individual and varies from individual to individual. Unlike Freud, in the deepest dimension of the Personal Unconscious Jung intercepted a Collective Unconscious, a great repository of mnemonic traces deriving from man’s ancestral past;

it is the psychic residue of the emotional development of man accumulated following the repeated experiences of many generations, its contents are linked to human experiences intimately connected with the biological structure of the brain and inheritably transmitted.

These psychic contents, inhabitants of the deepest layers of the human soul, gradually rise to an identical meaning for all the individuals of a particular stock, nation, religion, ethnicity. In other words, in each individual revived the experiences with which the previous generations phylogenetically reacted. The Collective Unconscious for Jung is universal, contains mythological, fantastic images, customs, traditions of past and present peoples. The concept of archetype is configured for Jung as something very similar to instinct: a preformed disposition to react to certain stimuli would structure more than acting, the unconscious imagining through the use of perception, of conscious imagination and from the Personal Unconscious thus giving rise to the symbolic images of the dream or to each psychic state where the control of consciousness has failed [11]. Archetypal traces can also be found in myths, folklore, fairy tales and religious traditions, and some archetypes have undergone an evolution such as to constitute themselves as distinct psychic instances: the Person, the Shadow, the Animus and the Anima.

For Jung, the Person on a symbolic level represents a cover that does not coincide with the true reality of the individual, in fact it is opposed by that other side of ourselves, part of the Personal Unconscious, called *Ombra* "the dark brother who, although invisible, is inseparable from us and is part of our totality" [12]. The Shadow constitutes that set of removed dispositions integrated to the global personality in a guise of contraposition to the imposed predispositions present in the Person enclosing forever useful values to the conscience and to the completion of the personality, even if difficult to integrate in life. In the Jungian conception, the Shadow constitutes a set of instinctual desires and primitive emotions in contrast with society, plays an influential role in the Personal Unconscious where it indicates the darkness of the individual and in the Collective Unconscious as a phenomenon common to all humanity.

At a deeper level of the Collective Unconscious there are the images of the Anima and the Animus, expressions derived from the dual feminine and masculine nature of the human being. On a psychological level this physiological characterization corresponds to the presence in both sexes of heterogeneous characteristics, the Animus and the Anima symbolize archetypal figures of the psyche, each of which is related to the opposite sex. They are the expression of the ancestral experience of man. Consequently, more women re-enter for man in his image of internalized woman and vice versa many men picture for women the representation of their male ideal. The influence of these two archetypes is much more difficult to delineate than the previous ones, but the awareness of both would allow the human being to discover and acquire the heterosexual element of his own psyche, widening the possibility and the conscience towards a greater wealth inner [11].

### Methodologies and Applications

The several schools born for the study of handwriting, using different methods and techniques, must be able to come to the same evidence, referring to certain theoretical assumptions which have been summarized by Bell [13, 14]. Referring to Bell hypothesis, a few years

later, McNeal affirmed that handwriting reflects the personality of the writer and graphological signs provide valuable information about the person; the author elaborated a procedure of handwriting analysis that included the evaluation of three aspects related to handwriting [15]. First of all, it is necessary to collect a handwriting sample with the largest number of alphabetical letters including a span of words ranging from 5 to 100, written using a pen on a white leaf that is devoid of graphs and lines. The study may be focused on two or three handwriting samples produced in a period of about one or two months. Useful supplement to improve the results of the survey were information about age, gender and the cultural level of the writer.

The assessment methodology could differently to refer to the same school membership of the graphologist. Objective tools for measuring were represented by ruler and protractor to calculate tilt, height and size; regularity, harmony and continuity were a variety of means complementary to the survey. The interpretation also considered comparisons between productions of the same writer and graphic elements of interpretation derived from empirical data of previous researchers. Handwriting for graphology was and is still regarded as an expression of projective aspects of the self of the person in the same way psychology uses projective techniques. These essentially consist of "ambiguous stimuli", with no formal and precise structure which allows the person wide margin of representation. Among the best-known examples, the test of Inkblots of Rorschach is most fitting [16]. The perceptual stimulus of the spots, similar, in our opinion, to the phenomenon described by Jaspers of "pareidolia", devoid of defined and recognizable formal connotations, this perceptive phenomenon evokes a subjective processing of apperception by the person who transfers something characteristic of his inner world to the image he analysed [17]. To this process can be add items related to patterns and processes of thought, defensive and emotional aspects of the mind.

The connotations of projective tests are according to Frank, therefore, linked to the lack of a structured stimulus, the wide range of response options [18]. Allport counted handwriting analysis between projective techniques [19]. Completely disagree with Frank, Driver *et al.* considered, unlike projective tests, graphology as a test sufficiently structured inherent in the writing itself and the lack of consideration of the textual content constituted one of the elements being assessed in responses to projective tests [13]. One common element, however, between the two points of view of graphology and projective tests is the lack of right or wrong production, in essence it is not among the psychometric instruments.

The areas of application and use of graphology interested in psychology, education, medicine, forensic context, couple, career guidance, personnel selection [20-23]. Graphology, in fact, attest its usefulness in gaining valuable insights about the character; in general, it can highlight elements such as vitality, energy, strength of will, originality, characteristics of intelligence and at the same time, any specific deficiencies, as a state of mental weakness, conditions of anxiety, emotional distress, and poor level of self-esteem.

In particular, it is interesting to quote the views of authors such as Dazzi and Pedrabissi attributing the graphology a title in evaluating the authenticity or otherwise of a writing; in their view it would seem likely recognize the writing of his own hand by a human being in the nature of

a “fingerprint” that allows to operate checks and calligraphic examination in the protocols used in forensics such as wills, documents written by the hand of a person and referring to that person [24].

To judge the validity of a disputed will is complex; however, a major problem is to estimate the state of the mental faculties of the testator at the time of the intentions expressed. In this regard, Balestrino and co-workers found that in some way the graphological signs may identify persons not in possession of the full capacity of discernment or otherwise intellectually impaired [25]. The usefulness of these parameters resides in assessing now, the will of the testator’s handwriting, by then, before his death, the mental condition of a deceased person. A significant correlation was found between the graphological evidence of a will and neuropsychological assessment scales used as the Mini Mental State Examination and the Milan Overall Dementia Assessment scale. In particular, a low score in both revealed a cognitive impairment. In this way, the posthumous checks graphology testamentary may represent aids to complement the existing psychometric techniques used simultaneously.

At work, the model found application in graphological personnel selection. In 1985 the graphologist had been employed in the field of human resources in different countries [26, 27]. It is not easy to determine the prevalence of the use of graphology in personnel selection [24, 28]. Only in Europe in 1985 Sharma and Vardhan had found that 85% of jobs working on farms was based also the use of graphology [27]. According to some investigation it turned out that in France 52% of assumptions had been made in this direction, to go down in the United Kingdom at 7%, in the Netherlands at 4%, in Germany and Norway at 2% [29]. Outside Europe, in Israel the estimated percentage was 16%, in America it was noted that more than 3,000 companies appealed to graphology in the personnel selection [30].

Some surveys indicate that it is rather rarely used outside of France, where estimates vary between 38% and 93% of organizations [31, 32]. According to recent surveys, in Italy, Greece and the Netherlands 10% of companies employing graphology in selection, while in Switzerland the percentage stands at 15.8% [28, 33-36].

On the contrary, regarding the belief that graphology is widely used in the selection of personnel in Europe, Bangerter *et al.* carried out five studies, which respectively revealed that job advertisements rarely require handwritten letters; these are seldom used for the analysis of handwriting; it has been overestimated the frequency with which handwritten letters are graphologically analysed; whether handwritten letters are requested, the candidates are expected to be examined also through handwriting analysis; finally, the evaluation of handwriting in personnel selection would seem to be overestimated by the candidates with respect to its use [28].

On the other hand, it is also reported in the literature that numerous companies of significant size make use of the services of graphology for trace elements and information about personality based on the assumption that handwriting and personality differ from person to person; according to what it is believed, therefore, that in the handwriting emerge aspects and features relating to the person who writes [37]. Finally, Brewer has argued that, with respect to nursing care, graphology has been an aid to the understanding and possible hidden inner conflicts

in students, nurses and other health professionals [38]. In addition, it is also mentioned the use of graphology in the coaching and development of the students who have a particular shyness or otherwise reserved or reluctant. Handwritings analysis of these persons has also allowed the identification of a capacity not yet developed, and to invest in the right direction [21, 38].

For graphologists the handwriting is one of those non-verbal forms of expression that underlie mental mechanisms a more or less conscious to the individual. This point of view was regarded with some favour by important psychologists such as Gordon Allport and Philip E. Vernon that refer to it in the Treaty “Studies in Expressive Movement” [39]. On the other hand, the handwriting seems to contain within it a myriad of facets and a wealth of features that could be difficult to disconnect from the writer’s own type [40]. Over time, the graphologist also noted that some aspects of affective disorders may be revealed in the writing style of some patients including those depressed showed a reduced size of the letters, keeping the line followed a sinuous or descending course, the pressure support appeared light, the letters showed an inclination reversed and the letters “i” and “j” were devoid of dots [41-43]. Robert derived from his studies that the negative mood was linked to the letters dissociated and the conduct of the graphic layout [44].

Already Teillard Ania in addition to the pressure of the tract had identified as characteristics of a mood inflection that the letters were presented through the acute form, garland, the letters were smaller in the middle zone of the handwriting and the diacritical mark in the letter “t” had a course oriented to the right [3]. In 1994, Kristeva concerning the same condition of psychological distress in addition to a lighter pressure in the tract showed several breaks irregularities, the letters “m” and “n” filiform and a descending line [43]. These findings were confirmed in manic-depressive handwriting from the studies of Stein-Lewinson who also pointed out the lack of rhythm [45, 46].

A series of studies on depressive evidence through the use of graphology have occurred over time [47]. Rosenblum *et al.* have focused on a group of 20 elderly people who had a diagnosis of major depressive disorder compared with a control group of the same number of people [48]. The assessment elements were concentrated on the pressure line and the spatial setting. The results from the study were a decrease in pressure in people affected by depression and a lengthening of the time of execution of the written in people suffering from depression in comparison with the control group. The data in accordance with previous studies deposed to give to the species pressure the best predictor index of depression [49, 50].

In 2013, Gawda hypothesized to verify specific signs in handwriting referable to a major depressive disorder in a group of 30 patients who received this diagnosis compared to a control group of 60 healthy individuals and another group of 60 persons suffering from a bipolar disorder of which 30 in the depressive phase and other 30 in that manic phase [47]. Some forensic graphologists were then engaged in the examination of the entire handwriting sample that turned out so 150 elements to search for signs graphics empirically measured and related to depression among which the direction of the line, the type of the tract, the conformation respectively of the affective letters and the letters “m” and “n”, the inclination, the initial and final traits, the size and the prevailing areas of handwriting.

The data emerging from the study showed significant differences for markers of depression among patients affected by depressive disorder and the control group. On the extreme side of depression, in cases of anti-conservative gestures, Mouly *et al.* conducted a study with the aim to investigate the level of accuracy in capturing data related to psychiatric conditions associated with suicide attempts from handwriting analysis produced by a sample of 40 people who had executed the attempt compared to a control group of 40 healthy people [51]. The results showed an acceptable level of correspondence and reliability of the graphological instruments such as to constitute an additional element in decision making in psychiatry and internal medicine. Aström *et al.* in a study conducted in patients with psychological distress noticed a correlation between the data derived from the study of signatures based on graphometric variables and personality characteristics together with the intellectual level [52]. In accordance with this correlation, the author led to further investigations that identified aspects graphometrically identifiable on character traits of extroversion or similar to some inner conflict [53].

Williams *et al.* departed from the hypothesis that the tendency to introversion, extroversion, reflection and impulsivity were aspects of personality detectable from an handwriting analysis [54]. They conducted a study on a sample of 46 university students, and factor analysis showed three different writing styles correlate to the three dimensions of character indicated.

Even in a study archival of 73 men and 168 women on the signature and the results of the scale of the Minnesota Multiphasic Personality Inventory-2 was observed a correspondence between graphological signs and psychological perception of their gender identity [55]. The extension of the graphological methodology also in the field of dentistry in a survey of 2013 differentiated behaviours and psychological tendencies manifested during the application of the prosthesis in relation to the emotional state [56]. The handwriting analysis is characterized as a valuable tool for the dental treatment of so-called difficult patients.

In terms of micromovement, handwriting is described as a succession and combination of muscular elements, perceptual and motor hand-related, which apparently could be automated, as in handwriting it has been integrated sensory functions, such as cognitive and proprioceptive to be seen as a complex process [57, 58]. In the alteration of this mechanism the motor slowing, for example, represents an important aspect of depression, Mergl *et al.* have started from the hypothesis that depressed patients drew and wrote much more slowly than the control groups as already shown by other studies, and examined 37 depressed patients and 37 healthy individuals [59]. Patients affected by mood depression have made a drawing with a speed significantly less regular than in healthy subjects, they also presented a handwriting abnormally slow. Instrumental analysis highlighted specifically a dysfunction of the basal ganglia and/or reduced activity of the sensorimotor cortex and supplementary motor area as a possible substrate for hand-motor disorders in depression.

The literature suggests that abnormalities of movement are a key feature also observed in psychosis [60]. In this regard, Dean *et al.* have examined the motion abnormalities in subjects at risk of psychosis by estimating the increased presence of displacing movements of the pen. The results were in agreement with the increasing evidence that

alterations of movement are a key feature of the risk of psychosis and that appear to be associated with a dysregulation of the dopaminergic fronto-striatal system since the literature reports that patients with Parkinson's disease treated with dopamine agonists displayed a higher frequency of displacing movements of the pen and patients who suffer from schizophrenia not treated with neuroleptics showed abnormalities of movement [61-64].

In a more recent paper, Crespo *et al.* investigated the use of handwriting in the study of motor abnormalities in patients suffering from bipolar or psychotic disorders. Outcomes demonstrated that individuals affected by schizophrenia spectrum disorder or bipolar disorder manifested significant motor impairments [65]. The handwriting of patients was distinguished by a significant decrease in velocity and acceleration and an increase in the length, disfluency and pressure with respect to controls. In 2019, Giannini and co-workers have tried to elaborate a handwriting analysis protocol in order to estimate severe major depressive disorder, achieving encouraging results [66]. Grace *et al.* investigate how children affected by autism spectrum disorder plan and control their handwriting actions [67]. The patients presented a breakdown in their ability to control and regulate their handwriting movements compared to the control group and these outcomes represented implications for the school-aged child who were constantly involved in handwriting tasks within the classroom environment.

The use of the techniques of graphology was suggested by Graumann in monitoring of a psychotherapeutic process than a declining its application nature included in an arc that moves between the possibility of complementary aid in the phases of psychological and medical research, assessments relating to the progress of care processes and their use in the re-education writing [68]. Graumann considered the use of the graphological tool in monitoring conducted on the progress of psychotherapy about the possibility of a developmental progression of personality in the course of treatment. The observations derived from his studies revealed in some neurotic patients during the course of therapy, the progressive disappearance of specific graphic signs such as the size and density in the lower zone, the bizarre decorations in capital letters, the alterations in the flow of the rhythm. These findings could argue for the success of therapy. However, in some patients it was observed a number of changes not less extravagant than those produced previously.

The interpretative hypothesis in these cases was that of a conversion of the symptom expression, which is not necessarily obvious to all patients in treatment. Generally, the findings observed are constituted by a handwriting more loose and fluent in parallel with a greater autonomy in behaviour, as an index of acquisition of a certain maturation of self. The author insisted on the prerequisites of the experience, training and observation in the use of tools of graphology, not separated even by good psychological skills.

In the context of science education and training Ward described a system of graphotherapy applied to primary school children who experienced issues of an emotional-behavioural or assisted-learning by the intervention in the classroom of teachers trained [21]. In addition, Ward found that the graphotherapy realized through written exercises could exert a positive effect on insomnia of adults favoring a more positive state of mind if repeated over a period of three weeks. Everything

presumably because it can be perceived as a focus or because it may have effects of meditation.

The method of writing Chinese calligraphy has been used and compared with meditation to test the hypothesis of the effects on stress reduction. It is the use of a soft-edge brush to play as a form of art, special Chinese characters on the moves of the great masters. In 2014, Kao and colleagues referring in the last three decades to the psychogeometric theory of Chinese character have focused systematically in a study of mental processes and the body resorting to the use of the method of writing Chinese calligraphy [69]. According to the authors, therefore, the practice of writing Chinese calligraphy could be used to improve the mental and physical health through stress reduction. The researchers started from the general assumption to seize beneficial effects through the use of this writing, particularly on children with attention deficit disorder with hyperactivity enhancing cognitive abilities, or the recovery of cognitive abilities in patients with Alzheimer's disease. They noticed even greater emotional stability among patients who had a depressive illness or a carcinoma.

On the other hand, the techniques of Eastern meditation such as Zen and yoga are traditionally an effective means for the psychological well-being, depressive disorders and generalized anxiety, substantiated by empirical evidence. These forms of meditation attested by instrumental data obtained, a brain activation, a regularized activity of the immune system, better intellectual capabilities. The researchers devoted themselves to the study of subjects who had suffered from physical and psychological stress showed the General Health Questionnaire. The participants for 8 weeks, monitored at the beginning, in the middle and in the end, were divided into three groups randomly distributed; the first was engaged in the use of Chinese calligraphy tool, the second meditation, the third served as a control group. The monitoring consisted in the measurement of respiratory rate, EMG signs and heart rate. In the results, the evidence concerning the first and second groups showed a reduction in heart rate and an increase in body temperature compared to the baseline measurements.

### The Neural Correlates of Handwriting

The act of writing is a complex cognitive process as it is based on complicated sensory, motor and perceptual functions. The handwriting process consists of hands stereotyped movements involving two basic motor components, that is, holding firmly a pen with fingers and moving hand and fingers to produce a text. Therefore, writing is a process that requires the integration of visual, proprioceptive (kinesthetic and haptic) and tactile functions for it to be completed [58]. In fact, the acquisition of skills for writers involves learning the shape of the letters that embodied in a perceptual component and the ability to draw the trajectory that produces the shape of the letter and which constitutes the graphomotor component [57, 70].

The neural substrates underlying handwriting are still not well understood because there are a number of brain areas which interact and which are responsible for various aspects of the ability to write. However there has been an upswing in the number of functional neuroimaging investigations in this field. The findings from these studies, along with those mainly provided by clinical literature examining correlations

between lesions and deficits, have promoted important insights into the neurobiology of writing activities.

Recent analyses of the cytoarchitecture and connectivity of neural areas have provided four key regions that appear to be important in categorizing the brain's writing system [57, 71-73]. i) The fusiform gyrus is most relevant to selectivity to letter, word stimuli and deriving "word-form" [74-78]. ii) The superior parietal lobule (SPL) is critical in guiding the movement of the body in the space, it has been linked with visuospatial and visuomotor neural processes and it is associated with the execution of writing [79-82]. iii) The inferior frontal gyrus (IFG) plays a role in phonological processing and verbal working memory and encodes letterforms and words [83-86]. iv) In the left frontal lobe, Exner's area is responsible for writing and reading and it appears especially relevant in orthographic or graphemic representations as well as in retrieving letter shapes from memory [74, 87-89].

Moving beyond the observation that the neural substrates underlying brain structures involved in handwriting process represent an equally intriguing yet elusive concept, Platon and co-workers described studies that have managed to move toward a greater understanding of the neural system contributing to written language productions [90]. They pointed out twelve cortical and subcortical functional regions associated at different degrees with writing processes. These regions are located in: i) the left superior frontal area, ii) the left superior parietal area, iii) primary motor and sensorimotor cortex, iv) the supplementary and pre-supplementary motor areas, v) right anterior cerebellum, vi) left posterior nucleus of thalamus, vii) ventral premotor area/inferior frontal gyrus, viii) right posterior cerebellum, ix) right superior frontal cortex, x) right inferior parietal lobule, xi) left fusiform gyrus, and xii) left putamen.

Among these, the left frontal superior sulcus area, the left superior parietal area and the right anterior cerebellum represent the areas that have shown a reliable and repetitive activation during handwriting and it does suggest a possible important role played in writing processes in accordance with the perspective taken into account by Sugihara and colleagues that have defined the posterior end of the superior frontal gyrus and the anterior part of the left superior parietal area as "writing centers" [91]. Platon *et al.* found an activation of neurons of the parietal cortex around the left superior parietal area which is part of the "writing centers" as reported by Sugihara *et al.* and could be considered a graphemic area as referred by Sakurai and co-workers such as an area in which "visuokinesthetic and sequential motor engrams for letters and words are stored" [90-92]. In this context Platon and colleagues argued that the superior parietal cortex might be concerned with the selection or representation of letter shapes and had a part of a high-level interface between motor and language areas during written language production [90].

Neuroimaging results indicated that the frontal lobe area showed repeated activation amounting as a region with a condition of high reliability and strong activity during handwriting [90]. This area is usually referred to Exner's area that is located within a small area along the lateral convexity of the left frontal lobe and it is identified as a major "writing center" [90, 93]. With regard to written production the specific function of this area is playing a role in allographic processing. There is a clear consensus regarding its functional role in writing that some

researchers positing that Exner's area act as an interface between orthographic or graphemic abstract representations and the generation of motor commands [89, 90]. The authors presented an activation of right cerebellum, in particular it has been reported increased cerebellar activation in the right anterior cerebellum and in the right posterior cerebellum [90]. Such activation is explained as the result of motor control functions derived from complex finger movements [94]. In this connection it may be interesting to remember that sometimes the activity of the cerebellum is evident even when the writing is "imagined" and when the control activity involves a manual motor task [90, 95].

Although the cerebellum has been associated with written word production, its specificity has not been clearly identified probably because the cerebellum is a complex structure involved in several functions such as motor learning, coordination of voluntary movements, cognitive functions, maintenance of balance and posture.

Panton and co-workers provide a quantitative review and synthesis of findings from functional neuroimaging studies [90]. They identified an essentially left-hemisphere network associated with written word production, providing estimates of the most likely locations of activation within these areas. Two frontal and parietal superior regions seem to be involved, whereas fronto-medial, precentral, frontal inferior, temporal posterior, thalamic and cerebellar areas act at different degrees, from orthographic selection to motor execution.

On the other hand, Rothlein *et al.* conducted a study focused on the identification of specialized brain areas according to the multiplicity of the representation of the letters such as motoric similarities "B" vs. "P", visual similarities "A" vs. "R", abstract similarities "A" vs. "a" [57, 96]. The authors provided novel neural evidence for abstract and modality-specific representations of letters and identifies the specific neural substrates in which these different representational types are instantiated. Their findings indicated a left hemisphere ventral temporal region selectively tuned to abstract representations of letters as well as substrates tuned to modality-specific letter representations [96].

From the neural perspective, Gimenez *et al.* investigated the specific neuroanatomical correlates of written language production in children [57]. Their results revealed that inferior frontal gyrus may represent a key link between phonological processing and written production quality in beginning writers. Additionally, these anatomical findings corroborate findings in functional neuroimaging studies illustrated by Panton and colleagues that conceptualized a positive correlation between inferior frontal gyrus and handwriting [90]. In addition, their paper argued the activation of inferior frontal gyrus is related not only to the volume, but also to a behavioural measure of phonological processes [57]. Results in this study showed that brain activity predominantly correlated with the right hemisphere indicating a greater neural efficiency positively modulated in the right hemisphere [57]. Finally, future research regarding the neural substrates of handwriting are needed in order to highlight critical questions concerning the neural bases of written language productions that still need to be addressed.

### Controversies Concerning the Application of Graphology

Some doubts have been raised about the validity of the character read from the handwriting. In this regard, we consider essential, in the debate

on the function and meaning of graphology, the considerations offered by Paola Urbani in the book "Process to graphology. Magic, art or science?" [97]. This is the first reflection which aims to delineate clearly the identity of graphology, facing with critical rigor the epistemic contradictions and doubts related to this discipline to outline horizons in which systematizing its contribution.

The change in handwriting in accordance with the physical and mental condition of a person such as anxiety, fatigue, stress, pain, even within in the same day has been indicated by Singer as an unfavorable element regarding the identification of a person character by the analysis of his or her handwriting since such conditions can influence it [98]. In our opinion, same subjects can be assessed from the point of view of their handwriting productions at different times, which refer to different conditions. It is possible to monitor the handwriting *in itinere*, that is, at separate times, taking into account the variables that can act and intervene on the human soul. Bradley recognized the need for systematic studies on a large scale to prove the validity of graphology noting that graphology has been developed using a combination of inductive and deductive reasoning [99].

Renna Nezos, director of the British Academy of Graphology and of the London College of Graphology, is a pioneer and bases his analysis of the handwriting on well-structured research methods. Barrett observes the multifaceted aspects of a personality that are reflected in the handwriting and can be expressed sometimes in contradictory sense [100]. With the study of handwriting some "paradoxes" of a person's character can be comprehended through graphology. However, in the evolutionary process of the person, handwriting also leads progressively to a maturation modulating and modeling itself over time. In fact, it is argued that if a person writes with a foot or with the mouth or with the other hand, the general characteristics of writing remain identical. The writing is, of course, less qualified, less elaborate, but to the skilled eye is exactly the same and shows the same characteristics, the same details and the same trends of the person that has been object of specific interest and expertise from graphology [101].

Other criticisms were moves to graphology in terms of scientific reliability already beginning to experimental work examined by Fluckinger and coworkers in 1961 that judged poor graphology inference; and subsequently Klimoski *et al.* have contested to graphology the usefulness of a reliable methodology [102-104]. Ben-Shakhar *et al.* recognizing to graphology an interest of modest proportions, ascertained common evidence among the findings from some graphological studies and deductible instead in his opinion even from simple impressions deduced by naïve in graphology placed in front of the same writings [105].

In 1991, a study conducted with the same intent did not seem to get anything of significant in the use of graphology on the evaluation of the aspects of personality [102]. Blinkhorn interrogated himself about the reasons for which the calligraphy and character should be connected as it is easy to show conferring to the handwriting to the appearance of a pure and simple peripheral motor habit [102]. Hence, he was in favour of graphology only for macroscopic evidence due to serious diseases of the central nervous system such as parkinsonism or Korsakoff's syndrome that have a clear influence on the handwriting easily detectable by an experienced eye; in his view, therefore, it is not possible to derive

a correspondence between handwriting and character. Nevertheless, for Blinkhorn handwriting represents “a part of the self-presentation”, excluding the relationship between the elements of the formation of a letter, the size, direction and continuity of the letters of handwriting and individual characteristics.

In the controversy between followers and detractors of graphology in the group of supporters Rafaeli and Klimoski hypothesized in graphology even a tool for prediction of success or not in the workplace [104]. In contrast, Ben-Shakhar *et al.* denounced in graphology a poor reliability on the assessment of personality traits and the prediction of achievement success in the workplace [105]. However, the limitation of this study would lie in the lack of statistical significance between the coefficients of correlation as the results do not justify a statistical inference to the general population. In a meta-analytic review conducted by Neter and Ben-Shakhar it has been stressed the predictive value determined by the acquisition of informative, autobiographical and content data in comparison with a pure handwriting analysis that overlooks the evaluation of the content of the text [106]. In truth, for the graphological international community the theme of the content of the writings is attributed to one area of assessment that is pertinent to the psychology, because it would have more exquisitely subjective and therefore psychological value.

King and Koehler have supported the phenomenon of illusory correlation in the use of graphology for the definition of personality traits [37]. They found that the semantic associations between the words used to describe personality traits were the source of the perceived correlation that might motivate the use of graphology in the face of evidence against its validity.

Lowis and Mooney examined whether specific components of the writing of a sample of 100 students could connect to the personality traits and the success that they obtained in written examinations [107]. It has been reported significant evidence for positive characteristics related to persistence and attention. In 2003, Furnham, Chamorro-Premuzic, and Callahan have demonstrated from their studies a certain estrangement between graphology and assessment of intelligence and personality [108].

Other works vice versa argue that through the use of graphology can be drawn some personality traits [109-114]. In a study related to school success, Oosthuizen investigated a sample of 50 university students who underwent a handwriting analysis and a personality assessment questionnaire [113]. Outcomes provided a higher correlation between the data obtained from some graphological signs such as, upper zone, lower zone, the angle of the line, the depth and the distance from the margins compared to the questionnaire of the predictive capabilities of academic success.

In two groups of 40 persons, the first composed by successful manager and the second by volunteers, graphics samples have been analysed by three graphologists that succeeded to identify with accuracy the handwritings respectively belonging to the group of professionals and those of the control group. In addition, the precision of the estimates did not depend on the contents of the writings, although the handwritten texts were spontaneously produced [115].

Among those who do not consider graphology a scientific discipline, Furnham referring to the book of Watson titled: “A Dictionary of Mind and Body: Therapies, Techniques and Ideas in Alternative Medicine [116]. The Healthy Arts and Psychology” had put the graphology close to “future-logy” [117]. The author mentions terms such as “graphotherapy” and “palmistry” named in the book of Watson. Practices relate to the future prediction are frequently used to describe, categorize and explain the present. In substance, it has been produced an assimilation between procedures concerning the personality evaluation and ranging from graphology to astrology, numerology up to include alternative forms of medicine such as osteopathy and acupuncture.

Lindeman reflecting on the reasons why people believe in pseudoscience had already compared astrology and graphology for the reason that both turn to aspects related to personality, generic and easily attributable to extensive ranges of psychological types in their generality [118]. These traits are easily recognizable by the common experience of everyday life; based on this assumption the same aspects can be grasped and attributed to people that a more detailed analysis would be rather different. These hypotheses are linked to those of the so-called “magical thinking” [119]. For example Linderman explained that the graphologist can recognize marked managerial skills to three different people without considering that one of them could recognize himself relating him to his own organizational skills, and the other to those relating to the knowledge of his work and the third to his interpersonal skills [118].

Therefore, the assignment of “managerial skills” would result rather vague and banal for the author, easily found in the thought of the common man. In Lindeman opinion, confirmation bias would be ascribable to the so-called Barnum effect, with regard to which people would believe in horoscopes as such under the awning of the Phineas Taylor Barnum’s famous circus live together so many different characters and numbers that everyone can find something fun, through the paradigm of Barnum effect it has been then explained the reason for the success of the circus [118, 120-123]. The coexistence of opposite conditions of human nature is so evident even more so it is subject to the mutations of the moments in fact everyone can be lazy and worker, timid and brave, dependent and independent. However, in our opinion seems trite and simplistic to attribute to graphology coarse inferences that link the size of the letters in the handwriting to a way to “think big” or not, or that the distance between the written words can defined exclusively and separately the dimension of writer proxemic attitude towards the other characterizing as well as distanced/detached or near/intrusive [54].

The discrepancy between dissimilar opinions constitutes a stimulus to deepen studies and verifications concerning the complementary use of graphology between the techniques of investigation into the psychological characteristics of the person. Graphology finds possibility of application in various areas such as orientation to the study, personnel selection, calligraphic expertise, handwriting effect in conditions affecting the neuromuscular system.

## Conclusion

Handwriting represents one of the most important elements of development in human culture. The words that are written somehow tell the story of those who produced them partly in a language of movement and partly in a language of symbolic images; psychiatry and psychology,

by approaching graphology, can acquire useful clinical information to outline a personality profile [124-126]. Like drawing, writing according to the techniques of graphological investigations illustrates a unique and unrepeatable way in every human being that is expressed more and more in the course of life in a spontaneous manner and through which the unconscious connotations of the human soul are projected.

The intent of the present paper was to establish an initial approach to the discipline and to the points of view of graphology through the research of the state of the art over time, starting from its beginnings. We have therefore proceeded to recognize, in the scientific sphere, the terms and definitions that have, with time, increasingly outlined its status. Gradually it has been possible to ascertain on how many and such fields of studies the graphological approaches have been engaged comparing them with opinions and feedbacks from the academic and scientific world.

In immersing ourselves in the universe of graphology we became increasingly aware of how much work and dedication has been done. As illustrated the lands explored by graphologists have ranged parallel or over time inspired by the most diverse points of view and culture: from China to Switzerland, to the United States and through the different countries of the Old Continent to the East and to the Middle East. The areas have moved from the legal sciences, to the identification of personal characteristics compatible with the labour market including the management of human resources, contributions have been directed to the medical, psychological, psychopathological, neuropsychiatric-child and neuroscience disciplines, to the evaluation of evolution of the individual starting from childhood and pedagogy [127]. To restrict the field to a psychological and psychological-clinical position, the stimulus that we felt in this exploration work could be to open a way of perspective comparison between different points of view in order to search for elements of correspondence in the study of personality and health mental, through the identification and use of tools that can be correlated between them by both parties respecting criteria of validity, sensitivity, reliability and significance.

The instrument of undisputed psychometric and structural value is the projective test of investigation of the personality based on the inkblots of Hermann Rorschach and which we believe represents a wonderful means of “scientific craftsmanship”. It would be particularly interesting to start from the characteristics traced by graphology, through such a refined and complex technique, to correlate them to the evidences that emerge from the use of the psychometric tools. This opportunity could emerge along a gestalitic *continuum* that starts from the identification of characteristics of the person, accompanies the maturing evolution of the human being up to constitute as a tool of monitoring and verification complementary to the progress of a psychotherapeutic process, passing also for neurophysiopathological stages as well as those of application in rehabilitation techniques. Our intent is therefore to start an effective collaboration in order to enhance the tribute of graphology as a “social science” to psychological speculation.

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