

# Relationship Between Personality and Kinematic Parameters of Handwriting

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**Abstract.** Motor and cognitive systems are largely involved in producing handwriting that develops with age becoming more and more personalized until it reaches a style proper to the subject. This fact has led graphologists to assert that by examining the handwriting it is possible to somehow trace the personality of the writer. Many studies have been carried out to demonstrate this assumption but they are all based on the graphic examination of the tract left on the sheet of paper. On the other hand, recently it has been possible to examine writing through the use of digital tablets capable of providing information also on the kinematic of the movement, extracting parameters used to examine in particular dysgraphia and some neurological pathologies. Aim of this study was to determine possible relationships between kinematic parameters extracted using digital tablets and personality traits. Sixty-one subjects took part in the study, executing three writing tasks (fast and accurate writing of an Italian phrase and fast sequence of cursive lowercase letters “lelele” without pen lifting for 30 s) and a personality test (IPIP-NEO-120). The linear regression between each of fourteen characteristic of handwriting and each of the five personality traits was computed. The results showed that four out of five main psychological tracts presented a linear relation with one or more kinematic characteristics. This study offers a first glance at a complex series of correlations, which will be investigated in future researches.

**Keywords:** Handwriting · Big Five · Kinematic parameters

## 1 Introduction

Handwriting is a complex process characterized by the involvement of cognitive and motor systems and, at the same time, it is a way to express one’s personality.

In order to describe individual differences in personality in a standard and efficient way, psychologists have developed many scales and different taxonomic structures of personality traits, also in response to specific aims (e.g. to obtain the grade of adaptability to a situation). A currently prominent model of personality traits is the so-called Five Factor Model, according to which the following five domains—identified by the

acronym OCEAN—represent the main biologically based and cross-culturally replicable individual differences: Openness, Conscientiousness, Extraversion, Agreeableness and Neuroticism. These domains also match the so-called Big Five psycholexical factors, which have been condensed from initial large lists of terms generally used to describe an individual’s stable characteristics and have been replicated in Western as well as non-Western languages [1]. Both the Five Factor Model and the Big Five model describe hierarchical structures of individual differences, with upper- as well as lower-level scales and several questionnaires have been developed in accordance with these models. In this paper, we used the IPIP-NEO-120 questionnaire, developed by Johnson in 2014 [2], a measure composed of 120 items (4 for each of six sub-dimension of each of the Big Five factors) that gives a general overview of the personality.

On the other hand, handwriting is widely studied both to examine its learning and its alterations due to dysgraphia as well as to tremor or other pathologies [3–5]. The approaches in evaluating handwriting can be divided in either graphical or kinematic features analysis. The first makes use of easily recognizable components as the lowercase letter “t”, lowercase letter “f”, space between the lines, baseline, word slant, connecting words/letters and writing pressure [6]. Thanks to the use of special digital tablets combined with pen capable of writing on ordinary sheets of paper, it is also possible to extract kinematics-related parameters from handwriting during the execution of specific tasks. The variables are calculated on the whole exercise (e.g. total length, duration on sheet or in air, mean velocity or mean pressure, etc.) or as parameters evaluated either on single components (tracts between two successive pen lift) or on single strokes (tracts between two successive minima of the curvilinear velocity) and averaged on the whole test [4, 5, 7]. However, although graphology hypothesizes a link between writing and personality, and there are some studies that analyse it, to our knowledge, only one study investigated connections between personality traits and handwriting and drawing features recorded through a digitizing tablet able to measure speed, pressure applied to the sheet, dimension and inclination of components [6]. The study showed that some personality traits can be revealed by handwriting/drawing features extracted from components.

The aim of this paper is to extend these results identifying possible correlations between personality domains of the Big Five model and other kinematic parameters related to motor programming of writing.

## 2 Materials and Methods

### 2.1 Subjects and Tasks

A total of 61 healthy young subjects were enrolled in this study, 32 females and 29 males, aged between 21 and 37 (mean  $24 \pm 3.3$  years). The handwriting was recorded during three different tasks: cursive copying in a fast (F) or accurate (A) way of the Italian sentence “In pochi giorni il bruco diventò una bellissima farfalla che svolazzava sui prati in cerca di margherite e qualche quadrifoglio” (*In a few days the caterpillar became a beautiful butterfly that fluttered over the meadows in search of daisies and the occasional four-leaf clover*), and the fast reproduction in cursive lowercase letters of “lelele” (lelele) sequence, without pen lifting for 30 s.

Furthermore, the subjects were asked to answer the 120 questions of the IPIP-NEO-120 test available at <https://bigfive-test.com/>, which gives a score between 24 and 120 for each of the five factors.

## 2.2 Data Acquisition and Analysis

The handwriting tasks were acquired with a graphics tablet (WACOM Intuos<sup>®</sup> 3) using an ink pen. A sheet of paper was placed over the tablet to provide visual feedback to the subject during the experiment. The data acquisition system sampled at 200 Hz with a spatial resolution of 0.02 mm the position (x y coordinates), the altitude, the azimuth, and the pressure of the pen. From the acquired data, strokes (segments between two successive minima of the curvilinear velocity) related to motor programming of writing were identified, and the following kinematic parameters were calculated on each stroke and averaged on the whole test: pressure, length, duration, horizontal, vertical, and curvilinear peak and mean velocities. Moreover, on the whole trace were computed the total time spent to complete the exercise, the total length of written space, the mean curvilinear velocity, the total duration of pen lift and the number of strokes. Recordings in which the subjects did not write in cursive were excluded.

In order to find possible correlations between each of the 14 handwriting parameters and each of the five personality factors, a linear regression between each pair of variables was computed. Only pairs with a significant linear relation ( $p < 0.05$ ), were considered. All the data processing was done on MATLAB<sup>®</sup>.

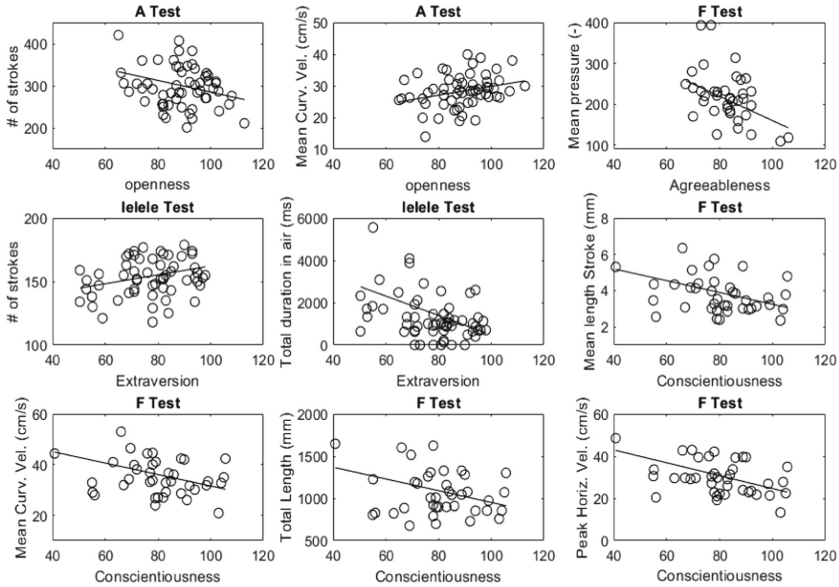
## 3 Results

Figure 1 shows some examples of the relations between the kinematic variables and the four factors that show a significant linear relation. For Neuroticism, there is no significant relation with any kinematic parameters. For all the relationships, it is possible to observe a pronounced inter-subject variability reflexed in the determination coefficient values,  $R^2$ , of the linear regression (Table 1).

Table 1 presents all the significant ( $p < 0.05$ ) linear relations found between the Big Five factors and the kinematic parameters in the different tasks, with the corresponding number of subjects considered.

Fourteen relations were found, mainly concerning velocity, pressure, length of written tracts, number of strokes and pen lift duration. In particular, increase of Openness was correlated with decrease of number of strokes and increment of mean curvilinear velocity and peak horizontal velocity of strokes, in the Accurate task. Increase of Agreeableness was associated to decrease of pressure in both Accurate and Fast tasks. Increase of Conscientiousness was linked to decrease in velocities (mean and peak curvilinear, stroke peak horizontal in Fast task and stroke peak horizontal in lelele task) and lengths (stroke mean in Fast and lelele tasks, total written in Fast task).

Finally, increase of Extraversion was correlated to increase in number of strokes as well as in decrease of the duration of pen lift, in lelele task.



**Fig. 1.** Examples of significant linear regression between pairs of personality traits and kinematic parameters in the three writing tests.

## 4 Discussion

The obtained results are not comparable with previous researches [8] because of different experimental protocols and features examined. Given that the comparison is done between objective measurements and self-report scores, an elevated variability is to be expected. Despite this, the study made it possible to highlight the existence of a series of relations existing between some kinematic characteristics, especially linked to motor programming, and almost all personality traits. In particular, considering Openness, all the variables significantly related to were obtained during the Accurate task. Higher value of Openness corresponds to higher writing velocity and lower fragmentation that can be explained remembering that higher Openness generally reflects a higher cultural level and presumably reflect being used to read and write more.

Agreeableness presented a significant relation with the mean pressure in both Accurate and Fast exercises, decreasing when pressure increases, thus suggesting that less prosocial, other-oriented and empathic individuals are more incisive in their writing style.

About Conscientiousness, several parameters related to velocities and lengths showed a significant inverse relation in Fast and lelele exercises. Greater Conscientiousness corresponds to lower velocity and less space utilized to write the same number of letters during tasks in which high velocity is required, that is, smaller size of the letters. Such a finding is in line with a typical profile of higher conscientiousness individuals which tend to control their cognitive and behavioural impulses, being more self-disciplined, controlled and with planned behaviour.

**Table 1.** Significant relations between personality traits and kinematic features. For each relation the corresponding task,  $R^2$ ,  $m$  e  $q$  parameters of the linear regression are reported.

Personality trait	Task	Feature	$R^2$	$m$	$q$	# of subjects
Openness	A	Number of strokes	0.08	-1.40	420	58
	A	Mean curvilinear velocity	0.09	0.14	16	58
	A	Stroke peak horizontal velocity	0.09	0.15	11	58
Agreeableness	A	Mean pressure	0.12	-2.10	380	58
	F	Mean Pressure	0.14	-3.00	460	40
Conscientiousness	F	Peak curvilinear velocity	0.13	-0.32	69	40
	F	Stroke mean length	0.14	-0.03	6.5	40
	F	Mean curvilinear velocity	0.11	-0.23	54	40
	F	Total written length	0.10	-7.00	1600	40
	F	Stroke peak horizontal velocity	0.20	-0.31	55	40
	lelele	Stroke mean length	0.08	-0.03	8.3	61
	lelele	Stroke peak horizontal velocity	0.10	-0.24	50	61
Extraversion	lelele	Number of strokes	0.08	0.35	132	61
	lelele	Total duration of pen lift	0.13	-46.0	5100	61

Finally, Extraversion showed significant direct relation with the number of strokes and inverse link with the total duration of pen lift in the lelele task corresponding to a higher fragmentation and a shorter programming time of writing. Such a finding could reflect Extraversion as a higher-order domain including expression of impulses, activity and excitement-seeking.

From a psychological point of view, the Big Five characteristics are not totally independent from each other, so considering a simple regression between a handwriting component and a single personality trait could limit the reliability of results. In any case this preliminary study opens up the possibility of being able to use the kinematic analysis of writing also in the psychological field.

## 5 Conclusions

Digital technologies enable the extraction of kinematic parameters not easily identifiable before. This means that novel correlations between them and other factors like for example the personality traits can be discovered, increasing the assessment tools available in the psychological field.

Aim of the present study was to determine possible correlations between personality traits and kinematic parameters of handwriting, in order to associate objective values to traits in a simple and economical way. The study, conducted on 61 young healthy subjects, outlined some relation between four of the five psychological traits and kinematic parameters of handwriting that mostly deal with velocity, fragmentation, pressure, size of letters and pen lift duration, giving a possible psychological explanation.

The results of the study are limited by the great variability present due in part to the small number of subjects who took part in the research. The next step will therefore be to increase the sample size.

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