NEUROPSYCHOLOGICAL CUES OF WRITING READINESS

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Abstract

The hypothesis that writing one's own name provides a reliable index of praxia development in preschool children was tested.

In a standardized setting, 245 Children aged 3 to 8 wrote their first name in any graphic way they wished. Ten parameters of the traces and a global index of prewriting were then used for internal and external reliability analysis.

Results show that "signature", whether a drawing, a sequence of pseudoletters or letters, or a full name, could be described according to at least ten components which correspond to perceptual, representational, and motor acquisition during childhood. Indeed, the components were found to have good internal reliability, are highly dependent on age and preschool grade, and statistically correlate with both language development and particularly strongly with praxia development.

A clinical application resulted from the research, that is, a normalized and standardized prewriting index.

Key-words

writing, prewriting, writing readiness, developmental praxia, child neuropsychology

1.- Introduction

Handwriting is the expression of language through manual motricity. Its learning depends on the joint development of digit skills and on phonem to graphem conversion. Dysgraphia and dysorthographia are writing learning disabilities that can be seen either separately or together.

Formal writing learning evolves in two steps. Firstly, prewriting relates to various graphomotor acquisitions that permit transition from drawing to writing, a stage where the child simulates writing by producing letterlike forms and by reading these letterlike forms in his/her own way. Secondly, in acquiring written language correctly it takes many years to learn the orthographic conventions and the redactional know-how.

There are numerous studies of writing learning during the school period, that is, during the second stage. In comparison, there are few prewriting studies in the literature (Edwards, 2003). Consequently, a study of writing readiness is presented in this paper. Writing readiness is the state of maturity of a child to enter the second, linguistic, phase and is studied by analyzing the neuropsychological components of this readiness.

In child neuropsychology, the motor and the linguistic stages usually overlap when learning is delayed, and so they take several years longer. This is why analyzing prewriting in more details and providing a writing readiness index for rehabilitation purpose is useful.

Previous studies

The French neuropsychologist Lurçat (1985) studied graphomotor psychogenesis, and in the same vein, Auzias and Ajuriaguerra (1986) stressed the slow development of motor coordination and motor immaturity before entering primary school, and recommended that educators be patient when teaching writing.

This French neuropsychological school specialized in diagnosing and remedying dyspraxia and dysgraphia. It is clear from the stage when the child runs and manipulates objects that he or she needs a subsequent period of several years to develop specialized perception, representation, and fine motricity fully in order to learn writing. Therefore, as Tolchinsky (2003) puts it, specialized abilities, sometimes independent of those that facilitate the ability to read, contribute to the cradle of culture.

The study presented in this paper aims to complete the previous pioneering work by examining both the perceptual and the motor development of writing readiness.

Perceptual aspects of writing

The act of reading involves the perceptual coordination of two planes in space: the retinal plane and the page plane. The retinal plane, which depends on the head position, must be in line with that of the page in order to recognize conventional reading directions. This suffices for reading in any body posture, whether sitting, standing, or lying. However, the manual involvement in writing requires the chest to be in line with the retinal and the external coordinates, mimicking the characteristic scribe posture. The secret of this posture is that it favors the unification of visual, proprioceptive, and spatial perception. Therefore, writing is made possible by projecting the body space on the graphic surface (Lurçat, 1980; Bullinger, 1988).

For example, discovering which hand one prefers to write with is such a subtle perceptual experience that it can only appear when the three planes are aligned and stabilized. Indeed, each hand has its own biomechanics to trace lines and volutes in one specific direction, mobilizing adduction or abduction differently. The various perceptions can only be unified from a stable posture from which prewriting learning can then be launched. The movement sequences can be cumulatively experienced and constitute the future grammar of action for writing (Goodnow & Levine, 1973).

In the western world, writing starts on the upper left of the page. The grammar of writing provides the child with a retinal and gravitational experience, that of the required arm and hand movements continuously moving in the same direction, from left to right and from top to bottom, whether it be at the level of the page or of the letter itself. Stroke direction habit acquisition has been used to predict school readiness (Simner, 1984b). Note that the linguistic marks of the directions, "top", "down", "left", and "right" are learned much later than the visual and proprioceptive experience of the coordinates made (Marr, Windsor & Cermak, 2001).

The stabilization of the planes in space means the coordinates of one plane can be transcoded to the other. The sense of verticality therefore applies to the flat table surface.

Writing letters obeys rules of economy in terms of muscular effort and comfort. A "descending" line drawn from farther away to close to the chest is preferred to an "ascending" line because pulling is perceived as being easier than pushing the pencil. The visual control of the trace on the "horizontal" axis is continuous if the pencil is pulled by abduction.

The sense of the vertical and the horizontal are strong in the initial steps of learning to draw and write (Lurçat, 1975; Ibbotson & Bryant, 1976) so much so that copying the oblique leaves the child without reference and induces "orthogonalization" reducing the oblique to one of the coordinates (Gaillard, 1983).

Curls are naturally drawn clockwise by the right hand and anticlockwise by the left.

Governed by these rules and many others, invariants of the writing gesture take place. However, perceptual aspects of writing often compete with motor invariants. For example, Simner (1984a) has shown that reversal errors cannot be explained by the grammar of action. The grammar of action adapts itself to the many circumstances where the visual project imposes upon the motor one. For example, varying the graphic instruments (finger, pencil, brush,...) and the support (sand, paper on table, wall,...) means the child's attention can be concentrated on the intended form instead of on the motor act.

Perceptual constancy preserves form recognition and helps in building the letter, whatever its size. The motor program is subordinate to the intention and to the visual project as can be seen in the fact that independent of the letter size speed of writing tends to remain constant (Zesiger, 1995).

Written letters progressively become the expression of internal schema. Characteristic features of the form also remain whatever motor realization is used, whether it is the preferred or the non-preferred hand, or even the foot in the sand (Wing, 2000).

From scribbling, forms can be assembled that represent a flower, a face, or a letter.

Coloring forms trains visual attention and motor control. It introduces the child to spatial precision, to the orientation of strokes, and to the idea that any graphic gesture needs to be calculated in terms of the available space and the imposed limits.

Representational aspects of writing

Representation emerges when the child allocates a meaning to his or her graphic trace. The experience of magic that the child first lives when creating a graphic trace on whatever surface then gives precedence to symbolization of a reality or an idea. He or she discovers that using a graphic instrument results in a communication as powerful as using words. Metawriting plays an important role in the emergence of writing (Tolchinsky, 2006).

Intentional gesture and speaking are neuropsychological twins. Their appearance precedes the holding of a pencil. However, the desire for sharing views about reality naturally suggests the child naming his or her graphic trace and seeing in it more than is recognizable.

Experimental studies on labeling have revealed early implicit knowledge of written notation (Ferreiro, 1988; Brennemann Massey, Machado, & Gelman, 1996). The child is already capable of making a mark on a box from the age of three in order to signify its contents, whether by a drawing, a sign, or a pictogram. If the sign is recognizable by the child only, it is already prewriting. But if the sign is copied from the alphabet, it is writing (Gombert & Fayol, 1992; Martlew & Sorsby, 1995; Brennemann et al., 1996; Tolchinsky, 2003).

Motor aspects of writing

Typical primary school calligraphy is acquired after many years of fine wrist and digital motor training. Ajuriaguerra, Auzias & colleagues have argued that writing didactics should patiently wait for sufficient neurofunctional maturity to become effective, and that this stage is only reached at six years of age (Auzias & Ajuriaguerra, 1986). Differentiation of all neuromuscular segments right to the tip of the fingers provides movement and tonus control, which in turn contains the strength to hold the pencil, the balanced pressure, and the gesture flexibility. Hand posture and movements are exercised according to lightness and comfort which guarantees perseverance in learning precision, speed, and automatization.

Preschooler's graphomotor activities correlate positively with the general level of motor development of children (Van Galen, 1980). Considering the kinaesthesic side of this motor maturity, Lazlo & Broderick (1991) even recommend waiting until seven years of age before requiring the child to write a line in his or her exercise book. These options are influenced by drawing and writing backwardness. However, it may be misleading to generalize to this extent for the pleasure of calligraphy can also be observed much earlier in some children, probably more often in girls than boys because of their relative motor suppleness and thanks to the sex-related linguistic advantage.

New movement economy rules emerge when the child joins two letters in a syllable. Indeed, the spot where the writing of the first letter ends favorably comes closer to the one where the following letter begins. Two letters are no longer two drawings: the biomechanics change. For example, the child finds it easier to draw the circle anticlockwise rather than in the natural clockwise direction so that the final spot of the syllable finishes on the right-hand side instead of between the letters. This example also shows that learning sometimes involves disobeying former rules, in this case countering neuromuscular habits that favor the direction in space and the orientation in the sequence (Meulenbroek, Vinter & Mounoud, 1993).

To write a digram fluently from left to right facilitates the adding of subsequent letters, and opens the way to writing a bisyllabic word. Biomechanics therefore helps the sequentialization of the writing. Dysgraphic children very often ignore where they are in the sequence, both manually and orally. In this case, the child’s confusion leads to letter omission or addition. This is where dysgraphia and dysorthographia meet, for lack of orientation prevents the writer from developing an orthograph.

Therefore, automatization of writing lightens the process of following graphem-phonem correspondence, that is to say, the fluent biomechanics frees attention from the visual sequence and delegates it to the oral control of the verbal sequence.

If the child is presented with a written model, he or she faces a new orientation task. The aim of the teacher is to link writing and reading together, which is intended to favor reciprocal learning. However, the child has to continuously know where he or she is, firstly in the model,

secondly in the copy, and thirdly in speech. We know of some forms of dyspraxia where the presence of the model actually adds confusion to the task.

The ability to follow both an internal and an external sequence mentally has been recognized as an important executive function, loaded with attention and working memory. This late maturing neurocognitive ability is required in order to learn to write and is solicited more intensively by copying writing.

School culture induces a specific graphic style, passing from capitals to lower case letters, and choosing which type of letter is written, that is, script or curl. The praxis of building letters requires specific features to be drawn that clearly differentiate them from each other. However, this differentiation process interferes with perceptual ambiguity provided by mirror images: the famous confusion between u and n, f and t (top-down mirrors), between b and d as well as p and q (left-right mirrors), between m and n, r and i (details in their shapes) and other common reversals: S,Z,3,5,7...

The child usually learns to write capitals first, which can be depicted relatively roughly using the arm. Capitals are favorably traced with reference to the coordinates by choosing a writing direction and avoiding reversals. However, the sense of the vertical is sometimes so strong that it leads to letter distortion, for example, drawing a slanted "A" because the first stroke is traced vertically in order to avoid the oblique.

As far as lower case letters are concerned, differentiation between mirrors depends on small localized features which differ from one writing style to another. The style sometimes changes the whole shape of the letter (r-r, s-s, f-f, to cite only the most frequent cases).

Mirror letters (or digits) are the most common and enduring of writing errors, with no further consequences for writing if it appears in isolation (Hill, 1980; Simner, 1982). In children who produce them, these errors usually disappear in the second grade, normally around eight years of age (Patton, Yarbrough & Thursby, 2000). Most children master reversals from the age of six. However, because reversals are physiological, they are overrepresented in dysgraphic children who suffer from a great many other difficulties in building words. Writing styles that impoverish the visual features sometimes prolong the tendency to reverse letters. Clinical cases are known for being trapped by either the variety of graphic styles (in migrants, for example) or by an exaggeratedly purified style.

Being aware of the whole writing surface and choosing the place to start writing appears relatively late, that is, after learning to form letters. The writing space must be perceived in anticipation as an already filled area that presents itself to the reader. This space is continuously organized during writing with reference to the coordinates (writing on a horizontal line) and considering the rules governing the linking of the letters, the separation of the words, writing several lines, and writing sentences with punctuation.

In the calligraphic stage, the child pays attention to the spatial parameters. It implies that the child no longer needs to trace the same letter twice or correct letters already written (auto-correction, alteration, and deletion) for the child no longer has any doubt about letter building and linking.

Experiments using a digitalized writing surface (see Zesiger, 1995) have shown the importance of graphic fluence, and for example have put forward the "In-Air" symptom

(Rosenblum, Parush & Weisse, 2003). This symptom stigmatizes the questions that impose themselves on the mind of the child while he or she writes. During the learning phase, this search for information typically deals with coordinating the various sequences, visual, motor and oral, and sometimes deals with body schema reference.

Writing speed, or the number of letters traced in a certain period of time, also represents the degree of writing automatization. In principle it is fastest in curl writing (Meulenbroek & Van Galen, 1990).

The present study takes the writing his or her own name by a child as a target. Even with a few letters, for the child the first name represents the most attractive goal in the earliest stage of writing. Several studies have also addressed the child writing his or her own name as a privileged production (Reimer, Eaves, Richards & Crichton, 1975; Green, 1998). Focusing on the prewriting stage, it is taken for granted that all preschool children take pleasure in training themselves to write their names and that the end product is the most reliable testimony of this learning. The various features of the learning-to-write process can be studied in these names. The prewriting cues emphasized in this paper are neuropsychological for they specifically illustrate the perceptual, representational, and motor development believed to be required to write. The traces were systematically analyzed and coded so that a prewriting index "signature" is presented, normalized and standardized for the different six-month-age-groups of the population sample, which is from three to eight years of age.

2.- Methods

Procedure

The study of a child writing his or her own name at the preschool level was part of an experiment concerning ideomotor praxia. Children sat or stood in front of a square table which had a flat surface and were presented with a white sheet of paper, 30 x 20mm. (A4) that was presented horizontally. The sheet was carefully aligned to the table edge.

Children were offered a black pencil and asked to write down their first name. If the children started writing straightaway, no other instruction whatsoever was given. If children ask a question regarding the way or the place of writing, the experimenter replied, "Do it as you prefer". Depending on age, if the child looked puzzled, they were invited to write down anything they knew about their names or if necessary to draw themselves. Following this, the children did the praxia tests: object recognition and naming, correct object use recognition from a choice of pictures, and finally, object use pantomime.

Whether the end product of the writing test was a drawing, one or more letters, or a full name, it was named "signature".

Participants

245 children from kindergarten and preschool classes in the Lausanne area of Switzerland took part in the experiment. They were aged 3 to 8 years (minimum 37 months, maximum 111 months). Table 1 shows the different age groups and their size. No selection of the subjects was introduced.

The exact age, sex, preschool grade (in Switzerland: kindergarten, preschool 1, preschool 2, primary 1 and primary 2), the language(s) spoken at home (school is in French), and the hand used by each child for drawing or writing were recorded.

Analysis

Ten neuropsychological cues of prewriting were identified (see the procedure for decoding the graphic trace in Appendix 1), and together with a global score, were subject to statistical analysis of reliability. Internal reliability was calculated using the Cronbach alpha method. Study of external reliability encompassed analysis of the role of the various dependant variables (age, sex, language, and handedness) and relationships with the praxia tests.

Finally, "signature" as a global index of prewriting maturity was calculated (see Appendix 1), which was normalized and standardized so that it could be used for clinical purposes as a reference for writing readiness (Appendix 2).

3.- Results

Internal reliability

Since the Alpha (Cronbach) for the scale reaches .9531 and varies from .9440 to .9593 for the items, signature is a scale with strong internal consistency. A split-half analysis shows a Guttman correlation of .9707 with an alpha of .8958 for the 5 first items and .9148 for the 5 last items (N=245). Relationships between the individual items are high and no item needs to be excluded in order to elevate reliability.

Independent variables

A three factor ANOVA (sex, mother tongue, and handedness) does not reveal any statistically significant difference between boys and girls, or between French speaking children and others (33%), or between righthanders and others (8%). There is no significant interaction between factors.

External reliability

Learning: development of signature according to age and (pre-)school grade.

Pearson Correlation between signature and the age of the subject expressed in months is .781 (N=245).
T-tests for mean difference between two consecutive age groups are presented in table 1 that shows a strong age-related progression of the signature index from 3 to 5 years old, that is, during preschool years. The index continues to rise between 5 and 7 years of age, after which it reaches its ceiling at 8, one point below the possible maximum (30 points).

insert table 1 here

A one way ANOVA between school grade and signature confirms the continuous progression of “signature” from Kindergarten to the second year of primary school ($F=164.600$, $df=243$, $p<.000$).

As shown in Table 1, the same analysis was performed for each item in order to illustrate which parameter of signature progresses at each age. A maximum significance threshold of .01 was chosen. It was found that not all of the items show the same development curve. A qualitative summary of the development of each item is now given.

Lower case is seldom used by three to four year olds (5% of the age group). However, all the other items show a regular progression.

3 to 5 years of age is the typical time children learn the alphabet or individual letters (from 5% capable of a minimum of one letter at 3 to 90% capable of writing all the letters in their name at 5), they inhibit static inversion – such as 3 for E (percentage reversals at 4: 20%, at 5: 12%), they link the graphems phonemically (from 5% to 85%), develop a certain sense of page topology (the 3-year-olds draw and write in the center, 30% of the 4-y.-o. and 45% of the 5-y.-o. write in the upper left quadrant). This is also the case for the symbolic age (from 10% producing a symbolic drawing at 3 to 85% writing their full name at 5).

From the ages of 5 to 6, the sense of coordinates, the trend towards micrography, the use of lower case, the marking of the first letter, and the graphic fluency continue to progress. Reversals drop to only 5% by 6 years of age.

From 6 to 7 years of age a progression regarding micrography is still observed in the use of lower case, the marking of the first letter, and writing in the upper left quadrant (6 years: 50%; 7 years: 85%). Reversals disappear from our sample from 7 years of age upwards.

“Signature” is a typical acquisition of 4½ to 6 years-olds. Before 4 ½, "signature" lacks gaussian dispersion and suffers a floor effect. The learning phase is entered at 4 ½ to 5 years of age where all the scores can be found in children of similar age. However, we encountered exceptions to this rule: the most precocious child in signing was a girl aged 3 years and 11 months who scored 19 points out of 30, a performance equivalent to the mean score of 5-years-olds (formal prewriting quotient: 5/3.9=128). Three children under 4 years of age (16%) obtained a "signature" score, but most of the 3-years-olds did not score at all. From 7 years-of-age "signature" again shows poor dispersion due to the ceiling effect.

External reliability
Correlation with other neuropsychological measurements

Since "signature" was part of an experimental design aimed at studying its relationships with praxia recognition and execution, praxia tests could be used to calculate its correlations. The praxia study was composed of recording the following:
1) the naming of the object to be used;
2) the recognition of the picture pantomiming its correct use;
3) the child pantomiming its use.

1) Pearson's correlations between object naming and each signature component for the 245 subjects are all greater than .30, far exceeding the significance of $p=.000$. The highest

correlations concern naming and marking the first letter (r=.58) as well as naming and "minuscule", the introduction of lower case letters (r=.51).

Naming and the "signature" index showed a correlation of .48.

2) Correlations between the recognition of the correct use of the object and each of the signature components were higher. They all exceed .50. The highest concerned marking the first letter (.68), micrography (.60), minuscules (.60), and graphic fluency (.60).

Recognizing the correct use of the object and the "signature" index showed a correlation of .68.

3) Correlations between Pantomiming the use of the object and each signature component were as high as for recognizing the correct use of the object, except for coordinates (.45) and Lettric (.49). Again the highest concerned marking the first letter (.66).

Pantomiming the use of the object and the "signature" index showed a correlation of .66.

It appears that “signature”, a productive task, has the same correlation with object use recognition as it does with object use pantomime. This fact adds weight to the opinion that prewriting is a perceptual acquisition at the same level as a motor acquisition.

In summary, "signature" has good external reliability with regard to other praxia tests. It can therefore be seen as a test of early praxia in the preschool period.

Figure 1 provides examples of stepwise acquisition of “signature”. The legend in Figure 1 follows the progressive intervention of the neuropsychological cues observed.

4.- Discussion

Handwriting learning from the age of 3 to 8 was studied, that is, during five years of critical development regarding written language.

245 traces representing the first name of the child were analyzed by clinically identifying ten components of the skill and it was postulated that these ten components would illustrate the age-related progression of prewriting. A prewriting index was developed for each component by scoring it from 0 to 3 points. This resulted in a writing readiness index of which the maximum was a micrographic and calligraphic first name, spatially placed and organized, fluently written, and representing the person of the author by individual scenic presentation, for example, by emphasizing the first letter.

The various components and the writing readiness index were submitted to both internal and external reliability analysis. Results show that all components were structurally coherent with the index and that none of them were superfluous. This does not mean that the spectral analysis of what was thought to be the first writing was exhaustive, but it does mean that at least all the writing cues considered were part of learning conventional writing in this culture.

The critical development of signing one’s own name occurs between 4½ and 6 years of age. "Signature" therefore represents the first steps in writing taken by a child. Because the task is short, well accepted, but nevertheless very informative, in applying a neuropsychological

analysis to its production, "signature" is a valid indicator of progression in the learning-to-write process.

External reliability confirmed that writing his or her first name for the child represents a constructional praxia that relates closely to ideomotor development, in this case to the ability to pantomime object use and also to recognize the correct object use gesture. Correlation of "signature" with the correct object use recognition was even greater than the correlation with pantomiming. This result emphasizes that there are many perceptual components in the graphic task.

Although writing seems to be an executive task, learning it mainly relies on progression in the perception of space. This represents a series of distinct acquisitions regarding symbolism, sense of the coordinates, transcoding of capitals to lower case letters, form recognition, direction of writing, distinction between mirror shapes, global vision of the writing on the page, graphic fluency linking the letters, and mission allotted to the name representing the person of the writer. These perceptual and representational components are an addition to those of the motor task. What remains motor in writing one's own name is possibly modest: the distal muscular control allows the child to draw small size letters, remarkable progress in ability that in this paper is called micrography, the child being physiologically macrographic in the earliest stages of drawing and writing. Therefore, training to write should consider the perceptual prerequisites as being as important as the manual components.

There is a general discussion in the literature on how and when to start formally teaching writing, whereas the present study finds several specific prerequisites of normal writing acquisition. Therefore, the knowledge reviewed here and updated with experimental data begs the question of whether or not formal training should be postponed until all the children have naturally acquired these prerequisites. This option still prevails in many countries just as it does in Switzerland. Could at least some of the components of the prewriting experience the present study has stressed be subject to formal training during the preschool years, with the benefit of preventing subsequent writing difficulties and literacy handicap?

The contribution to the latter objective made by this study is an index that places the child on a prewriting developmental scale which helps detect writing difficulties both in the normal and in the rehabilitation population.

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Table 1. "Signature": mean and standard deviation scores, statistical differences between age groups (t-test).

agegroup (in years)	N	Mean signature	SD signature	t	df	p
3	19	1.63	4.72			
4	44	13.39	9.44	*6.58*	*61*	*.000*
5	64	20.88	5.01	*4.82*	*106*	*.000*
6	41	24.51	3.19	*4.14*	*103*	*.000*
7	48	28.19	2.32	*6.12*	*87*	*.000*
8	29	29.00	1.10	*2.07*	*75*	*.042*

Appendix 1.
"Signature", an index of writing readiness

Procedure

The experimenter presents to the child a sheet of white paper 30 x 20 cm (A4) placed horizontally, the edge facing the child aligned with the straight table border. He/she says: "Please, write down your name (specifying "first name", if necessary), or whatever you can write of it. If you don't know the writing, draw yourself."

Analysing "signature". Quantitative evaluation

Ten parameters receive from zero to three points each. The minimum score is 0, the maximum 30 points. The naming of the parameters is pure convention. Each parameter can be composed of more neuropsychological cues than its name suggests.

1.- Symbolism

0 no graphic trace, or scribble, meaningless straight or circular line(s).
1 one recognizable letter, letter-like drawing, or any symbolic drawing like a person, house, flower, whatever its execution.
2 incomplete name regarding the number of letters, too many or too less.
3 entire name, only from the number of letters point of view

2.- Lettric (praxic production of recognizable letters)

0 no clearly recognizable letter, letter-like drawing.
1 from 1 to 49% of the letters are clearly recognizable, alternatively 2 letters are missing or exceeding.
2 from 50 to 99% of the letters are recognizable, alternatively 1 letter missing or exceeding.
3 100% of the letters are recognizable.

3.- Coordinates

This parameter relates to the inferior line of the writing, it is the line between the bodies of the first and of the last letter. Do not consider intermediate letters, nor the letter jambages. However, if the first capital letter is not aligned with the rest of the name, consider the slope.

0 no writing line recognizable, more than one line of letters, no letter, drawing only.
1 sloping writing more than 10 degrees and/or letter rotation.
2 slightly sloping writing, from 5 to 10 degrees, also letters progressively greater or smaller.
3 writing on one line without slope (less than 5 degrees).

4.- Reversal

0 static and kinetic reversals together (T3R for TRE), or no letter.
1 static (TR3) or kinetic reversal (TER for TRE), one or more letters.
2 right to left complete writing (ERT for TRE) without letter reversal.
3 left to right writing without reversal.

5.- Linguist (percentage of phonological links between the letters) TRE for TRE= two links)

0 no phonological link, no letter or one single letter.
1 from 1 to 49% of the phonolocal links respected.
2 from 50 to 99% of the phonological links respected (here, we consider the case when letters are in exceeding number).
3 all the phonological links are respected.

NB no penatly for static reversal(s) nor for right-to-left writing. However, a cinetic reversal penalizes the phological links.

6.- Graphic Fluency

0 no letter or one letter only.
1 alteration, deletion and overlaping.
N.B. : do not consider alteration due to anticlockwise drawing of circular forms. However consider here an i or a j without point or with the point represented by anything other than a point (whatever its size), a circle, a scribble, a dieresis. Consider also any circular form drawn by two superposed circles.
2 all letters (capital or lower case) clearly separated from each other, no alteration, delation, nor overlaping.
3 Complete name with no alteration, delation, nor overlaping and clear graphic fluency. In case of script style, letters closely written (space too short to insert a letter).

7.- Lower Case

any style, script or curl

0 no lower case letter.
1 from 1% to 49% lower case letter (do not consider the first letter if capital).
2 from 50 to 99% lower case letters (do not consider the first letter if capital).
3 100% lower case letters (do not consider the first letter if capital)

NB : do not consider here reversals, nor μ for n ; K for k ; † for t ; i without point. However, the following misdrawing of lower case letters are not accepted: i with circle, d for o, o for a, d for a, m with four legs.

8.- Topology

the horizontale page is divided in nine sections

1	2	3
4	5	6
7	8	9

0 no graphic trace
1 any graphic trace (drawing, writing) in sections 3,4,6,7,8 or 9 (consider the greatest part of the drawing, writing).
2 graphic trace centered in section 2 (like a title) or 5 (like a target).
3 graphic trace in section 1 (consider the greatest part of the drawing, writing).

9.- Markprimo

the marking of the first letter

0 first letter smaller than the following ones (minimum reduction: 20 %), one letter only, no letter.
1 apparent height equivalence. All letters capitals (even if the first one is greather that the followings). First letter lower case and others capitals.
2 First letter capital, the following one or some or even all others lower case.
3 First letter capital and distinct from the others as far as height and shape are considered. (minimum enlargement: 20 %). The smallest flourish, either conventional or original counts. Also name framed by the first and the last brought out letters.

10.- Micrography

0 no letter
1 smallest letter higher than 12 millimeters.
2 smallest letter between 6 and 11 millimeters of height.
3 smallest letter less than 6 millimeters of height.

Signature = total score of the 10 parameters (minimum 0, maximum 30)

Qualitative evaluation

a) hand used, and, if the case, hand changing.
b) speed of writing (very much dependant of the child's knowledge, abilities and training).
c) general acceptance of the task (pleasure in writing, writing avoidance, writing phobia).
d) child's verbal comments on the task and during the task.
e) information gathered about school and cultural prewriting instruction and training.

Appendix II
Conversion of "Signature" raw scores into prewriting quotients

	age groups									
age (years)	4	4½	5	5½	6	6½	7	7½	8	age (years)
age (months)	36-53	48-59	54-65	60-71	66-77	72-83	78-89	84-95	90-111	age (months)
	N=36	N=44	N=57	N=64	N=58	N=41	N=38	N=48	N=56	
Prewriting Quotient M=100 sd=15	raw scores									Prewriting Quotient M=100 sd=15
140	-	-	-	-	-	-	ceiling-effect			140
135	-	-	-	-	29	-				135
130	26	-	-	-	28	-				130
125	22	-	-	-	27	-				125
120	19	26	26	27	26	29				120
115	17	23	25	26	25	28	30	30	30	115
110	-	20	22	24	24	27	29	-	-	110
105	9	17	19	23	23	26	28	29	-	105
100	7	13	17	21	22	25	27	28	29	100
95	4	-	-	19	-	23	26	-	28	95
90	0	7	12	18	21	22	25	27	-	90
85	floor-effect	4	6	16	20	21	-	26	27	85
80		1	4	-	19	20	24	-	-	80
75		-	2	12	18	19	23	-	26	75
70		-	0	-	-	-	22	-	-	70
65		-	-	-	17	-	-	-	-	65
60		-	-	-	16	-	-	-	-	60
55		-	-	-	-	-	19	21	-	55
50		-	-	-	-	-	18	-	-	50
45		-	-	3	-	-	-	-	-	45
40		-	-	2	-	-	-	18	21	40

Fig.1. Typical samples of "signature" in 3- to 7-year-old children (see legend below).

Legend Fig.1.
black borders show the limits of the page. 1-3: use of all the page (1,3) or bottom of the page (2) for doodling (1), dot arrangement (2) or figurative drawing (3): butterfly, sun, flowers, clouds, floor and ceiling.
4 (name Iris): emphasized drawing of the first letter.
5 (Alessandro): letters and pseudo-letters.
6: autocorrection regarding coordinates.
7: topology and avoidance of the oblique for the first stroke.
8: disrespect of the coordinates.
9-15: static and kinetic reversals: 9 (Louis): anchoring to the coordinates, right-left direction of writing, up-and-down mirror letter as well as left-right mirror letter. 10 (Tiago): right-left direction of writing without mirror letter. 11 (Jules): anchoring to the coordinates, right-left direction of writing, mirror letters except the last one. 12 (Alexis): right-left direction with and without mirror letters, letter disorientation. 13 (Alex): left-right direction, left-right mirror letters., loss of the coordinates. 14 (Chiara): anchoring to the coordinates without anticipating enough space, continuation on the next line from right to left without mirror letter. 15 (Pelin): topology and kinetic reversal, violating the graphem-phonem correspondance.
16 (Ilir): anchoring to the coordinates, writing on the bottom edge.
17-19: violation of the graphem-phonem correspondance with letter addition (17, Gabriel), anchoring to the upper edge and pattern repetition (18, Laetitia), letter omission (19, André).
20-22: graphic fluence. 20: topology and clear marking of the graphic fluence in lower case writing. 21: clear separation between lower case letters. 22: topology and autocorrection in favour of the graphic fluence.
23-25: marking the first letter. 23-24: letter height contrary to the emphasizing of the first letter(s). 25: Clear marking of the first letter.
26-28: relative micrography and topology characterize the mature first name writing. 26 (Myriam): difficulties with the relative height of lower case letters, no first letter marking. 27 (Suzanne) and 28 (Lirian): maximum score of "signature".

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