

Chapter #15

DYSGRAPHIA, EDUCATIONAL INTERVENTIONS AND DIDACTIC IMPLICATIONS: FROM PREVENTION TO INTERVENTION¹

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ABSTRACT

Dysgraphia is a widespread disorder among school children. The prevalence for developmental writing disorders is about 7–15% among school-aged children (Döhla, & Heim, 2016; Katusic, Colligan, Weaver, & Barbaresi, 2009). It has become clear now that learning to write has an unquestionable educational value. According to Konnikova (2014), it is not only what children write that matters, but how they write. That's why we need to examine and understand which education and didactic methods can be useful to teach handwriting to those children that find it difficult or that, despite all the efforts, have an unreadable handwriting. It is also necessary to investigate the best way to intervene, especially since writing difficulties are often related to other learning disabilities.

This paper contains the conclusions of a lengthy period of observations and data collecting on those children identified by the authors, who suffer from writing difficulties. This work was aimed at identifying an educational working methodology to prevent writing difficulties or recover from them. We will describe here early manifestations of dysgraphic disorder and show efficient educational and didactic intervention tools within the school context.

Keywords: dysgraphia, prevention, specific learning disorders, motor education, special education.

1. INTRODUCTION

The University of Verona and its Department for Human Science - in a research on specific education for impaired children (Sangalli, 2003, 2005; Larocca & Sangalli, 2005, 2006; Lascioli & Sangalli, 2009; Lascioli, 2011) - has carried out a project aiming at developing several specific educational interventions to prevent and correct learning disorders. Combining experience in the field with scientific observation and research has demonstrated that intervening and taking focused and special education-related actions, can improve - sometimes even remarkably- the learning ability of impaired children.

A research methodology of the empiric type has been used, through which efficient educational strategies or didactic actions have been selected on the basis of experimental evidence (Evidence-Based Education), that is, capable of functioning in a wide range of contexts (Calvani, 2012, p.10).

In the research presented here, we have identified special education-related interventions that we have tested while treating writing difficulties both in children with certified impairment and in children without a well-defined clinical diagnosis. We have described specific educational and didactic intervention tools which we have identified and

¹ The chapter is the result of the joint work of the three authors. For the sole purpose of identifying the parties, Angelo Luigi Sangalli is the author of paragraph 4, Angelo Lascioli of paragraph 3, Andrea Lascioli of the introduction, paragraph 2 and conclusions.

tested while treating writing difficulties in both impaired and non-impaired children. We have achieved significant results improving both writing and learning abilities.

Taking educational actions on precursors of school performances (Asonitou, Koutsouki, & Charitou, 2010), but in general on all children, in order to prevent learning difficulties during school years, represents an important contribution for promoting and developing Inclusive Education (European Agency for Special Needs and Inclusive Education, 2014).

The problem is that still too little is known about written expression disorders, which can also occur in the absence of a reading impediment, intellectual disabilities, problems of visual acuity or inadequate education. Being able to learn to write in a legible manner is for many children an insurmountable problem, not without consequences for their progress in other aspects of learning, for which, in many cases, there is no known solution. (apart from compensatory measures). Hence the importance of identifying methodologies of intervention that offer operational guidance for such interventions to educators in pre-schools and teachers, both in terms of prevention and rehabilitation and that are adept at finding case by case “where the problem is”, “what it consists of” and “what is to be done” to help the children overcome it, putting into effect the available resources in the normal educational and/or didactic contexts.

2. VARIABLES INFLUENCING HANDWRITING ABILITY

A recent exploratory study (Lopez, Hemimou, & Vaivre-Douret, 2017) showed that immaturity in the handwriting gesture is a possible underlying mechanism responsible for poor handwriting. Dysgraphia is associated with specific impairments in spatial organization of letters and in motor control of handwriting gesture. Handwriting is in fact influenced by different factors ranging from cognitive skills (like intellectual ability) to - even more important - specific sensory and motor skills (like spatial-visual or fine motor abilities) (Tseng & Chow, 2000). Children with handwriting difficulties seem, in fact, to fail in the praxic component, in particular in the spell-check related skills, and more specifically in the hand-eye coordination (Goldstein, & Britt, 1994; Sovik, 1975, Sovik, Arntzen, & Teulings, 1982). Evaluating handwriting difficulties requires, therefore, a careful observation of the graphic gesture, i.e. the way in which children control the graphic tool while drawing the graphic sign, giving particular consideration to the movement of the arm, of the hand and of the fingers (Thomassen, & Teulings, 1983) It requires also a careful observation of the graphic space, i.e. the way the sight and the spatial organization work (Mati-Zissi, & Zafiropoulou, 2003). Researches investigating the prevalence of cultural and linguistic variables in the development of handwriting (Margolese, & Kline, 1999) have also confirmed that the praxic components play a relevant role and value for the identification of the pre-requisites for the correct development of the handwriting skills.

Eden and colleagues (1995) have discovered that children with learning disorders generally perform below the level in tasks that require speed and sequential processing. These skills depend, in fact, on sensory, motor and visual perceptive skills as well as from visual motor coordination (or visually guided motor behaviour).

Acquiring specific sensory motor skills can influence those brain processes, which are responsible for cognitive functions governing more complex learning processes (Kulp, Edwards, & Mitchell, 2002). The value and relevance of these skills for preventing learning difficulties at school has also been largely demonstrated in recent studies (Wang, Tseng, Liu, & Tsai, 2017). And this was also the point of view characterizing the present research and the relative observations in searching for pre-requisites to attain correct handwriting. These prerequisites are necessary both for preventing dysgraphia and for defining possible educational and didactic interventions to treat such disorder.

3. SEARCHING FOR PREREQUISITES FOR HANDWRITING ABILITY

In this section we present what we - through our research - have defined as essential prerequisites children should have to attain correct handwriting (Lascioli & Sangalli, 2009; Sangalli, 2011).

3.1. Head and shoulder control

Our observations and research have clearly demonstrated that children who have not developed a good head control and / or possess a low shoulder tone, might also encounter problems using their hands while handwriting. Difficulty controlling the head also generally results in difficulty using the hands: this becomes even more evident, but not exclusively, in children with motor deficit. The graphic gesture, in these cases, requires an excessive effort. There might be excessive shoulder movement and the writing gesture becomes therefore heavy and gross. Sometimes the hand grasp is too high and the wrist does not lean on the horizontal plane (this condition usually occurs in hypotonic children). The head may sink between the shoulders and by turning around, eyes and head are unable to perform any anticipatory movement independently from the trunk. Even when walking, the movement might not appear well coordinated.

3.2. Proper muscle tone

Pupils with muscular hypotonia deriving from genetic syndromes (like the Down Syndrome) get easily tired from writing. A lack of proper muscle tone is a common cause of severe fatigue from handwriting because it does not allow children to grasp the necessary graphic tool properly with the hand. These children get tired very easily, even when scribbling; they keep on moving the graphic tool from one hand to the other and often end up abandoning what they are trying to do.

3.3. Stable sitting posture

Children who sit improperly on the chair, who cannot reach the floor with their feet flat or cannot lay their arms properly on the table because it's higher than their elbows, are constantly searching for better posture. This constant postural adjustment interferes with the graphic production. On the other hand, stability in the sitting position allows major concentration in the motor task, especially for children with poor motor control.

3.4. Hand (haptic sensation)

A proper haptic perceptual organization of hands and fingers allows children to handle the graphic tool properly. Children with good haptic sensation can feel the tool properly and scale the force output with respect to the object they grasp. Thanks to the sensory receptors on the hand skin different kinds of haptic experiences (proprioception) are possible. For the purpose of our research it is useful to differentiate between superficial touch (which depends most of all on cutaneous receptors) and deep touch (which depends on encapsulated receptors: baroreceptors). An insufficient proprioception of the hand may hinder the process of learning correct handwriting. For example it might lead to difficulties in the perception of superficial haptic experiences and therefore with the perceiving and/or grasping of the writing tool (for example children might not use enough strength to grasp the pen or the pencil, or enough pressure to draw a visible graphic sign). It might also lead to difficulties in the processing of deeper sensory information (pressure) which result in opposite problems when grasping the writing tool: for example children might use too

much strength while holding the writing tool or too much pressure while writing on the piece of paper. They get easily tired, frustrated and, in most cases, give up very soon (by exerting too much pressure they make a hole in the piece of paper with their pen or they cause themselves soreness where the skin presses against the pencil or pen). Alteration of haptic sensation like Hypersensitivity or Hyposensitivity, forces children to hold the tool between the fingers with exaggerated strength (in order to feel it better) with the result that even the graphic sign is over marked. In these cases, children usually get easily tired and give up. Other children with altered haptic sensation, on the contrary, hold the graphic tool with insufficient strength. In these cases, the graphic sign is almost invisible and unmarked. The pencil keeps on slipping out of their hands and they cannot carry out the writing task. Issues in the haptic perception tend to delay the development of manual skills in children. Children who suffer from autism or Asperger syndrome very often have sensory processing disorders (Tomchek & Dunn, 2007; Bogdashina, 2016). These disorders imply difficulties with perception, modulation, integration and organization of sensory stimuli (Bundy, Lane, & Murray, 2002) with evident implications also in the use of hands as tools (Sangalli, 2009).

3.5. Visual convergence and accommodation

According to the research carried out by Tseng and Chow (2000), the three significant predictors for slow handwriting are age, visual sequential memory and visual-motor integration. In particular a correct visual convergence should allow children to keep the face at a distance of 20-40 cm from the table, to focus the image clearly, to write and to draw. Issues with visual convergence may be the cause for specific behaviours which prevent the children from focusing on their task. For example, children that keep looking around and not at the piece of paper while they are colouring. Convergence problems are the reason why eyes do not follow what the hands are doing (Larocca, & Sangalli, 2005).

3.6. Brain dominance

It has been observed that if establishment of hand dominance is delayed, the organization of a specialized movement scheme is likely to be problematic. Problems also arise with wrong limb selection (either in case of constraint or because the child has difficulties in establishing a preferred hand autonomously).

3.7. Running with contralateral gait pattern

We have found a significant correlation between coordinated running and difficulty in writing. Pupils with handwriting problems (in particular related to wrong grasp and poor wrist control while colouring) also have problems with contralateral gait pattern. These children run in an uncoordinated way, their arms do not swing at the frequency of the contralateral leg, resulting in a disharmonious movement. According to the maturation theory, children develop motor skills with a cephalocaudal trend (head and axis control precede limb control) and proximaldistal trend (from the centre of the body outwards). This is the reason why an incomplete development of arm control is reflected in the ability to use hands: we have observed this in children who hold the pencil too high with respect to the table or, in any case, in a wrong way.

3.8. Correct hand grasp

A correct hand grasp depends on whether children have acquired the graphic motor pattern suitable for handwriting. Correcting hand grasp appears, therefore, to be a successful intervention for improving the handwriting. Correction cannot, however, take place simply with writing tasks. If pupils learn to write with a wrong grasp, writing exercises are not suitable for correction (it is wrong to correct a writing issue while exercising writing itself) because children can concentrate either on listening and looking at the shape of the letters or on doing the correct writing gesture. Only when the writing gesture becomes automatic, pupils can concentrate on listening and on looking at the shape of the letters while writing. Repeating the writing task is not useful at all. It would be better to use other exercises suitable for developing the correct motor automatism for handwriting gesture. This takes time and practice and rarely comes from a spontaneous self-correction. Teaching children how to improve the grasp so that they gradually abandon the incorrect pattern is therefore preferable.

3.9. Hand-eye coordination

Hand-eye coordination is a fundamental field of intervention in teaching handwriting. This field of intervention also includes the development of a correct visual perception of the space on the worksheet (Decker, Englund, Carboni, & Brooks, 2011). In fact, children lacking coordination between their eyes and their hand do not have a sufficient visual perception of space. They often do not use the entire available space and scribble on the same spot (Larocca & Sangalli, 2006), sometimes even making holes in the piece of paper.

3.10. Controlled mark by colouring (3 different typologies)

It has been noticed that pupils suffering from dysgraphia are low skilled also in colouring. Assessing this skill in children can be useful to predict future dysgraphia. By looking at colouring tasks it is possible to evaluate the stage of the maturation in the hand motor control of children. Through observation we have identified three stages in colouring that reflects stages in the child's organization of the graphic gesture:

- First stage: controlled mark at the edge of the Figure.
- Second stage: independent mark control and wrist control.
- Third stage: wrist rotation and autonomous movement with fine finger motility.

3.11. Wrist control

The wrist and its motor organization are fundamental for developing a correct handwriting gesture. A high grasp or a rigid wrist in holding the writing tool, are likely to reveal a dysgraphic disorder.

3.12. Wrist pressure

Also the pressure that the hand exerts on the worksheet is a valid indicator for assessing writing-related motor skills. Suspects arise when the children use too much pressure (and end up tearing the sheet) or, on the contrary, when the mark is almost invisible.

3.13. Finger motility

Handwriting is a fine-motility gesture. Dysgraphic children have not reached a sufficient finger motility to carry out the movement required for handwriting. The handwriting gesture is therefore slow and inaccurate, often carried out with wide movements of the hand, which should compensate the lack of finger motility.

3.14. Shape orientation with respect to squares, lines and worksheet

Having a correct perception of the shape with respect to the worksheet space is one of the most important prerequisites for developing a good handwriting. Difficulties in perceiving the space on the worksheet, also results in difficulties in visualizing specific shapes. Children who fail to reproduce the original graphic sequences of shapes and to maintain the same shape orientation probably have difficulties with spatiality in general (that means visual orientation of the worksheet), and tend to overlap letters. That is because letter orientation is difficult for children who do not properly perceive the space in which they operate.

4. POSSIBLE EDUCATIONAL INTERVENTIONS

In this section we will present different educational interventions that can be carried out when the prerequisites that we have identified so far for good handwriting have not been sufficiently developed in children. In order to choose the right type of exercise, it is important to assess first of all the handwriting prerequisites in children. During the assessment, the teacher should determine case-by-case, which type of intervention is the most suitable for the child. Our experience in the field has allowed us to verify that there are neuro-genetic correlations among the prerequisites, so the failure to develop some prerequisites may affect the acquisition of others. We have also noticed that if no recovery measures are taken and, despite their efforts to autonomously compensate the lack of these prerequisites, children do not obtain the desired results and their handwriting difficulties persist. The order of pre-requisites we have chosen reflect, in our opinion, the neuro-motor organization of the handwriting gesture (Lascioli & Sangalli, 2009) so even the teacher's assessment should take place following this sequence.

4.1. Head and shoulder control

Children lacking this prerequisite should have training in gross motor activities like walking or crawling, as well as doing psychomotor exercises with a ball, games with vestibular or sensory stimulation and crocheting activities. If these playful activities are still not enough for recovering the prerequisite, one should seek the advice of an expert in physiokinesitherapy. This becomes, however, essential if children have no head control. In fact, we have noticed that, in this particular case, educational activities involving the use of hands do not lead to positive results (Sangalli, 2005).

4.2. Stable sitting posture

The most suitable posture for organizing the writing gesture is sitting on a chair that allows the child's feet to rest well on the ground, and the child's knees to be slightly higher than the pelvis. Tables should be placed at a suitable height, so that children can lay their arms on the tabletop and their elbows form a right angle with the table top. This posture allows the child to stabilize the trunk and make better use of their hands (Figure 1).

*Figure 1.
Optimal posture.*



4.3. Proper muscle tone

In many cases, difficulties in handwriting are related to hypotonia. It becomes, therefore, necessary to develop a proper muscle tone (to improve hand grasp), which can be obtained, for example, with suspension exercises. In general, all motor activities are useful to improve the muscular tone of shoulders and arms and therefore helpful to improve drawing, colouring, or writing performances. The children should hang on the bar as long as they can (without any constriction). This exercise improves the muscle tone of the shoulders considerably so that shoulders, arms and hands also become more resistant while writing. We have in fact noticed a significant correlation between this exercise and the increasing resistance of children in writing activities (Figure 2).

*Figure 2.
Exercise to improve muscle tone of the shoulders.*



4.4. Hand (haptic sensation)

Hands, as we know, are a fundamental tool for exploration and knowledge. However, some children find it problematic to use hands for exploring, touching, etc. (this is more evident in case of autism and other genetic syndromes). Helping children to improve the use of their hands as tools for exploring, touching, playing etc. is also essential to improve their handwriting skills. Useful games can be, for example, tactile boxes with materials of different consistency, such as rice, flour, maize, little stones, etc. In these boxes you can hide very motivating objects such as cars, toys and plastic animals. We have noticed that with a regular exercise (changing the kind and the amount of objects to look for), children

develop the ability to concentrate on the task. Searching and digging with hands, helps children to improve the use of their hands, and in particular of their haptic sensation. Touching alternatively light and heavy objects induces the organization of good hand tactility and it is also very important to promote an intelligent use of the hands. For example, children can be taught to recognize objects inside a bag or box, without seeing them. Both activities help children to obtain a superficial and deep level of haptic sensation, which is useful for developing a correct perception of the graphic tool. Improving tactility allows and facilitates the improvement of manual skills (Sangalli, 2009).

4.5. Visual convergence and accommodation

Our observations stress that some of the difficulties children encountered in colouring or drawing were clearly due to problems related to visual convergence. It is obvious that if children lack visual convergence, they find it difficult to focus on the working table or generally on what the hand is doing, and they cannot shift their attention from what they are doing to what the teacher is explaining. Children need to be able to listen and, at the same time, to perform actions. However, this depends on a specific neurofunctional organization of the brain area responsible for visual and auditory information. Our observations have allowed us to verify that stimulating the vestibular system (for example: by rolling) improves the children's visual and auditory coordination as well as the ability to concentrate on one's task. The vestibular stimulation deriving from rolling improves the visual convergence and its accommodation, activates the superior colliculus and enables the children to develop and maintain visual, motor and auditory concentration at the same time (Berthoz, 1998).

4.6. Brain dominance

According to our research and experience the establishment of lateralization is very important for improving handwriting skills. It is undeniable that many children have problems in establishing which side of the brain is dominant and these also have difficulties with handwriting. We have also seen that simple motor exercises (sliding, rolling, racing) are helpful to speed up the establishment of dominance. If carried out for at least one month, they gradually improve the ability of discriminatory using the contralateral hemi-body.

4.7. Running with contralateral gait pattern

Children who are able to run with contralateral gait pattern have reached an important stage in their neuromotor development. They usually learn to walk and run in a coordinated way in the first three years and, during this phase, even their hands reach a fully neuromotor maturation. Our experience in the field showed us that children start to use hands properly after they have acquired the ability to independently use arms in a coordinated way when walking and running. Moreover, we have noticed that the contralateral gait pattern can be improved by playing on the ground: in particular with creeping activities (Figure 3).

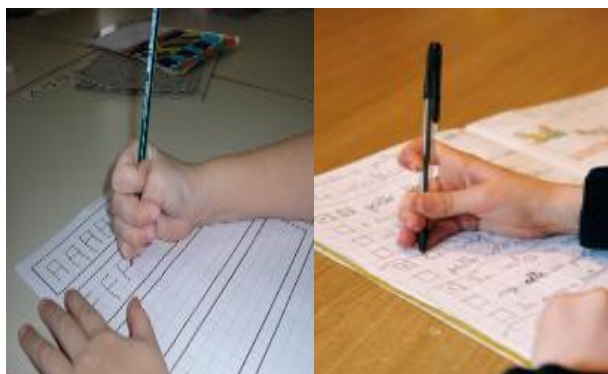
Figure 3.
The game of crawling on the floor.



4.8. Correct hand grasp

There is a correlation between dysgraphia and wrong hand grasp (in figure 4 you can see two examples of wrong/dysfunctional hand grasp). That's why it is always better to react when children hold their writing tool in the wrong way. The best moment for intervening, if necessary, is usually at the age of three. There are some very easy and not invasive tips to favour a correct hand grasp.

Figure 4.
Two examples of dysfunctional grip.



For example, when children grasp the pen like a hammer and keep a very rigid wrist, a little plank of wood can be useful (Figure 5). Once the children have learnt to maintain a secure hold on the pen with their whole hand, it can be effective to make use of a small piece of cardboard taped along the pen (Figure 6) or a sock with two holes (Figure 7), in order to teach them to use thumb and forefinger properly. These are just simple solutions to correct hand grasp without great effort. Improving hand grasp is also possible if children are already able to write. In this case one has to keep in mind, that intervention has to rebuild the child's motor memory. The correction of hand grasp should not, therefore, take

place with the aid of writing exercises but with different exercises such as colouring (for children it is easier to train the correct hand grasp while colouring rather than while writing).

We have already said that asking children to correct hand grasp while writing is not the right way to intervene. By colouring, on the other hand, children are able to pay attention both on the task and on the correct grasp. The correct hand grasp becomes gradually familiar while colouring and children acquire a motor automatism in the most natural way. At this point they can also extend what they have acquired by colouring to handwriting.

Figure 5.
Felt pen with table.



Figure 6.
Pen with paper support.



Figure 7.
Sock with two holes.



4.9. Hand-eye coordination

Hand-eye coordination is achieved through specific motor activities like creeping, crawling and rolling. Thanks to the motor pattern that they activate, creeping and crawling in particular favour hand-eye coordination. On the other hand, rolling stimulates eye convergence, which is fundamental to reach and consolidate hand-eye coordination (Sangalli, 2009).

4.10. Mark control by colouring (3 different typologies), wrist control, wrist pressure, and finger motility

The movements necessary to complete handwriting tasks reach maturation through three different stages which are described here with the aid of colouring tasks.

Figure 8 shows the first colouring task. It is a stencil with a black card. Children are asked to colour every white space. This exercise helps them to develop the control of the colouring mark. The size of the image that they have to colour must be very small at first and can gradually increase along with the children's improvement. We have seen that using thicker and glossy paperboard for colouring tasks is useful when children tend to make holes in the sheet. It seems that they unlearn to press too much with the marker.

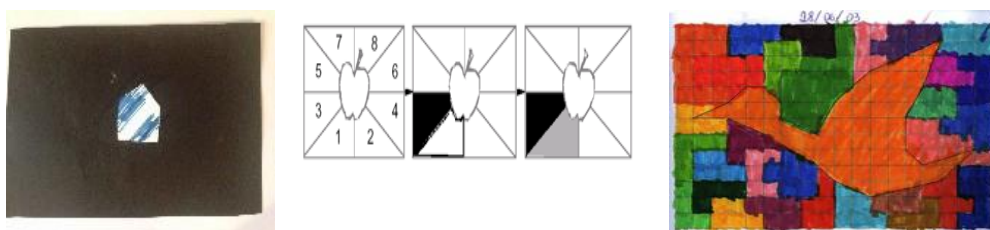
Figure 8 shows the second colouring task. Children have to colour different images, but one section at a time. It is the adult's task to outline which section the children have to colour. With this exercise children improve wrist control and increase wrist mobilization.

In figure 8 we see the last colouring task called 'Tetris'. When children master this task, they are actually ready for handwriting. This fine motor task of colouring activates all neuronal areas of the arms and the hand, which are involved in handwriting. Children learn how to turn their wrist and use it independently in order to colour all Tetris parts of the drawing and they also acquire all fine motor movements of their fingers. This task is also useful for left-handed children. They usually write covering the words they have just written while right-handed children can write and then control what they have written. With this type of colouring task and especially when they colour horizontal marks, left-handed

children learn to turn their wrist, which is what they are supposed to do when they write in order to control the letters they have just written.

In order to obtain a better finger motility (if it is necessary to intervene in this sense) colouring 0,5 cm large Tetris squares with wood crayon seems to be very useful.

Figure 8.
Examples of coloring exercises.

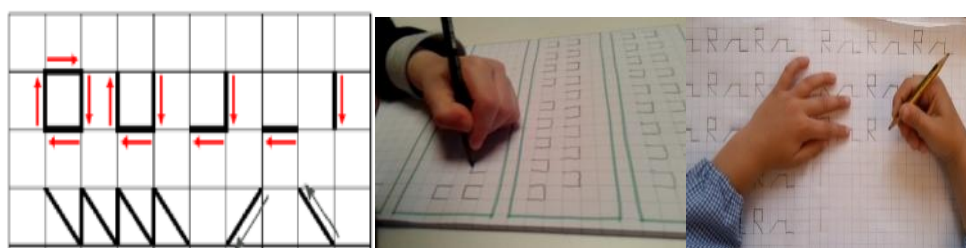


4.11. Spatial organization of the worksheet, squares and lines

The following figures show some prewriting exercises, which should teach children how to specially organize the tracing in the worksheet with respect to squares and lines.

You need a lot of colouring practice on one centimetre squared sheets. First of all, it is necessary to work with geometric shapes (like squares) representing letter patterns: colouring squares can be helpful at this stage. Then children also have to be trained in writing procedures, in particular the writing direction and orientation, by drawing the vertical and horizontal lines of squares, for example. These exercises represent the basis for learning how to write letters (Figure 9). The same procedure must be done for each letter and repeated several times. From a psychomotor and cognitive point of view, there is a strict connection between central cognitive systems (that govern the shape of letters) and the motor pattern of the hand (Sangalli, 2009).

Figure 9.
Examples of exercises to learn the direction and orientation of writing.



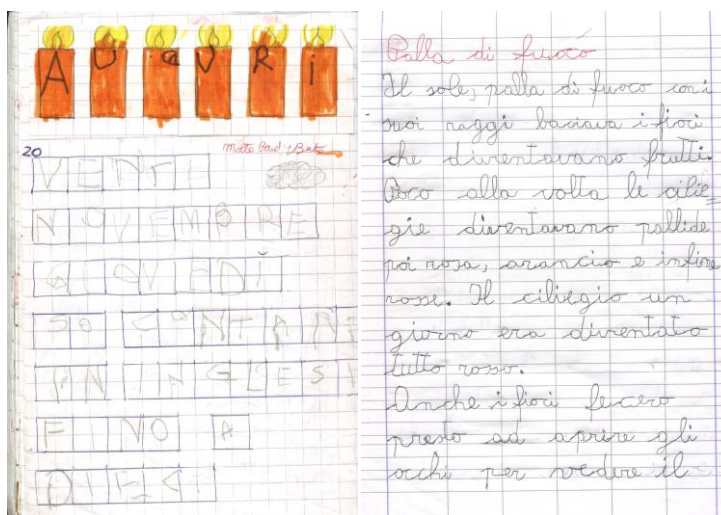
5. CONCLUSIONS

The educational interventions and the didactic solutions that we have applied to solve the problematics of writing have proved to be efficient, since there has been improvement in the writing ability of all the children with whom they have been put into effect (as an example, in figure 10, we show the comparison between a test written by a child before our intervention and another test written by the same child after our intervention). The

improvements we observed following our interventions were numerous. For example, there was improvement in the quality of the writing, the legibility of the written text, the organization of space on the page, the ability to write keeping the letters on a straight line or writing numbers in the small squares, etc. The general psychological approach of the children towards writing and learning has also been improved: The diminishing of the writing difficulties with the increase in the quality of the written product have generated a greater interest in the use of such a means of expression, increasing the levels of motivation towards the use of the written form. The observations that we have so far collected will be studied in depth by us in the course of further research, also with a view to define even more analytically the efficiency of the practices we have described. At the moment, for example, we are endeavouring to understand whether, by intervening at an early age on the prerequisites of the ability to write (which we pointed out and described in paragraph 3 of this article) through specific actions of educational support, it is possible to reduce the incidence of dysgraphia disorder in primary schools. To answer this question, we have chosen a sample of 100 children attending the primary school, with whom, during pre-school, we put into effect an educational action of prevention on the prerequisites of writing ability as defined by us. The data that is emerging from the research is reassuring. That which can be hypothesized is that intervening precociously on writing prerequisites not only counteracts the problematic of learning to write to the exclusive advantage of children at risk of dysgraphia (already per se, an important result) but rather an overall increase in learning ability of all the children is obtained and the levels of educational inclusion of every child are improved.

Figure 10.

Comparison between a test written by a child before our intervention and another test written by the same child after our intervention.



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