Opportunities for distal graphomotor skills

A different approach to graphomotor skills in young children creates new options for helping children of all ages to improve their handwriting skills.

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For some years now, several penmanship teachers at the Script Development Foundation (Stichting Schriftontwikkeling) have been researching improvements in teaching handwriting skills and new options for instruction in this field. A study conducted last year on the options for teaching a correct pen grip and precise distal graphomotor activities in young children showed that teaching handwriting in children not only involved proper grip and posture, but that working on a mental attitude also played a major part. In this context, the results of the study offered opportunities for a new approach to remedial education in handwriting problems.

Proximal - distal

Since it was proven at the end of the previous century that distal and proximal motor skills develop independently and are controlled separately, we studied the consequences of these findings in a number of primary schools in the Netherlands. This study assumed that the proximal motor skills no longer had to be seen as a precondition for exercising the distal motor skills, and that the young child could practice fine graphomotor tasks from the beginning of the first year of primary school. In practice, proximal motor skills are generally described as ‘gross motor skills’ and distal motor skills are referred to as ‘fine motor skills’. This designation is incorrect, since it is equally possible to perform very fine movements from the shoulder. We will therefore use the terms ‘proximal’ and ‘distal’ from now on, as this refers to the location rather than the size of the movements. This article focuses primarily on researching the graphic options in relation to distal motor skills.

An important condition for writing, besides the aforementioned basic principle, is the ability to utilize the flexion and extension options of the three writing fingers up to 8 mm (Fig. 1). The focus of our study was therefore the concept that it is not necessary to first practice movements from the torso and shoulder before being able to perform distal graphomotor exercises properly. Initially, children from various kindergarten groups (ages 4-5) were given a sheet of 8 mm ruled paper and asked to draw a house between the lines, and next to it a “person that lives there”. All the young children were able to do so (Fig. 2).

The children then performed fine graphomotor tasks, focusing primarily on a number of applications of fine motor skills:
1. The aforementioned flexion and extension of the three writing fingers;
2. Controlling pressure;
3. Improving accuracy.

The term ‘proximal motor skills’ describes the location of the motor system: in close proximity to the torso. In this case, it means ‘shoulder motor skills’. Distal motor skills describes the hand and finger motor system, farther from the torso.

Flexion = bending; extension = stretching

This distance is related to the most common line spacing on ruled paper.
In these tasks, the children practiced the following graphic skills:
1. Opaque colouring (exerting more pressure; colouring for longer in a single location);
2. Near-opaque colouring (less pressure; colouring for less time in a single location);
3. Colouring in colour gradations (progressive change in pressure);

These exercises focus on movements that are used in writing, without linking them to e.g. writing patterns. This is important because writing patterns often differ just slightly too much from the final shape of the letter, therefore teaching the child the wrong way to write the letter at an early stage. For example, they do not teach children where a straight line transforms into a curved line (Fig. 3). We will discuss later why automaticity at an early age is not advisable.

To facilitate the most accurate results possible, the children received the following instructions:
1. Make sure you colour inside the lines;
2. Do not leave any white areas;
3. Colour using tiny circles, the size of your pencil point;
4. When you colour an area in dark (opaquely), try to make that area the same colour as the point of your pencil.

The first two tasks used (well-known) principles of precision. The researcher demonstrated how to colour evenly and set that as a goal for the children. The last two tasks concerned technique and set a framework of reference for these tasks; this enabled the children to see the size they were trying to achieve as they coloured, and 'compare' the graphic results. The first aspect is the size: the size of the point of the graphic material. The point of the pencil is about the same size as the loop of the average printed letter e. Moreover, it is positioned exactly where the child is looking and is not particularly large. This makes it a good preliminary exercise for writing.

The second aspect is the graphic effect of the amount of pressure applied: as dark as the point of the pencil or coloured pencil. This point of reference is also located precisely where the child is looking and offers an example of the desired saturation of the colour being applied. This approach proved effective. The young children generally understood what was expected of them fairly quickly. They practiced in a few small areas (no more than 1 cm²) before performing the final task. Finally, the criteria were compared to the end result using evaluation and reflection. (“Why is that area lighter?” It is important to observe the children very closely while they are colouring. Sometimes a child moves a pencil too quickly to another area, leaving a lighter area. During the study, this was then discussed with the child.)

Grip
A proper grip is essential to the correct completion of any distal graphomotor task. In this case, we refer to the tripod pen grip (Fig. 4), in which the middle finger supports the pen or pencil and the thumb and index finger are pressed against the sides of the writing tool. A proper grip received extensive attention during the study, and the researchers did not accept any wrong grips (Fig. 5). When the researchers constantly demonstrated the correct grip and consistently corrected the wrong grip in a friendly tone of voice, the children proved able to draw the tiny circles asked of them within a few minutes (Fig. 6).

Material obstacles to flexion and extension
It became clear during the study that the diameter of the writing tool affects the flexion and extension range of the three writing fingers. The figures show that the fingers can bend when thin tools are used, but not when thick tools are
used. In this case, the children have a weaker grip on the writing tool and, accordingly, have less control. This means that proper control is only possible if the writing tool is not too thick (max. 10 mm). Thick writing tools held in small children’s hands make it necessary for the child to extend the three writing fingers. This not only reduces options for distal locomotion, but also limits the proprioceptive information received by the skin receptors and the finger joints. Bending and stretching the fingers sends proprioceptive information to the brain. This information is required for an awareness of the position and motion of the fingers, and for the necessary control resulting in part from good hand-eye coordination.

Obstacles in hand-eye coordination
The thicker graphic materials also pose an obstacle to developing hand-eye coordination, because the point of the pen or pencil disappears behind the thicker writing tool (Fig. 9).

In our study, the young children were given the opportunity to use either the classical, slim, hexagonal coloured pencils, or high-quality triangular coloured pencils. In the end, the children all chose the hexagonal pencils without any exceptions, because the precise method of working that they had learned set higher standards for what the coloured pencils could do.

Because the children also learned to spin the pencils regularly while colouring, to maintain the point as evenly as possible, the triangular pencils were less popular. It is more difficult to rotate the triangular pencils (Fig. 10), because it is only possible to hold the pencil in three positions. Moreover, wear from use causes flat areas on the point, which makes the writing tool more difficult to control. The point of the hexagonal pencil, in contrast, is much easier to maintain in an even cone during colouring.

It is also much more difficult to sharpen a triangular pencil, because the point of a triangular pencil forms a larger (more obtuse) angle than the hexagonal pencil (Fig. 11).

In comparison, we should also discuss an auxiliary tool which is widely used: grippers. These not only inhibit sideways mobility, but also make it necessary, just as thick writing tools do, for the children to stretch their fingers. This is because the grippers slide onto the writing tool, significantly increasing the total diameter (see the previous section on flexion and extension). Grippers that have dents in the sides (Stetro grips) also inhibit progressive and regressive mobility, disrupting the back-and-forth rolling motion of the fingers during flexion and extension (Fig. 12).

We strongly advise against using these ‘helpful’ aids. Young children can learn to function much better without these inhibiting auxiliary materials. A proper grip should come from proper instruction, not from materials that artificially impose a specific position.

Pressure control
Because many children unconsciously grip their writing tool tightly while writing, the researchers also took the opportunity of these exercises to make children aware of the pressure they exerted on the graphic materials. Giving the children exercises where pressure control is expressly required helps them learn to control that pressure. To that end, the children first learned to colour in two shifts. The figures that the children coloured in were adapted accordingly, generally consisting of two areas. The smallest area had to be coloured in opaquely (full saturation), while the larger area could be coloured in at a lower level of saturation (Fig. 13). The concept of ‘opaque’ or ‘full saturation’ was explained to the children in terms of ‘dark’, while a lower level of saturation achieved using less pressure was described as ‘light’; full saturation was compared to the colour of the pencil point. It is never possible to achieve exactly the same colour, since the colour of the paper also plays a role, but it turned out to be a very effective comparison.

Time is also a factor. Colouring for longer in a single location causes more saturation. In this context, lighter areas can be coloured in more quickly.
In subsequent sessions, the children were taught to colour in three gradations. The accompanying figures accordingly consisted of three areas of different sizes. The smallest area was coloured in ‘darkest’, the largest area ‘lightest’ and the third area somewhere in between (Fig. 14).

The children also learned to hold the pencil in a more vertical position when they increased the pressure (Fig. 15) and to hold the pencil farther from the point when colouring lightly. This changed grip made it easier for them to apply light pressure (Fig. 16).

**Relation between surface areas of pencil point and area to be coloured**

The child is aware of the proportionate surface area of the point of the graphic tool used in comparison to the area to be coloured in. That is why children automatically switch to proximal locomotion (‘wiper motion’) when colouring in larger, A4 colouring pictures, because that type of motion will fill in the area quickest. This type of locomotion is completely unrelated and has no application in primary education other than to fill in large colouring pictures (Fig 17).

Learning to colour using distal locomotion is a different matter entirely, particularly using the three writing fingers, which play a very important role in writing. When children colour in small pictures using the technique described, they intensively practice the motions important to writing, without relating the motions to a continuous line or route. The child colours in an area by bending and stretching the fingers correctly, without the distraction of tracing lines or drawing in specific directions, as is the case with writing patterns. Meanwhile, the child practices hand-eye coordination by colouring inside the lines, while learning to observe very precisely in order to evaluate the result.

If the child exercises more and less pressure to colour in areas with different gradations of saturation, the child must learn to observe carefully in order to evaluate the result properly and gain a sense of the connection between pressure and graphic effect. By colouring using a rotating motion, the child achieves complete proprioceptive feedback through the finger joints and the skin.

The small colouring pictures serve another important purpose: many children place the hand that they are not using for colouring ‘somewhere’ on the paper, or even off the paper altogether. They often don’t need this arm because they place the forearm of the hand they are using for colouring on the paper to hold it in place. However, this limits their freedom to use the hand and fingers for colouring the way they should. When small colouring pictures are used, the children have to use their other hand as well. The children in the study were taught to place their thumb below the point of action and the other fingers above that point (Fig. 18).

This prevents the paper from turning.

Finally, it is worth noting the effect of how the children experienced success. Because the pictures are small, it is easy for young children (and older children too!) to maintain a complete overview and colour them in. This increases the child’s willingness to do something well within a short time period. The figure shows two results from an initial colouring session with children from the second year of primary school (age 5). The smaller pictures were then combined into a larger ‘group artwork’. In these exercises, the choice of colour was left entirely up to the children. The children were clearly very satisfied with the result they achieved (Fig. 19).

**Hatching**

Linking graphic techniques to aspects of penmanship development is not a new concept. De Ajuriaguerra et al. already recommended such an approach, which was developed in the Netherlands by H.F. Pijning (1969). These studies often also concerned painting from the shoulder, but did not include the practice needed for writing. Subjects were assigned small areas to hatch as exercises for distal locomotion. Unfortunately, there was no follow-up to this initiative. At the time, there was as yet no interest in the typographic features of the letters. This meant that there was no focus on the essential value of the downstroke versus the upstroke. The downstrokes represent the legible part

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5 The information from the motion and pressure receptors in the skin, muscles and joints, which give the child information e.g. on the position, pressure level and motion results of the fingers.
of the letters and should therefore be drawn as parallel to each other as possible (Fig. 20).

![Fig. 20 Functional differences between upstrokes and downstrokes.](image1)

Hatching is therefore an excellent preparation for writing. Hatching involves bending and stretching the three writing fingers and drawing equidistant parallel strokes. This allows the children to practice even, regular spacing in a playful manner. Many examples of poor penmanship are characterized by poor letter spacing, which strongly influences the legibility (Fig. 21).

![Fig. 21 Irregular spacing.](image2)

Despite this fact, this feature is wrongly undervalued in the existing lists of criteria for penmanship quality.

In the study, the children initially hatched between existing lines, using a ½ mm mechanical pencil or fountain pen. Sometimes the fountain pen was turned over so the children could draw finer lines (Fig. 22). The task was not to touch the lines (Fig. 23). Although there was some difference in the quality of how the lines were drawn, all the young children proved capable of completing this assignment.

![Fig. 22 Fig. 23](image3)

The strokes could be straight or curved. The aim was to place each stroke in relation to the other strokes. In all cases, the children were able to point out the wrong strokes without fail in the evaluation stage.

![Fig. 22](image4)  
![Fig. 23](image5)

A subsequent stage involved closed and open figures placed at a set and regular distance from each other. The greyscale value of the area also eventually plays a role. The children initially only had the task of positioning the figures equidistant to each other, as would generally also be the case in writing letters (Fig. 24). Letter positioning is particularly important later, in the final years of primary school, when children start writing print script; they need to learn to position the letters in such a way that they create an optical connection, causing visual word formation. These are also excellent exercises for children with penmanship problems. It simultaneously prevents them from developing an aversion to writing, since this can be seen as a stimulating form of practice, giving the child a certain degree of freedom in execution. The result shows that the child can in fact work accurately at graphic tasks.

![Fig. 24](image6)

It is also quite possible to combine colouring and hatching, as shown below (Fig. 25). Another aspect that became clear during the study was the difference in development in hatching curved areas. Children that are slightly more developed can draw lines that are parallel in relation to each other rather than to the outline of the shape by using a parallel motion, even if the area is curved. This process is known in mathematics as translation on a plane, i.e. movement without rotation or reflection. This means that the direction and shape of the strokes are unrelated to the area (Fig. 26). Other children who are less well developed make a radiating motion. In this case, the strokes are adapted to the form, radiating out from an imaginary centre or turning point.

![Fig. 25](image7)  
![Fig. 26](image8)

**Translation**

**Rotation**

**Rhythm and motor program**

We would like to state explicitly that we deliberately did not use the concept of rhythm or music in any way during hatching, or any other graphic action whatsoever. Links between graphic constructions and rhythmic auditory information can disrupt the graphic result, because the strokes are not all equal in length (similar to letters that are all different in the length of the path to follow and the number of downstrokes), while rhythm imposes an equal duration for drawing each stroke. The strokes should also explicitly be placed at a specific distance from each other, a distance that must be evaluated visually. Any form of musically imposed time pressure would disrupt this process. We should prevent a situation where the children are not open to feedback, because a motor program has caused them to automatize their handwriting at an excessively early stage (Van Leyden Sr. 1993; Pijning 1983). Rhythmic and grapho-musical training sessions make it possible for children to automatize motions at an excessively early stage.

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4 By translater parallel movement.  
7 The children turn their strokes with the bowed side of the plane.
Letters should not become a matter of automaticity until they are properly formed and no longer change shape significantly. That is not the case until the final years of primary school. Schools often use an observed ‘visual rhythm’ in connection with a musical rhythm. Any calligrapher knows that strokes can appear visually rhythmical without having been drawn rhythmically (Fig. 27).

This calligraphic approach is generally slow and constructed in nature. In this case, there is a vast quantity of applied cognitive feedback.

The accompanying example shows that it is only possible to achieve equidistant downstrokes in print script. In joined script, the connections between the letters cause different distances and make it impossible to write ‘rhythmically’ (Fig. 28).

Research on graphomotor skills
Our findings largely concur with graphomotor research by E. Del Giudice et al. (2000). In this study, the graphomotor skills of children in five different age groups between the ages of 3 and 5 years were studied. These skills were progressive by age category. The study distinguished e.g. between perceptive and graphic skills. This research corresponded to our study in that visual perception scored significantly higher than graphic execution. One very important conclusion was the fact that the oldest group of 4.5 to 5 year olds scored 73 out of a possible 80. The data shows that visuospatial and execution skills develop rapidly as children grow. However, there is a serious lack of sufficient guidance.

Research on the graphomotor skills in selected children
Based on these findings, the researchers invited a primary school offering special education to select ten children for whom the ‘assumed poor fine motor skills’ would play a role in penmanship. To facilitate this study, a number of graphomotor items were designed (Fig. 29), which required positioning the pen point and drawing lines precisely between other lines. For two of these children, concentration played an influential role in working on a number of the items. They recovered and were able to complete the other test items sufficiently. These results did not support the concept of ‘poor fine motor skills as the underlying cause of poor penmanship’.

An important factor in such a test is the proper demonstration by the test supervisor. If necessary, the test supervisor should practice simple motions with the child in advance, discuss, demonstrate and explain the technique involved and encourage the children to do their very best. This aspect may cause different researchers to achieve different results. We accordingly argue in favour of encouraging children to do their best on comparable tests, because any test only shows what a child does in that specific situation, but it may not accurately show what a child is capable of. These two aspects should overlap as closely as possible.

The role of the test supervisor can therefore be an important factor in differing test results. Besides the fact that each of the various motor system tests often fail to confirm the results of the other tests (Netelenbos 1998), this is a second important indication that it is crucial to approach the results of motor system test with a certain degree of caution.

Relation between distal locomotion and writing problems
We also applied the approach to colouring discussed above to children who had writing problems. We had noted that these children completed the colouring and hatching tasks reasonably well, despite the fact that they were often considered to have poor (fine) motor skills. The accompanying examples show such a result. The style of colouring not only shows that the children have good distal motor skills, but also that their perception and hand-eye coordination is good (Fig. 30). Why, then, do they demonstrate such poor penmanship?

Fig. 30 This boy (8 yrs) also displayed poor penmanship, despite very accurate colouring from example (on right), including attention to detail.
The same phenomenon can be observed in the next handwriting sample. One correspondence between the two examples is an unclear understanding of equal body height and incomplete awareness of the presence of a body section in letters that often consist of multiple zones. These colouring pictures show that the cause of these writing problems lies not in the locomotion, but in the cognition. This experience shows the child that it does have the ability to observe and perform tasks precisely and this knowledge provides a renewed incentive to start writing again.

Based on these results, it was researched in several cases whether a different approach would lead to better penmanship. For example, the boy in the picture below (Fig. 31) was instructed to write much more slowly, which produced a clear improvement in how he shaped his letters. This was evidenced primarily by the higher percentage of straight letter sections and smaller handwriting. This advice proved similarly helpful to other children (Fig. 32). Right or wrong, many children constantly feel that they have to work very quickly. This means that they do not take time to focus on the shape of the letters.

Conclusions from this empirical study
This study in five primary schools led to the following findings:
- It is possible to practice and guide fine motor skills and fine graphic activities in very young children;
- All A4 colouring pictures should be reduced down to at least A5 size;
- Thick writing tools (and accordingly also various grippers) reduce the flexion and extension possibilities and the proprioceptive feedback from the three writing fingers;
- Poor penmanship can be attributed to a lack of knowledge about the letters, rather than poor distal locomotion;
- There are possibilities for helping children whose graphic skills lack precision to practice to improve skills;
- Poor grips should not be tolerated. The remedy should be “intervention and guidance”. Do not give up; instead, continue encouraging the child in a friendly manner to use the proper grip.

Starting stimulating guidance of precise distal graphomotor locomotion at an early stage can prevent a great deal of imprecision in practice. As in so many things, an ounce of prevention is better than a pound of cure - or, in this case, early instruction is better than remedial teaching. 8

8 If you want to try yourself the aforementioned possibilities, you can apply for exercises and a description of the techniques at the Script Development Foundation info@schriftontwikkeling.nl

Literature
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