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Effect of Pencil Grip on Handwriting Speed and Legibility

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ABSTRACT *Four variations in the dynamic tripod grip (that used for standard pencil grasp) were examined for their influence on the handwriting speed and legibility of 282 children aged between 8 and 14 years. No significant difference was found for either speed or legibility. Further analysis of standard versus non-standard grips and fast, legible versus slow, illegible writers also failed to support the view that writing was related to the type of grip employed. These findings question the emphasis placed on so called 'correct' pencil grip and suggest more attention should be focus upon other factors underlying poor handwriting performance.*

When describing children with handwriting difficulties teachers often focus on the way in which the child's pencil is held. This, either directly or indirectly, is assumed to underlie the production of fast and legible script. The need for children to use a standard dynamic tripod grip when writing (i.e. pencil resting on the distal aspect of the middle finger while being controlled between the pads of the thumb and index finger) is widely held. However, verification of the necessity to do so is lacking. Could it be that the variations in grip seen in children with poor handwriting are also evident in children whose performance is considered good? This question forms the basis of the present investigation which examines the effect of pencil grip on handwriting speed and legibility.

Speed and legibility are key characteristics in handwriting performance and factors with which most teachers are concerned. In general speed has been shown to: increase with age (Ayres, 1912; Groff, 1961); be faster in girls than in boys (Groff, 1961); and be unaffected by laterality (Smith & Reed, 1959). The measurement of speed generally consists of counting the number of letters written within a specified time period. Legibility is more difficult to measure but is seen to depend upon a number of underlying components, including letter formation, slant, size, alignment, and spacing (Fischer, 1964; Graig, 1966; Quant, 1946; Rondinella, 1963).

Although some researchers suggest that legibility can only be examined by evaluating the effects of underlying characteristics (Askov *et al.*, 1970) few such studies have been conducted. Helwig *et al.* (1976) attempted to devise an objective method of evaluating one of these components—letter formation. More recently, checklists for the evaluation of handwriting have appeared which incorporate letter formation, writing size, slope and spacing (Alston, 1983, Stott *et al.*, 1985) This highlights the effects of these factors on teachers' overall perceptions of legibility.

Evaluation by an experienced teacher remains the most comprehensive and efficient measure of overall legibility and this evaluation has been shown to reflect the influence of the above mentioned characteristics (Ziviani and Elkins 1984).

One factor that is claimed to influence handwriting is the development of a 'dynamic tripod grip' which employs the thumb, index and middle fingers in a coordinated fashion to manipulate the writing instrument. Wynn-Parry first coined this term in 1966. Rosenbloom & Horton (1971) charted the maturation of this grip in children between 1·5 and seven years. First is the 'tripod posture', in which children acquire the finger positions, but fine muscle movements are absent. Then follows the 'dynamic tripod', which demonstrates the fine muscle action essential to handwriting. Rosenbloom & Horton (1971) detected the mature dynamic tripod grip among children between four and six years. A replicative study among Japanese children reported much younger ages—as early as three years in some subjects (Saida and Miyashita, 1979). The apparent explanation was practice effects: Japanese children are exposed to tasks requiring similar fine muscle action (manipulating chopsticks) at an earlier age. Although other factors such as visual perception, muscle tone and eye-hand coordination can affect writing, some populations of children with poor handwriting (spina bifida and learning disabled) have been noticed to use unusual pencil grips (Anderson, 1975, 1976; Carter & Synolds, 1974). However little research traces the 'normal' progression of the dynamic tripod grip beyond the age of seven years.

Recent clinical observations and a pilot investigation, however, identified four grip components that vary in the dynamic tripod grip of seven to 14 year old children (Ziviani, 1982): (a) the degree of index finger flexion; (b) the degree of forearm pronation (forearm turned palm down); (c) the number of fingers positioned on the pencil shaft; and (d) the presence of thumb and index finger opposition (pad to pad contact). A later, more detailed study (Ziviani, 1983) found that younger children between seven and 9·5 years, were more likely to have: (a) greater than 90 degrees of flexion of the proximal interphalangeal joint (that closest to the knuckle) of their index finger with possible hyperextension of their distal interphalangeal joint (that closest to the finger nail); and (b) less than 45 degrees of forearm supination (forearm turned palm upwards). This pattern also appeared to be more pronounced in girls than boys. The presence of pad to pad opposition and the number of fingers placed on the pencil shaft were randomly distributed and unrelated to age. Although these variations have been seen in the normal population of seven to 14 year olds, it has not been determined if they affect the speed or legibility of writing.

The question posed by the present study revolves around the assumed necessity for children to use a standard dynamic tripod grip for handwriting. It appears widely accepted that the development of this grip is essential and some studies have detailed how this might be best attained (Mendoza *et al.*, 1978). However, there is no experimental evidence to support this view.

Method

Subjects

Two hundred and eighty two children (140 girls and 142 boys) were selected from four Brisbane schools. The children ranged in age from 6·8 to 14 years.

Procedure

With the assistance of the State Education Department Research Branch, four primary schools were randomly selected from the metropolitan region of Brisbane, Australia. From each of these schools one class in each of Grades 3 to 7 was also randomly chosen. Pupils were considered by their teachers to be within the normal range of intellectual abilities. Each child was tested individually in a small, quiet room, usually the health room. Beforehand, children were told that they would be required to do some simple pencil and paper exercises and have their photographs taken. All seemed relaxed during the procedure and eager to participate.

Children were seated at tables and chairs appropriate to their height and presented with a sentence copying task, in the course of which they were asked to maintain their pencil grip while a photograph was taken. In this way the examiner was able to ensure that the grip photographed was representative of that normally used while writing.

Photographs were taken from a lateral and anterior angle with a 35 mm Nikon camera fitted with a 52 mm+3 magnifying lens. The camera was mounted on a specially designed 550 mm square board that was placed atop the desk. The board was fitted with a small dowel protrusion on three sides on which the camera rested. Thus the camera position was kept constant.

Two raters viewed photographs of each child and graded them according to the criteria specified by Ziviani (1983). Grips were classified on the basis of four components: (a) degree of index finger flexion (Fig. 1); (b) degree of forearm supination/pronation (Fig. 2); (c) number of fingers on the shaft of the pencil (Fig. 3); and (d) finger opposition (Fig. 4). Inter-rater agreement (Cohen's Kappa) was high for all measures: index finger flexion 0·94; forearm pronation 0·87; fingers used 0·97; and opposition 0·90. Having established the reliability of ratings, further analysis was undertaken using only one rater's score.

As part of a broader assessment (Ziviani & Elkins, 1984), the children were asked also to complete two other tasks. First they were asked to copy the phrase 'cats and dogs' as many times as possible within a two-minute time limit. This was done on a 210 mm×297 mm piece of bond paper upon which lines were ruled 13 mm apart. This task was chosen to measure writing speed, since it utilised a phrase that students could easily memorise, was applicable across a wide age range, and had been used in earlier research with seeming success (Smith & Reed, 1959). Secondly, children were asked to write the standard passage, 'the quick brown fox jumps over the lazy dog' in their normal writing on a 125 mm×200 mm index card.

Writing speed was calculated as the number of letters written per minute. This was done primarily for comparability with previously known writing speed studies (Ayres, 1912; Groff, 1961). A legibility score was obtained by asking an experienced teacher to rate the writing samples on the basis of overall legibility. Index cards containing writing samples were coded on the reverse side and then given to the teacher to rate on a scale from 1 to 7, with 1 representing the poorest and 7 the best performance. This seven-point scale was chosen because some authors have argued that people have difficulty handling more than a range of seven (Miller, 1956), and that seven tends to encourage a more normal distribution of ratings.

Once an initial sorting of cards was completed the teacher was instructed to ensure that a normal distribution of scores between 1 and 7 had been achieved for the purposes later statistical analysis of data (Hays, 1963). If specific score cate-

(a)

(b)

FIG. 1. Scoring for grip components: index finger flexion. (a) Score 1: index finger PIP joint flexed 90 degrees or more with possible hyperextension of DIP joint. (b) Score 2: index finger PIP joint flexed less than 90 degrees.

gories had too many or too few cards, the teacher, working in from both extremes, would take adjacent sets of cards (i.e. 1 and 2, 6 and 7) and re-sort until the desired distribution had been achieved. This procedure consisted of sorting groups 1 and 2, then 2 and 3, and so on.

Rater reliability was established by taking a random sample of 20 cards that had already been sorted and asking the teacher to reassign them. The teacher was told that these are additional samples and not those already sorted. Agreement proved to be high, with a correlation of 0·89.

Results and Discussion

Prior to more detailed analysis the influence of handedness was examined for its impact on writing speed and legibility. On both counts (speed $t=1{\cdot}59$, d.f.$=281$, $p>0{\cdot}05$ and legibility $t=0{\cdot}19$, d.f.$=281$, $p>0{\cdot}05$), this was not found to be

(a)

(b)

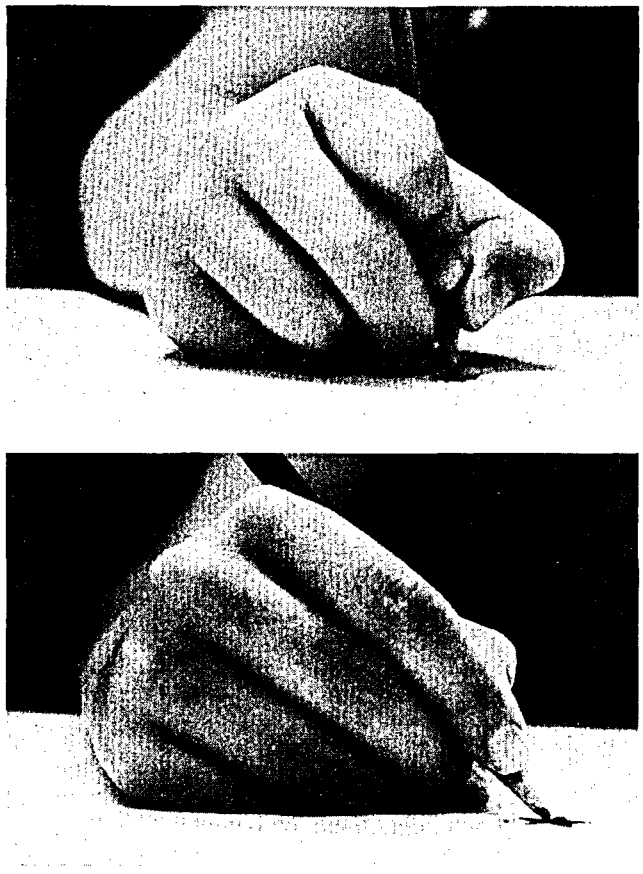

FIG. 2. Scoring for grip components: forearm supination/pronation (a) Score 1: forearm supinated less than 45 degrees. (b) Score 2: forearm supinated more than 45 degrees.

significant and confirmed the earlier findings of Smith & Reed (1959). Hence results for right and left handed children were pooled for the remaining analyses.

The four components of pencil grip—index finger flexion, forearm pronation/supination, number of fingers on the pencil shaft, and presence of opposition—were subjected to a monothetic divisive method of cluster analysis (Wishart, 1978). This is a method usually employed in cases where data is binary and involves the set of subjects (and each subgroup subsequently formed) being divided successively on the attribute which best separates the subgroups formed (Everitt, 1980). This was done first on a randomly selected set (N=134) of the sample and then again on the remaining set (N=148), in order to provide cross-validation. It can be seen that for the first four divisions on both sets of subjects, the splits are on the same variables (i.e. Variable 1—index finger flexion; Variable 2—forearm supination/pronation; and Variable 4—opposition). Extension of the divisive process to eight subgroups did not introduce Variable 3—number of fingers on the pencil shaft, into the

FIG. 3. Scoring for grip components: number of fingers on pencil. (a) Score 1: more than index finger and thumb on pencil shaft. (b) Score 2: only index finger and thumb on pencil shaft.

analysis. Figure 5 illustrates the dendrogram formed by combining subgroups from the two sets of cluster analyses.

The four identified grip clusters were: (a) index finger flexed more than 90 degrees with forearm less than 45 degrees supinated; (b) index finger flexed more than 90 degrees with forearm supinated more than 45 degrees; (c) index finger in relaxed flexion with fingers not opposed; and (d) index finger in relaxed flexion with fingers in opposition (Fig. 6). Writing speed and legibility were compared for these four grip types and means and standard deviations for these are presented in Table I. A one-way analysis of variance found no significant differences for either speed or legibility ($F=0{\cdot}90$, d.f.$=3,278$, and $F=0{\cdot}48$, d.f.$=3,278$ respectively).

Further analysis explored the grips of those children identified as having either fast and legible or slow and illegible writing. Only two children wrote at speeds greater than 58 letters per minute while also having legibility ratings greater than 5 on a seven-point scale. Both these children demonstrated what most educators define as a desirable grip (i.e. thumb and index finger opposed on the shaft of the pencil, the pencil resting on the distal phalanx of the middle finger, index finger in relaxed flexion, and the forearm held in more than 45 degrees of supination).

(a)

(b)

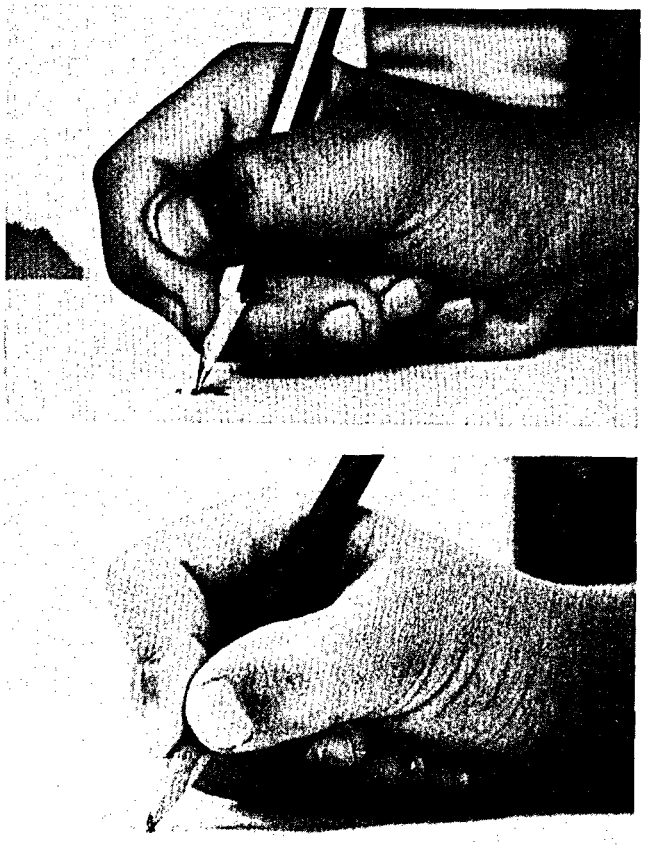

FIG. 4. Scoring for grip components: opposition. (a) Score 1: thumb and index finger not in pad to pad opposition. (b) Score 2: thumb and index finger in pad to pad opposition.

However, such a finding is only weak evidence that this grip produces fast and legible writing. Similarly inconclusive findings resulted from the grips of three children who wrote more slowly than 23 letters per minute and had legibility ratings of less than 3. All three children used different grips, including the standard dynamic tripod.

The reverse strategy was then employed. Those grips that were defined as most desirable or undesirable were identified and respective writing speeds and legibility ratings were examined. Desirable grips were those that scored 2 on all the grip components, while undesirable grips were those that scored all 1s or received a score of 1 on all but one grip component. Using this criterion, 70 children demonstrated desirable grips, and 29 showed undesirable grips. The means and standard deviations for these grip clusters are presented in Table II. No significant differences were found for either speed ($t=1{\cdot}15$, d.f.$=97$) or legibility ($t=0{\cdot}86$, d.f.$=97$).

On the basis of the analysis of static pencil grip reported in this study, it would appear that the way children hold their pencils while writing does not necessarily influence the speed or legibility of their writing. As with most motor skills there is a

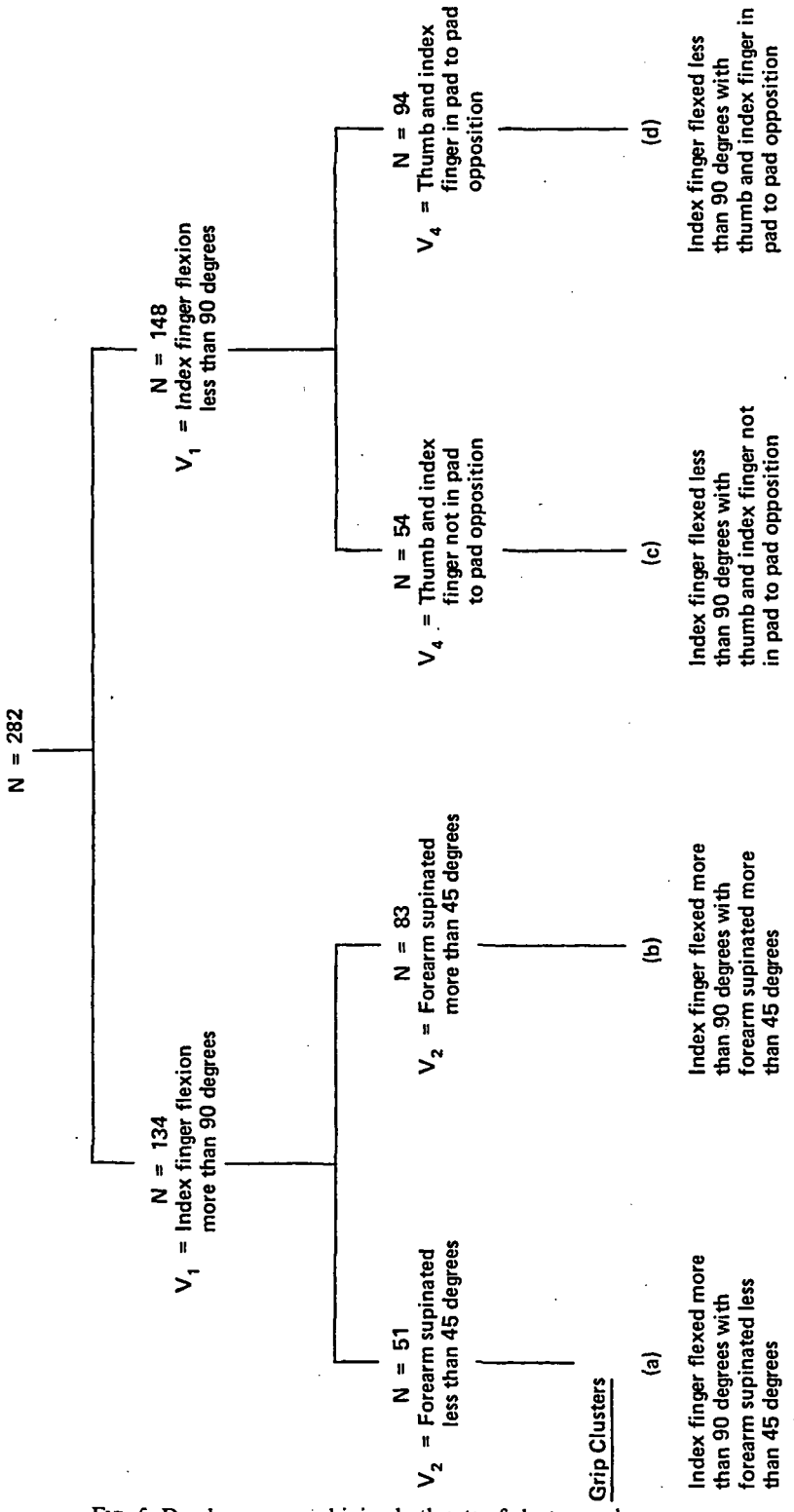

FIG. 5. Dendrogram combining both sets of cluster analyses.

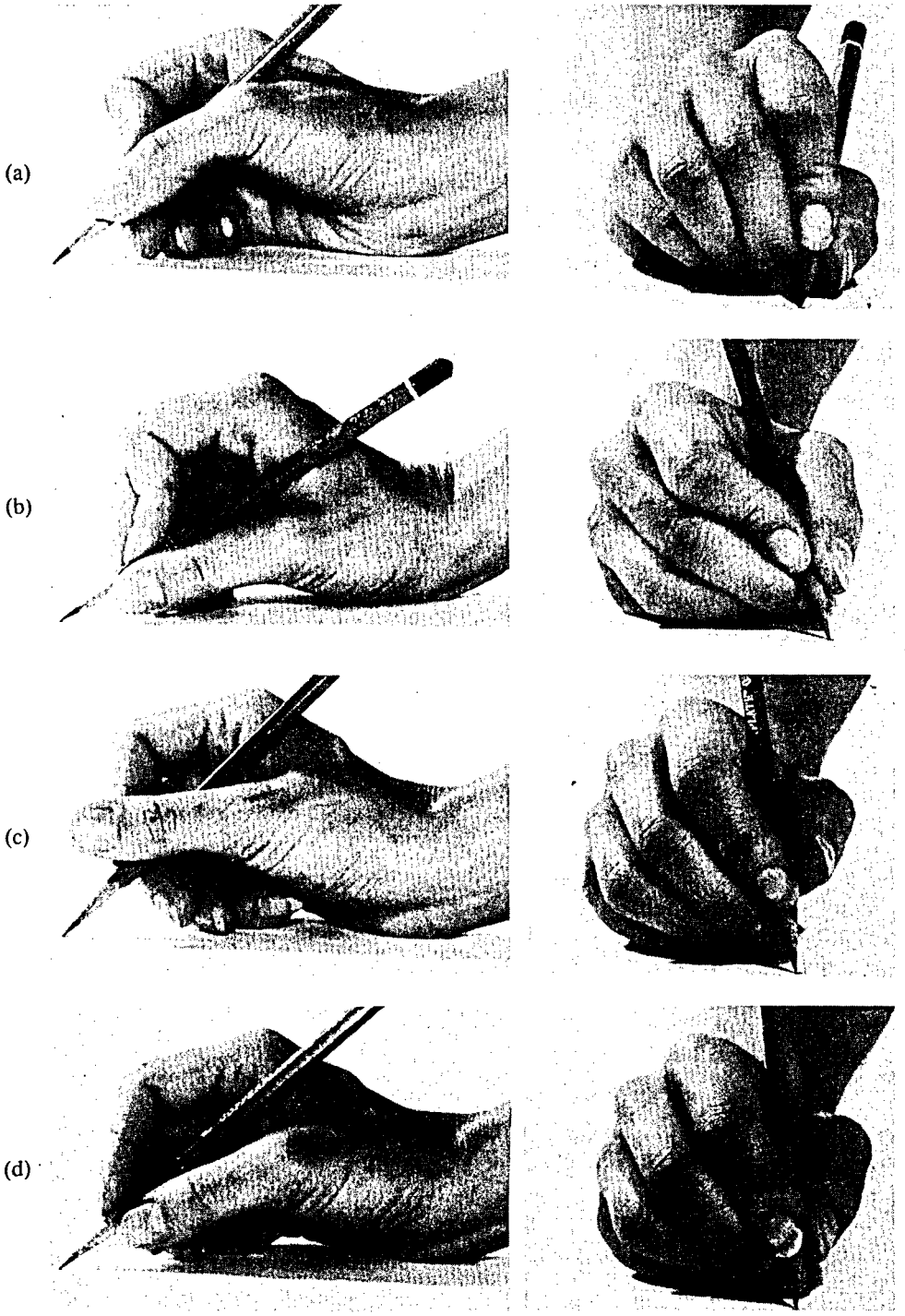

FIG. 6. Four identified pencil grips on the basis of cluster analysis. (a) Index finger flexed more than 90 degrees with forearm less than 45 degrees supinated. (b) Index finger flexed more than 90 degrees with forearm supinated more than 45 degrees. (c) Index finger in relaxed flexion with fingers not opposed. (d) Index finger in relaxed flexion with fingers in opposition.

TABLE I. Means and standard deviations for writing speeds and legibility scores on the basis of four grip clusters

Grip	Mean speed (letters per min.)	Standard deviation	Mean legibility score	Standard deviation	Number of children
(a)	35·89	4·62	4·02	1·24	51
(b)	36·89	4·01	3·88	1·15	83
(c)	38·15	5·06	3·80	1·72	54
(d)	37·35	4·53	4·11	1·91	94

TABLE II. Means and standard deviations for writing speeds and legibility scores on the basis of 'desirable' and 'undesirable' grips

Grip	Mean speed (letters per min.)	Standard deviation	Mean legibility score	Standard deviation	Number of children
'Desirable'	37·62	5·69	4·11	1·56	70
'Undesirable'	33·75	4·72	4·03	2·01	29

degree of individual variation which is apparently not detrimental to the performance of a task. This needs to be taken into account when evaluating the pencil grip used by children who are demonstrating handwriting difficulties.

Having said this, it is important to note that only static grip has been analysed. The way in which students use grip—its dynamic application—is perhaps more relevant to writing performance. To examine this issue in more detail, further study is required. The use of cinematography may well help in the investigation of dynamic writing processes.

The effect of fatigue was not examined in the present study. This certainly is a relevant issue. Most teachers are aware that under conditions of stress students' writing can deteriorate. Some grips may be better adapted to writing under stressful conditions than others. As with most research on handwriting, this study raises more questions than it answers, thus emphasising the paucity of work in this field. What the study does show is that grip is unlikely to be the sole cause of poor writing, and that teachers should not focus exclusively on what might appear an obvious factor to the exclusion of other influences.

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REFERENCES

ALSTON, J.A. (1983) A legibility index: can handwriting be measured? *Educational Review*, 33, pp. 237–242.

ANDERSON, E.M. (1975) Cognition and motor deficits in children with spina bifida and hydrocephalus with special reference to writing difficulties, *unpublished Ph.D. thesis*, University of London.

ANDERSON, E.M. (1976) Handwriting and spina bifida, *Special Education Forward Trends*, 3, pp. 17–20.

ASKOV, E., OTTO, W. & ASKOV, W. (1970) A decade of research in handwriting: progress and prospect, *Journal of Educational Research*, 64, pp. 101–111.

AYRES, L.P. (1912) *A Scale for Measuring the Quality of Handwriting of School Children* (New York, Russell Sage Foundation).

CARTER, F.L. & SYNOLDS, D. (1974) Effects of relaxation training upon handwriting quality, *Journal of Learning Disabilities*, 7, pp. 236–238.

EVERITT, B. (1980) *Cluster Analysis*, 2nd edn (New York, Halsted Press).

FISCHER, G. (1964) Zur faktoriellen struktur de handschrift (Factorial structure of handwriting), *Zeitschrift fur Experimentelle und Angewandte Psychologie*, 11, pp. 254–280.

GRAIG, M.C. (1966) An analysis of the relationships between the care of reading sixth grade handwritten papers by peers and teacher evaluation of the handwritten papers with selected handwriting factors, *Dissertation Abstracts*, 27, pp. 325-A.

GROFF, P.J. (1961) New speeds in handwriting, *Elementary English*, 38, pp. 564–565.

HAYS, W.L. (1963) *Statistics for Psychologists* (New York, Holt, Rinehart & Winston).

HELWIG, J.L., JOHNS, J.C., NORMAN, J.B. & COOPER, J.O. (1976) The measurement of manuscript letter strokes, *Journal of Applied Behavior Analysis*, 9, pp. 231–236.

MENDOZA, M.A., HOLT, W.J. & JACKSON, D.A. (1978) Circles and tape: an easy, teacher implemented way to teach fundamental writing skills, *Teaching Exceptional Children*, 10, pp. 48–50.

MILLER, G.A. (1956) The magical number seven, plus or minus two: some limits on our capacity for processing information, *Psychological Review*, 3, pp. 81–97.

QUANT, L. (1946) Factors affecting the legibility of handwriting, *Experimental Education*, 14, pp. 297–316.

RONDINELLA, O.R. (1963) An evaluation of subjectivity of elementary school teachers in grading handwriting, *Elementary English*, 40, pp. 513–517.

ROSENBLOOM, L. & HORTON, M.E. (1971) The maturation of fine prehension in young children, *Developmental Medicine and Child Neurology*, 13, pp. 3–8.

SAIDA, Y. & MIYASHITA, M. (1979) Development of fine motor skill in children: manipulation of a pencil in young children aged 2 to 6 years, *Journal of Human Movement Studies*, 5, pp. 104–113.

SMITH, A.C. & REED, G.F. (1959) An experimental investigation of the relative speeds of left and right handed writers, *Journal of Genetic Psychology*, 94, pp. 67–76.

STOTT, D.H., MOYES, F.A. & HENDERSON, S.E. (1985) *Diagnosis and Remediation of Handwriting Problems* (Guelph, Brook Educational Publishing).

WISHART, D. (1978) *Clustan: cluster analysis package* (Edinburgh, University of Edinburgh, Program Library Unit).

WYNN-PARRY, C.B. (1966) *Rehabilitation of the Hand*, 2nd edn (London, Butterworth).

ZIVIANI, J. (1982) Children's prehension while writing, *British Journal of Occupational Therapy*, 45, pp. 306–307.

ZIVIANI, J. (1983) Qualitative changes in the dynamic tripod grip of seven to fourteen year olds, *Developmental Medicine and Child Neurology*, 25, pp. 778–782.

ZIVIANI, J. & ELKINS, J. (1984) An evaluation of handwriting performance, *Educational Review*, 36, pp. 249–261.