Chapter 11

THE DEVELOPMENT OF GRAPHOMOTOR SKILLS

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CHAPTER OUTLINE

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SUMMARY

This chapter provides information on the development and execution of graphomotor skills, as a basis for remediation. Concepts common to both drawing and handwriting such as motor learning theory and grasps used with writing and drawing tools are discussed first. Following are detailed sections on drawing and then handwriting. The emphasis in these sections is on outlining research that broadens our knowledge of the development of drawing and handwriting and deepens our understanding of the factors that are associated with graphomotor difficulties.

Graphomotor skills comprise those conceptual and perceptual-motor abilities necessary for drawing and handwriting. Drawing is defined as the art of producing a picture or plan with implements such as pencils, pens, or crayons. Handwriting is the process of forming letters, figures, or other significant symbols, predominantly on paper. Both these activities can be used to record experiences or thoughts, as well as communicate these to others. Drawing and handwriting are complex motor behaviors in which psychomotor, linguistic, and biomechanical processes interact with maturational, developmental, and learning processes (Smits-Engelsman & Van Galen, 1997). The need to develop proficiency in activities as fundamental as drawing and handwriting may be questioned in relation to the growing reliance on electronic communication devices. It is the position of this chapter that graphomotor skills represent more than a means of recording thoughts or conveying experiences. Developmentally these skills allow for experimentation and self-expression in the way a child interacts with the environment. Furthermore they are a means by which children learn basic tool use and are able to produce a product that is socially recognized and rewarded. As such they form an important part of the development of an individual.

GENERAL GRAPHOMOTOR COMPETENCY

ACQUISITION OF GRAPHOMOTOR SKILLS

Children, when presented with tools for inscription, readily smear paint, scribble with crayons, or draw. The nature of the inscription varies depending on the developmental status of individuals and their motor learning in relation to prior exposure to graphomotor experiences. In its most basic form simple inscription with an implement onto a page can be understood as a perceptual-motor act (van Galen, 1991). The learning of a skilled task such as handwriting or drawing,
however, involves an interplay among the individual, task, and environment (Shumway-Cook & Woollacott, 2001). Figure 11-1 summarizes these with respect to handwriting (Jongmans et al., 2003; Shumway-Cook & Woollacott, 2001). Each child’s individual capacity to mesh the task and the environmental contributions to handwriting determines the extent to which effective handwriting will be acquired.

Motor Learning
Handwriting and drawing have been conceptualized as learned motor tasks. Motor learning theorists explain the control of coordinated movement in terms of open- and closed-loop systems (Mathiowetz & Bass-Haugen, 2002; McGill, 1998). The closed-loop system involves afferent feedback. In the case of handwriting, feedback is received from the pressures exerted on the writing implement and the writing surface, from the senses of touch and movement in the fingers, hand, and arm, and from visually monitoring written work. This afferent feedback is used to update the nervous system about the accuracy of the handwriting. The feedback is used to modify and control subsequent handwriting. In open-loop control systems there is no afferent feedback and the central nervous system directs movement. Theorists have postulated that the acquisition of drawing and handwriting skills can be understood best within the framework of a closed-loop theory. That is, afferent feedback is relied on to learn the skill. However, once learned, it is postulated that handwriting moves into the domain of an open-loop skill (van der Meulen et al., 1991). This means that instead of remaining dependent on vision and other sensory feedback, the skilled writer is able to write so quickly that there is no time to modify performance on the basis of afferent feedback. Movements that are entrenched in memory may predominate as handwriting becomes a proficient skill (Grossberg & Paine, 2000). In reality, the environmental and task demands of handwriting are diverse and dynamic and preprogrammed motor acts are not adequate to respond to the changing requirements of various handwriting tasks. Consequently, it is more likely that closed- and open-loop systems work cooperatively, interacting with the various individual task and environmental factors to achieve handwriting output (Mathiowetz & Bass-Haugen, 2002).

The Roles of Vision and Kinesthesis
Vision is essential to children learning to handwrite as they plan, execute, and monitor their attempts. Reliance on vision generally diminishes as skilled handwriting develops and feedback provided by the somatosensory system has greater influence in directing skilled and precise movement (Cornhill & Case-Smith, 1996). However, the visual sense is thought to remain active in children who are experiencing difficulties in mastering handwriting. Wann (1987) found that good and poor writers used different movement patterns when asked to reproduce letters and words. Wann recorded the performance of good and poor handwriters using an xy digitizer, and movement patterns were categorized according to their velocity and acceleration characteristics. Poor handwriters used more patterns of movement indicative of reliance on visual feedback as a major source of environmental information during handwriting. Although not suggesting that the more proficient writers were not using visual feedback during letter production, Wann (1987) postulated that they were probably less dependent on it as a means of control. He went on to point out that deprivation of visual feedback resulted in the deterioration of even the most proficient writer’s performance. Other researchers (van der Meulin et al., 1991) have supported the view of Wann and suggest that children with difficulty in visual-motor control compensate by adopting a greater reliance on visual monitoring and that this in turn results in slower performance. These issues warrant greater atten-
tion because they can influence the adoption of appropriate remedial strategies.

The role of kinesthesia is frequently discussed in relation to drawing and, particularly, handwriting. Kinesthesia relates to the information received from muscles, joints, and skin about body and limb position, and the direction, extent, and velocity of movement (Harris & Livesay, 1992; Sudsawad et al., 2002). An impairment of kinesthesia may influence the refinement of fine motor skills; children are not able to perceive and therefore monitor and correct errors of movement, particularly those of small amplitude, which are observed in handwriting (Harris & Livesay, 1992).

Much of the work around kinesthesia in relation to handwriting involves the Kinesthetic Sensitivity Test (KST). This norm-referenced test consists of two subtests: Kinesthetic Acuity and Kinesthetic Perception and Memory. Each subtest has specific equipment that was designed to eliminate the need for motor control, thus allowing passive movement of children’s hands and arms to determine kinesthetic ability. Laszlo and Bairstow (1985a) developed the test to identify kinesthetic deficits and reported that training children using this test equipment resulted in improved drawing skills in children with poor kinesthesia. However, the relative importance of the role of kinesthesia in acquisition of proficient handwriting remains unclear. This subject is elaborated on in the review of handwriting later in this chapter.

**Implement Grasp and Manipulation**

Brushes, crayons, pencils, felt-tip markers, and pens are the primary tools used by children in their graphic endeavors. These implements form an extension of the hand, and their control and manipulation are important in attaining skilled copying, drawing, and handwriting. Only through experimentation do children become skilled in adapting to implements of different weight, length, and graphic quality. Different grasps may be adopted with a change in implement and task to achieve an optimal outcome (Schwartz & Reilly, 1980; Thelen & Smith, 1994).

**Grasps**

Many children acquire a dynamic tripod grip by about 6½ years of age as their means of implement manipulation for drawing and handwriting. Children progress through a range of precursor grips—palmar, incomplete tripod (or palmar supinate), and static tripod—before adopting the dynamic tripod grip (Dennis & Swinth, 2001; Rosenbloom & Horton, 1971; Sada & Miyashita, 1979). Schneck and Henderson (1990) propose a 10-grip scale to classify the developmental range of grasps. Level 1, or the lowest level of the scale, describes a palmar grasp, whereas Level 10 describes a dynamic tripod grasp. The scale is a “whole-configuration system,” which means that all the components of the grip can be described together rather than evaluating various components of a grip separately. Adoption of a scale such as this has the potential to inform comparisons with and between children and to contribute to a system of uniform terminology (Windsor, 2000).

The dynamic tripod grasp, generally viewed as the mature grasp, is one in which the writing implement is grasped between the radial surface of the middle finger and the pulp surface of the thumb and index finger, with the thumb relatively opposed (Elliott & Connolly, 1984). However, not all children acquire or use this grip. Research suggests that the dynamic tripod is used by only 50% to 70% of children in a given sample (Benbow, 1987; Blote & van der Heijden, 1988; Dennis & Swinth, 2001; Schneck & Henderson, 1990). Other grasps, such as the lateral tripod and quadripod, also allow ulnar stability and controlled dynamic finger movement, which are considered important for skilled handwriting.

Diverse ways of categorizing variations in the dynamic tripod grasp have been used. Ziviani & Elkins (1986) used a series of four nonexclusive categories that described grips on the basis of the number of fingers held on the shaft of the writing implement, degree of forearm supination, hyperextension of the distal interphalangeal joint of the index finger, and thumb and index finger opposition. Sassoon, Nimmo-Smith, and Wing (1986) used a classification of pen holds that examined the position of digits on the pencil shaft, their proximity to the writing tip, and the shape of the digits. Furthermore, Sassoon described grips in relation to the shaping of the hand, the positioning of the upper body, and the specific orientation of the writing paper. Neither Sassoon nor Ziviani’s studies found writing speed was compromised by unconventional pencil holds. Subsequent studies have confirmed that grips affect neither legibility (Koziatek & Powell, 2003) nor the undertaking of long writing passages (Dennis & Swinth, 2001). However, all these studies have been undertaken with children without identified disabilities, and have not taken into account the dynamic aspect of adopted grips.

Schneck (1991) found that children who used variants of the dynamic tripod grip also had impairment of proprioceptive/kinesthetic finger awareness. Schneck hypothesized that the grips may not themselves lead to poor handwriting but, in conjunction with poor proprioceptive and kinesthetic perception, might contribute to poor handwriting performance. Research that examined the impact of joint laxity has supported this view (Summers, 2001). In Summers’ study, positive
but nonsignificant trends emerged between joint laxity and the failure to develop a dynamic tripod grip in 55 7-year-old children. Poorly established hand preference has been linked to developmentally immature grips (Rosenbloom & Horton, 1971; Schneck, 1989), but also can result from insufficient prerequisite experience. Poor hand preference is thought to impede the refinement of the manipulative skills needed for good pencil control. This view is consistent with Exner’s (1990) posit that the development of in-hand manipulation skills is dependent on well-defined hand preference.

In a practical and clinical sense, therapists are confronted by the issue of whether to assist children to modify the grip they are using as part of an overall strategy to facilitate an improvement in handwriting performance. The following points may be worth considering when this situation arises:

1. Mechanically the dynamic tripod grip offers a high level of precision and control (Elliott & Connolly, 1984). The dynamic tripod grip should be encouraged when the child is young enough and has not developed a fixed writing posture. In fact some have argued that inadequate training in the use of a dynamic tripod grip is one of the reasons it is not used by greater numbers of children (Benbow, 1995).

2. Variations of the dynamic tripod grip do not, of themselves, contribute to handwriting difficulties. In typically developing students there appears to be no difference in the speed or legibility of handwriting using the dynamic tripod versus atypical dynamic grasps (Dennis & Swinth, 2001; Sassoon, et al., 1986; Ziviani & Elkins, 1986). Differentiation should be made, however, between a modified version of the dynamic tripod grip and a grip that is developmentally immature. The latter may be part of a broader picture of developmental difficulty. More research is necessary to determine if there is a relationship between typical and atypical grasps and legibility in children who are poor handwriters (Schneck, 1991).

**Writing Implements**

A further issue related to implement manipulation is the nature or type of writing tool used. Traditionally young writers are given lead pencils with a larger than normal lead and barrel for drawing and handwriting instruction. This practice is based on the premise that it is easier for their small hands to hold and manipulate a larger barrel. However, studies have demonstrated that the legibility of kindergarten children’s handwriting is not associated with the tool used (Oehler et al., 2000). The maturity of grasp employed, nevertheless, may vary with the specific tool used (Yakimishyn & Magill-Evans, 2002).

This section of the chapter outlined the processes involved in acquiring proficient use of tools for drawing and handwriting and about the grasps used when manipulating these tools. The next section is about the development of drawing ability.

**DRAWING**

**The Nature of Drawing**

When considering drawing, the simple copying of shapes and figures should be differentiated from the creation of pictures from memory or imagination. The present discussion is concerned primarily with copying skills (the perceptual-motor elements of drawing).

Certain characteristics are thought to distinguish younger children’s drawings from those of adults. Children’s drawings have been described as being formula-like and depicting subjects as they are perceived to be rather than how they look (Freeman, 1980). Apart from exceptional children (Selfe, 1985), most children in their preschool and early school years construct their drawings from simple geometric forms and do not compose broad outlines that are then detailed. Fenson (1985), in a detailed longitudinal study of one child, found that a fundamental shift occurred between 3 and 7 years of age in the structure of drawing. The child moved from a constructional style to the use of contoured forms.

The term constructional in this context relates to the assembling of simple geometric forms into a pictorial representation (e.g., the use of a circle for a face and a rectangle for a body when drawing a person). The term contoured, on the other hand, refers to the sketching of an outline, which is subsequently detailed to achieve the desired representation. Although no attempt is made to explain why a shift might occur from the former to the latter, it is postulated that the motivation is a quest for realism. This quest, in conjunction with greater skill in visually controlling actions and the ability to plan spatially and execute actions, constitutes the move from a juvenile to a more adult approach to drawing. Obviously such assumptions require further investigation.

There has been little advance on the seminal work of authors such as Luquet (1927) and Kellogg (1969) when considering the maturation of children’s drawings. These authors considered that children between the ages of 2 and 3 years make scribbling marks on paper with no representational intent. The fascination is thought to be more with the process of experimentation and exploration of media than with an intended product. The drawing by a 2 1/2-year-old child in Figure 11.2 demonstrates how repetitious marks (in this case

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**Figure 11.2**

The drawing by a 2 1/2-year-old child in Figure 11.2 demonstrates how repetitious marks (in this case...
circular) are employed in exploring the use of a drawing implement on paper. Only at the completion of these marks is a border introduced as a way of demarcation. Demarcating parts of a picture is argued to indicate the beginning of an interpretive phase, which occurs between the ages of 3 and 4 years. During this phase a child begins to interpret a drawing, but generally only after it has been produced. The representational intent is not there at the outset. For example, Figure 11-3 was drawn by a 3½-year-old child. The task commenced with the scribbling at the top of the page with no apparent commitment as to the topic of the drawing. At the completion of the task the child was asked to talk about what had been drawn. The child nominated the descriptions that have been inserted in print but only after some reflection and consideration.

In the next stage (4 to 5 years) the nature of the drawing is announced before its commencement, but the coordination of individual elements remains difficult. At this stage children label and sign their drawings (Devlin-Gascard, 1997). Words are incomplete and letters are often reversed, but the comprehension of symbol and meaning is observable. The drawing of a ship by a 4½-year-old boy in Figure 11-4 demonstrates the use of word labels to describe the intent of the drawing. In this case it was to inform the viewer that the drawing was of the ship Oronsay, which had hit a rock and was badly damaged.

The 6- to 7-year-old child is able to include all the characteristics of objects being drawn as they are known to him or her. This is not always consistent with the way they are in an adult reality. Figure 11-5 demonstrates how a 6-year-old girl perceives her school. The drawing is not a realistic representation but it does contain features of her school and it highlights her understanding of a friendly environment. Finally, from around 8 years of age the child begins to take into account visual perspective; object position and orientation also become more important. This shift represents a progression from intellectual realism, in which the child draws what he or she knows about a stimulus, to a stage in which the drawing depicts what actually can be seen (Laws & Lawrence, 2001). This shift also has been associated with an increase in the amount of attention given to the object being drawn (Sutton & Rose, 1998), suggesting that realism is based on ability to attend to detail.

The ability to produce and appreciate graphic perspective has received considerable attention (Freeman, 1980; Freeman, Eiser, & Sayers, 1977; Nicholls & Kennedy, 1992; Toomela, 1999). Some authors see the onset of perspective as evidence of cognitive maturation (Reid & Sheffield, 1990), whereas others argue that it is necessary to learn the rules about how to represent something in true perspective (Hagen, 1985; Orde, 1997). This latter view is based on studies that found little difference between the way in which children handle the three-dimensional plane and the methods adopted by adults. In both populations, individuals who have no special artistic talent or training reproduce the visual structures that they see in natural perspective along a continuum from orthogonal (no diminishing
Figure 11-3  Beginning of interpretive phase. Naming occurs verbally at completion (3½-year-old boy).

Figure 11-4  Labels incorporated into picture as a way of demonstrating intent (4½-year-old boy).
projected size with increasing distance) to projective (image size decreases as distance increases). As with other skills that have learned elements, Messaris (1994) argues that enhancement of depth perception might lead to a more general stimulation of the capacity for perceiving and thinking about three-dimensional space, an important component of general intelligence. Figure 11-6 demonstrates the use of foreground and background, as well as three-dimensional perspective. Some uniformity exists in the way certain objects are drawn. Both convention and handedness have been implicated in this uniformity (van Sommers, 1984). For example, right-handed people tend to commence the drawing of a free-standing circle at around the 12 o’clock position and invariably draw counter-clockwise, whereas a little more than 60% of left-handed people draw a circle in a clockwise direction. Another interesting convention is the direction in which profiles are facing. Most profiles of faces, for instance, are drawn turned to the left, as are most cars. Glasses are drawn with the lenses to the left, pencils have points to the left, spoons and pipes have bowls to the left. On the other hand, most flags are drawn flying to the right, and cups and buckets have their handles to the right. The foundations for these uniformities have not been documented and neither have there been
any reports located that explore the impact of left handedness on these tendencies.

Children maintain individuality in their drawings of the most common objects even though they may have constant access to other children’s drawings. When children do adopt stereotyped formulas, they frequently include their own versions alongside. The drawings of one child over time may be very repetitive in the treatment of the same subject material (van Sommers, 1984). The logic is that flexibility of drawing is lost because of the repetition of early drawing strategies. This is not to say that children’s drawings never change but that they evolve by gradually modifying existing drawing strategies, rather than by a revolutionary rethinking of their basic representational strategy. Following this line of reasoning, innovation in drawing is thought to occur late in the sequence of producing a drawing and not in the initial strokes (van Sommers, 1984).

There has been some discussion in the literature about the role of coloring-in and the development of children’s graphic skills (Duncum, 1995). Debate seems to surround the use of coloring-in as a means of developing pencil control as opposed to being part of artistic development. Coloring-in, or the use of pencils, crayons, or other implements to provide a color fill within a space defined by lines, is widely undertaken by children and is promoted by teachers, parents, and commercial enterprises (King, 1991). For example, it is employed for the purpose of product promotion for movies and by fast food outlets, and as a means of keeping children occupied when they are on plane trips. Further, proficiency of coloring-in is judged and rewarded as part of promotional competitions for various products.

Distinction needs to be made about the use of coloring-in that is predetermined by the presentation of a figure and coloring-in that children choose to undertake after they have produced a drawing. The former, which opponents call “dictated art” (Herberholz & Hanson, 1985, p. 5), and place in the same category as paint-by-numbers, is thought to detract from appreciation of shapes and forms and their creation. Conversely, when children color-in their own creations they are more highly motivated and better able to adhere to the structures they create (Duncum, 1995). Jefferson (1969) proposed that coloring-in per se can be used as a means of improving fine motor skills associated with handwriting. This proposition has not been researched; therefore the practice, although widely adopted, seems to be based in convention more than research.

**Computers and Drawing**

The production of pictures by young children using the computer is now quite a common practice. The computer mouse is considered the most child-friendly interface for accessing a wide range of software (Lane & Ziviani, 1997). The mouse is used in a variety of ways depending on the nature of the program. The range of tasks required of a mouse to achieve the desired outcomes includes tracking, clicking, and dragging (Lane & Ziviani, 1999). As with drawing, producing computer graphics makes varying demands on visual motor control. There have been preliminary attempts to assess children’s skill proficiency using the mouse (Lane & Denis, 2000) but little documented about the spontaneous attempts of children to draw using a computer. Figures 11-7 and 11-8 are two examples of how children use this medium. The picture in Figure 11-7, by a 6-year-old boy, demonstrates many of the characteristics thought to manifest in pencil and paper drawings at this age. There is evidence of spatial realism with respect to the placement of the bus in relation to the road and the use of objects (i.e., helicopter) for
scenic representation. The mouse functions of tracking, click, drag, and place have been used in this drawing. In another example of freehand drawing (see Fig. 11-8), a 6-year-old girl demonstrates the use of click and drag to create a self-portrait. There is scope for further research in this domain to examine comparability between the production of drawings using pencil and paper and computer software.

**Drawing and Developmental Evaluation**

Children’s drawing ability is incorporated into a number of assessments of developmental status. The ability to reproduce a straight line, a cross, and a circle, for example, is used in a number of assessments as indicators of developmental maturity (Bayley, 1993; Folio & Fewell, 2000; Gesell, 1956; Griffiths, 1970). Furthermore, one of the most widely used tests of visual-motor integration, The Developmental Test of Visual Motor Integration (VMI) (Beery, 1997) evaluates children’s accuracy in reproducing shapes to determine their visual-motor maturity. Some researchers have determined ability in this assessment as being directly related to subsequent handwriting skill (Oliver, 1990).

A number of studies have associated the ability to draw a human form, such as found in the Goodenough Draw-A-Man Test (Goodenough, 1926) with a range of cognitive (Harris, 1963; Scott, 1981), behavioral (Hartman, 1972; Pope-Grattan, Burnett, & Wolfè, 1976), and emotional (Fu, 1981; Roback, 1968) characteristics in children. To date the findings from these investigations remain inconclusive. Other issues related to the perceptual-motor ability necessary to draw a human form, the gender variability in drawings of this nature, and the efficacy of drawing the self as opposed to a male or female form have been investigated (Short-DeGraff & Holan, 1992). Short-DeGraff and Holan found that factors in preschool children’s self-drawing were significantly and positively related to visual-motor skills as measured by the Test of Visual Motor Skills (Gardner, 1986) but not with a measure of verbal intelligence. Short-DeGraff and Holan also explored alternatives to scoring the drawing to those originally proposed by Goodenough. The high association between their simplified scoring methods and Goodenough’s more complex methods suggests that simplification of scoring criteria is possible. Further research of the scoring criteria, as well as extending the ages of children under investigation, is warranted based on these preliminary findings.

Obviously, for those children with motor impairment (e.g., cerebral palsy, spina bifida) the quality of drawings may be affected. The differences between their drawings and those of children without disability should be considered within the context of the child’s perceptual-motor limitations, cognitive impairment, and possible environmental restrictions. Determining the relative contribution of each factor is not easy. Unfortunately, many assessments of developmental and cognitive abilities rely, in part, on copying abilities, especially for preschool children (Moore & Law, 1990).

An attempt has been made by Reid and Sheffield (1990) to accommodate perceptual-motor limitations when examining children’s drawings. These authors adopted a cognitive-developmental model for the analysis of drawings in children with myelomeningocele. Reid and Sheffield argue that instead of attending to the quality of drawings, which may be detrimentally affected by motor disability, the subject matter and its depiction should become the focus for determining developmental maturity. They propose four complex stages through which children pass in the development of mature drawings. Perspective plays an important part of their conceptualization of a mature drawing. Preliminary observations suggest that Reid and Sheffield’s stages and conceptualization of the content of drawings are a useful analytic scheme for children with myelomeningocele. However, other experimenters argue against the developmental significance of perspective (Bremner & Batten, 1991; Hagen, 1985). Further research to examine the potential clinical utility of Reid and Sheffield’s (1990) findings, especially in the more complex final stages of their model, is warranted.

A view of unique developmental progression in the drawing ability of children with Down’s syndrome has been advanced by Laws and Lawrence (2001). They found preliminary evidence that the spatial characteristics of drawings of children with Down’s syndrome may follow an alternative route to those of children without Down’s syndrome because of problems related to motor planning, motor weakness, and aspects of language development. Children with Down’s syndrome in their study did follow the expected developmental, albeit delayed, trajectory of children in the control group. Yet there were elements in the drawings of children with Down’s syndrome that attested to motor planning, motor weakness, and aspects of language development. Children with Down’s syndrome in their study did follow the expected developmental, albeit delayed, trajectory of children in the control group. Yet there were elements in the drawings of children with Down’s syndrome that attested to their ability to account for aspects such as spatial relationships, although not in the same way as children without Down’s syndrome. However, the two groups were comparable with respect to drawing detail. The authors of this study join others (Eames & Cox, 1994) in advocating the use of measures sympathetic to children with different developmental profiles.

This section has discussed the development of drawing and the expectations of the composition of drawings for typically developing children. It has shown the importance of considering the different ways that children with special needs may interact with writing implements and develop their drawing competence. The
following section focuses on a different graphomotor skill, that of handwriting.

HANDWRITING

HANDWRITING AND WRITING: COMPLEMENTARY CONCEPTS

There is an important differentiation, but also relationship, between handwriting and writing. Handwriting refers to the process of transcribing letters to form words and words to form sentences. Writing, on the other hand, is the composition and content of the material that is handwritten. Proficient writing relies on well-developed handwriting skills. Jones and Christensen (1999), for instance, reported that handwriting skills accounted for 50% of the variance in the quality of writing content in a sample of 6- and 7-year-old students. Both handwriting and writing are complex abilities that are acquired hand-in-hand with children’s acquisition of language. As with drawing, the foundations for both handwriting and writing are the integration of intrinsic and extrinsic factors. Extrinsic factors involved in handwriting include instruction in handwriting, the quality and extent of practice undertaken, the requirements of the task, and the materials used. Intrinsic abilities include orthographic coding, orthographic-motor integration, visual-motor skills, fine motor skills, cognition, linguistic skills, and motivation (Tseng & Chow, 2000). Orthographic coding involves developing a visual representation of letters and words, knowledge of the process of forming each letter, a verbal label for each letter, an accurate representation of the letter’s form in memory and the ability to access and retrieve this information from memory (Edwards, 2003; Jones & Christensen, 1999; Weintraub & Graham, 2000). Orthographic-motor integration is the way in which this letter knowledge can be motorically transcribed to form letters and words on paper. Writers who have poor orthographic coding and ortho-motor integration, and thus need to attend to the mechanics of handwriting (e.g., letter formation, spacing, alignment), have less attention and working memory that can be directed to composing written work and spelling, monitoring, and revision of the written work (Edwards, 2003; Swanson & Berninger, 1996).

Children’s competence in writing depends, in part, on the mastery of handwriting (Graham, Harris, & Fink, 2000). The ability to write legibly and in a timely fashion is necessary for children to adequately document their knowledge and learning. Children’s documentation is largely the basis on which their knowledge acquisition is judged. Research has shown that lower marks are ascribed to work that is less legible even when the content is the same as more legible work (Graham, Weintraub, & Berninger, 2001). Children with handwriting difficulties may avoid writing, or the effort involved in the process of handwriting may impede the ability to generate text that adequately reflects their knowledge. Handwriting difficulties are a significant problem for educationalists and occupational therapists. Berninger and co-workers (1997), for instance, identified 202 (29%) at-risk writers out of 685 children screened and another study identified 24% of children in a sample of 798 kindergarten and grade 1 children as having poor handwriting (Harris & Livesay, 1992). Further, a survey of grade 1 to 4 teachers reported that 23% of children had handwriting difficulties (Hammerschmidt & Sudsawad, 2004). Handwriting proficiency remains a fundamental educational goal despite the availability and uptake of computer technology. The focus of this section is on understanding handwriting as a basis for intervention.

THE DEVELOPMENTAL NATURE OF HANDWRITING

Several features of handwriting development are consistent from both historical and cross-cultural perspectives. At least some characteristics of handwriting are likely to be common across cultures, language, and written script (Yochman & Parush, 1998). For example, there is a developmental progression of both speed and legibility of handwriting with age and a relationship between visuomotor skills and handwriting. Also girls tend to write faster and more legibly than boys and more boys than girls have handwriting difficulties. Further, about 10% of a population is left handed but left handedness is not associated with illegibility or slower speed of handwriting. These relationships have been relatively consistent in studies of handwriting of English, Chinese, Hebrew, and Norwegian children (Graham, 1998; Karlsdottir, 1996; Tseng & Cermak, 1993; Tseng & Chow, 2000; Yochman & Parush, 1998).

There are also consistent factors that seem to operate in the development of written script over time: The size of the writing diminishes; letter formation, spacing, and horizontal alignment become more accurate, simplified, and standardized; the handwriting may become abbreviated; and cursive forms evolve with curves replacing angles and ligatures joining letters (van Sommers, 1991; Yochman & Parush, 1998). Children personalize their own style of handwriting as formal handwriting instruction diminishes. The personalized style generally is faster and more efficient, which may result in a deterioration of letter formation at times. Personalized handwriting tends to become a mix of manuscript and cursive letters, which develops...
either or both of these aspects are appropriate for the performance changes both qualitatively and quantitatively. Handwriting quality and quantity translate, respectively, into legibility and speed. How do we judge if either or both of these aspects are appropriate for the child’s chronologic or developmental level and what factors constitute handwriting dysfunction? Handwriting difficulties become apparent when children write too slowly to record sufficient quantities of work or when the written work is difficult to read. For instance, teachers report that failure to read student handwriting was the most important criteria in determining whether a child had handwriting difficulty (Hammerschmidt & Sudsawad, 2004). Poor handwriters are more likely to have inadequate closure and line quality of letters, poor orientation to the writing line, poor spacing between words and letters within words, and inconsistent sizing of words and of letters within words (Malloy-Miller, Polatajko, & Anstett, 1995).

Although children with handwriting difficulty should be seen within their social and educational contexts, general developmental expectations do exist. One study documents the grade level expectations of children between 7 and 14 years of age in terms of handwriting size, horizontal alignment, spacing consistency, and letter formation (Ziviani & Elkins, 1984). Drawn from a population of Australian schoolchildren, these data support the assumption that letters become more accurately formed, spacing becomes more consistent, size diminishes (more particularly in girls), and handwriting attains better horizontal alignment.

Information about developmental expectations and the factors contributing to handwriting illegibility provide a useful baseline measure for children exposed to similar educational instruction. Ziviani, Hayes, and Chant (1990) used the normative data discussed previously to help specify the nature of difficulties experienced by children with spina bifida who were able to attend regular schools. Their findings indicated that speed, horizontal alignment, and letter formation were the handwriting characteristics most detrimentally affected. Meanwhile, handwriting size fell within two standard deviations of the normative means, and spacing consistency often was better than in the normative sample. Such findings are useful in delineating handwriting dysfunction to target intervention and not just accepting a global disability.

Handwriting quality appears to be an elusive concept to measure despite the development of both global and detailed handwriting assessments. A review of frequently used handwriting tools was written by Feder and Majnemer (2003). A global measure such as the Test of Legible Handwriting (TOLH) (Larsen & Hammill, 1989) compares the individual’s performance with a series of model specimens and the important consideration in scoring is overall legibility (Feder & Majnemer, 2003). However, researchers have sought increasingly to break down handwriting samples into their component parts and over the years a wide variety of handwriting scales (Amundson, 1995; Phelps,

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**BOX 11-1**

The First Nine Forms of the Developmental Test of Visual Motor Integration in Order of Increasing Difficulty

1. Vertical line
2. Horizontal line
3. Circle
4. Cross
5. Right oblique line
6. Square
7. Left oblique line
8. Oblique cross
9. Triangle

Stempel, & Speck, 1984; Reisman, 1993; Stott, Moyes, & Henderson, 1985; Ziviani & Elkins, 1984) and checklists (Alston, 1985) have been produced to reflect this approach. Most of these tools identify characteristics considered to contribute to handwriting legibility.

In general, the handwriting characteristics specified in these detailed tools can be classified as giving form (letter legibility and formation, size) or spatial alignment (space between letters and words, alignment with lines) to handwriting. These tools provide a more comprehensive way of understanding legibility difficulties than global handwriting assessments and offer a basis for designing appropriate remedial interventions. Graham, Weintraub, and Berninger (2001) reported that several factors were significantly related to good overall text legibility. These factors include letter legibility, the absence of additional lines or strokes attached to letters, correct within-letter proportions, correct letter formation, and no rotations of letter parts. There are other factors, arguably overlooked, that relate to movement and that contribute to handwriting legibility (e.g., pressure while handwriting, frequency of pen lifts). Of all the elements, individual letter legibility (which incorporates letter formation, proportion, and shaping, and letter identification out of the context of a word) is considered the most important to overall text legibility (Graham et al., 2001; Mojet, 1991).

Handwriting speed is not necessarily related to legibility; that is, handwriting speed is not predictive of legibility and vice versa (Wann, 1987; Weintraub & Graham, 1998). There is a trade-off, however, between handwriting speed and legibility when children are specifically asked to write neatly or quickly. Children asked to write neatly, for instance, do so at the expense of speed, and children’s legibility decreases when asked to write more quickly (Weintraub & Graham, 1998). Authorities differ in terms of expected handwriting speeds for children at various ages. A summary is presented in Table 11-1. Most variation in handwriting speed normative information may be attributed to differing test instructions (“write normally” versus “write fast”). In appraising handwriting speed tests and their relevance to assessing handwriting speed, consideration needs to be given to the nature of the text being written (whether it is copied or self-generated), the timing of data collection in the school year, and variation in teaching practices. We know that the speed of handwriting slows and that legibility and the quality of letter formation decrease over a lengthy handwriting sample in both good and poor handwriters (Dennis & Swinth, 2001; Parush et al., 1998a). Fatigue affects handwriting; therefore the length of text used to evaluate handwriting speed and legibility and its relationship to everyday writing tasks needs to be considered.

Further work on tests of handwriting speed is necessary to update and validate findings. Standardized data used to evaluate handwriting ability and compare performance with norms should reflect the child’s cultural and educational environment. Teachers’ observations within a peer-appropriate context are critical when deciding if a child’s performance is within developmental expectations. Teachers are accurate in categorizing children with and without handwriting difficulties when compared with a standardized assessment of handwriting ability (Cornhill & Case-Smith, 1996).

### Table 11-1  Reported mean handwriting speed (letters per minute) by school grade

<table>
<thead>
<tr>
<th>Author</th>
<th>School Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groff (1961)</td>
<td>35.1 40.6 49.6</td>
</tr>
<tr>
<td>Hamstra-Bletz &amp; Blote (1990)</td>
<td>25 37 47 57 62</td>
</tr>
<tr>
<td>Phelps, Stempel, and Speck (1985)</td>
<td>35 46 54 66</td>
</tr>
<tr>
<td>Sassoon, Nimmo-Smith, and Wing (1986)</td>
<td>64</td>
</tr>
<tr>
<td>Wallen, Bonney, and Lennox (1996)</td>
<td>54.2 57.1 63.8 80.7 94.2</td>
</tr>
<tr>
<td>Ziviani and Elkins (1984)</td>
<td>32.6 34.2 38.4 46.1 52.1</td>
</tr>
</tbody>
</table>
Factors Contributing to Handwriting Performance

Effective intervention can be planned when the factors affecting an individual child’s ability to complete legible and timely handwriting are clearly understood. In addition to changes to handwriting legibility and speed that occur over time in children’s handwriting, various constraints to handwriting acquisition operate at different stages of development. Berninger and Rutberg (1992) suggest that neurodevelopmental constraints in orthographic coding, fine motor function, and orthographic-motor integration are likely to interfere with the rapid automatic production of written language in younger children. Later, when most children can automatically write the alphabet and spell a set of functional words, the writing process is more probably constrained by verbal working memory and ability to generate the major units of written language—the word, the sentence, or text-level structures. Once proficiency in generating units of language is achieved, writing can be constrained by cognitive processes such as planning, translating, and revising when composing larger pieces of text.

For older children constraints may still be operating at the neurodevelopmental or linguistic, as well as the cognitive levels. Inefficiencies in the low-level neurodevelopmental processes early in handwriting acquisition can contribute to future higher-level writing disabilities, both directly (because production of written material continues to be a problem) or indirectly (because of an aversion to writing arising from early frustration and failure) (Berninger et al., 1997). Some of the major factors implicated in handwriting performance follow.

Working Memory

Swanson and Berninger (1996) demonstrated that individuals have a unique working memory. Working memory is the ability to temporarily retain information during the processing of other information. During handwriting, orthographic codes are retrieved from long-term memory and held in working memory while the writer is developing the text (Weintraub & Graham, 2000). More processing functions are available for idea generation, translation, and sequencing of ideas to text, and revision of writing when aspects of handwriting (including orthographic skills and even punctuation) are automatic (Jones & Christensen, 1999). Further, ideas that are held in working memory may be lost if a child needs to focus attention on the mechanics of forming a letter (Graham et al., 2001). Evidence for this derives from studies that have shown a relationship between orthographic-motor integration and written expression and have demonstrated that writing (written expression) improved after intervention that specifically targeted orthographic-motor integration by teaching correct and automatic letter formation (Berninger et al., 1997; Graham, Harris, & Fink, 2000; Jones & Christensen, 1999). An essential educational goal is to provide handwriting instruction that develops automatic, fluent handwriting to free working memory for writing; that is, generating ideas, monitoring, and revising content (Berninger et al., 1997).

Handwriting Instruction

Handwriting is heavily influenced by the nature of the instruction received and the extent of practice undertaken by the individual. In fact, the main factor that influenced legibility in a study by Lamme and Ayris (1983) was the great variability in handwriting instruction provided by the teachers involved in the study. Handwriting probably receives insufficient emphasis in school curricula: Teachers (62% of sample) reported that they would like to spend more classroom time on handwriting instruction (Hammer Schmidt & Sudsawad, 2004). Berninger and co-workers (1997) surveyed teachers who reported that students were becoming less proficient at handwriting when they reached year 1 than students of previous years.

The importance of focused handwriting instruction to both legible handwriting and writing has been demonstrated in a number of studies (Berninger et al., 1997; Graham et al., 2000; Jones & Christensen, 1999; Jongmans et al., 2003; Karlsdottir, 1996). Important components to include in handwriting instruction are listed in Box 11-2 (Berninger et al., 1997; Graham et al., 2000; Hayes, 1982; Jones & Christensen, 1999). It seems that providing more types of cues or perceptual prompting of letter formation may result in better outcomes.

Adi-Japha and Freeman (2001) found that by 6 years of age children’s writing and drawing systems were differentiated. Children as young as 3 years of age produce different scribbles when asked to write their name than those scribbles generated when drawing a picture (Haney, 2002). Writing specific cortical routes emerge probably as a result of practicing handwriting. Writing within a script context (e.g., words and letters on a page) rather than writing within a picture context produced more fluent handwriting (Adi-Japha & Freeman, 2001). The importance of handwriting practice in early learners and thus a differentiation and specialization of writing is reinforced by these findings. Further, consideration needs to be given to the teaching and practice of handwriting within writing specific contexts; that is, using dedicated writing implements and books, and reducing drawing conditions when the aim is handwriting proficiency. Working within a script context activates the writing system, and activation of
the writing processing system separately from a drawing context prepares for more accurate and automatic handwriting output.

The outcomes of the studies that have focused on developing orthographic skills and automatic handwriting have all been positive. The results suggest that poor letter knowledge and orthographic skills are major contributors to handwriting difficulties and are essential to consider in handwriting intervention. Other studies provide useful information to consider when planning handwriting intervention. One study examining the ability of children in years 1 to 3 to write manuscript letters reported that some letters were more difficult to form legibly (Graham et al., 2001). Overall these letters, in descending order of difficulty, were q, z, u, j, k. Fortunately some of these letters are not frequently used in handwriting but may require more focus during handwriting instruction and should be introduced only after mastery of easier letters. Despite ongoing debate, it seems that teaching slanted or elliptical manuscript does not have advantages over traditional manuscript in legibility outcomes or assisting the transition to cursive handwriting (Graham, 1998). Karlsdottir (1996) showed that handwriting quality of older (10-year-old) students was significantly enhanced by reintroducing each letter form with accompanying visual and verbal cues. Thus one should consider these orthographic factors even in more mature writers. Older writers also tend to personalize handwriting by mixing manuscript and cursive text, among other things. Generally this is to the advantage of both speed and legibility and need not be discouraged.

Factors That Influence the Effectiveness of Handwriting Instruction

Factors such as kinesthesis, fine motor skills, and visual motor abilities are associated with handwriting development and performance (Weintraub & Graham, 2000). Researchers exploring these factors operate under the assumption that they underlie handwriting performance and that understanding their relationship with handwriting assists with developing and evaluating intervention programs (Tseng & Cermak, 1993). Further factors, such as posture while handwriting, paper positioning, and stabilization of paper, as well as other ergonomic factors, discriminate good and poor handwriters (Parush, Levanon-Erez, & Weintraub, 1998b). Posture and stabilization anomalies may result from similar mechanisms to those that cause handwriting difficulties. It is not yet known whether remediating kinesthesis, fine motor, visual motor, ergonomic, and other factors improve handwriting output and writing outcomes.

Issues in relation to motor execution specific to handwriting were introduced in the earlier section on the processes of acquisition of graphomotor skills and are expanded here. When an orthographic code is mobilized from memory for handwriting, a motor program is executed that encompasses manipulating a writing implement to form letters and words (Weintraub & Graham, 2000). Two aspects of motor execution are examined in the literature, fine motor skills (including in-hand manipulation) and abilities related to kinesthesis.

Isolated and graded finger movements are necessary to provide precise and rapid manipulation of a writing tool for handwriting. On the basis of this premise, fine motor skills and in-hand manipulation are frequently assessed as part of a handwriting assessment. Fine motor skills are assessed globally by tools such as the Peabody Developmental Motor Scales—Fine Motor (Folio & Fewell 2000). Fine motor skills incorporate the basic patterns of reach, grasp and release, and the more complex skills of in-hand manipulation and bilateral hand use (Exner, 1989). In-hand manipulation, then, is an essential component of dexterous hand function and can be assessed separately using tools such as those developed by Exner (1993) or Case-Smith (1995). These assessments include some of the defined features of in-hand manipulations such as rotation (e.g., turning an object over using the fingers of one hand) and translation (e.g., using the fingers of one hand to move objects in and out of the palm). In-hand manipulation is assessed as its own entity in handwriting evaluation because of a perceived relationship to pencil manipulation. In reality the association between fine motor skills

**BOX 11-2 Important Components to Include in Handwriting Instruction**

- Copying model letters
- Visual directional cues provided by arrows
- Verbal prompting of letter formation (both instructor and self-verbal prompting)
- Copying from memory
- Reinforcing letter names and practice of letters with a focus on committing these to memory

or in-hand manipulation and pencil grip and handwriting speed and legibility has not been extensively explored. Rubin and Henderson (1982) found that children with poor handwriting did not have significantly different scores from a group of good handwriters on the Test of Motor Impairment, but they did have more variability of their scores. Tseng and Chow (2000) on the other hand, found that Chinese handwriters, categorized as slow writers by their teachers, had significantly lower scores on the Upper Limb Speed and Dexterity subtest of the Bruininks-Oseretsky Test of Motor Proficiency than normal speed handwriters. Cornhill and Case-Smith's work (1996) provides us with some evidence that in-hand manipulation is a significant predictor of handwriting legibility. Their sample of year 1 students with handwriting difficulties had significantly lower in-hand manipulation scores than fellow students with good handwriting. Still we do not know whether improving fine motor and in-hand manipulation ability results in more legible or faster handwriting.

Debate continues about the role of kinesthesis in handwriting performance and the effectiveness of kinesthetic training in improving handwriting. Laszlo and Bairstow (1985b) have argued, based on their work with the KST, that kinesthetic memory, more than kinesthetic acuity, is primarily responsible for the skilled performance of writers. Studies investigating the proposed relationship between training children using the testing equipment of the KST and handwriting performance have reported contradictory findings and have cast a shadow on the psychometric properties of the KST (Hoare & Larkin, 1991; Lord & Hulme, 1987). Two of the stronger studies provide the best evidence that the KST is not associated with handwriting. Copley and Ziviani (1990) found no significant relationship between the KST and handwriting quality when testing good and poor handwriters. A well-designed randomized controlled trial evaluated handwriting outcomes after kinesthetic training on the KST equipment (Sudsawad et al., 2002). There were no significant between-group differences in these grade 1 children after kinesthetic training compared with a sham intervention and no intervention. Previous studies have evaluated kinesthetic training in children with poor handwriting without identifying whether or not they had kinesthetic difficulties. An important difference of Sudsawad’s study from previous ones is that the children recruited were identified as having handwriting difficulty, as well as kinesthetic impairment identified by the KST. The evidence suggests that kinesthetic training using the KST equipment is not an effective handwriting intervention.

Research on other aspects of somatosensory ability and handwriting are inconclusive. Weintraub and Graham (2000) found that “finger function” was a strong predictor of good or poor handwriting ability. Rather than reflecting strictly fine motor ability, the finger function tasks contained largely proprioceptive and somatosensory ability. Yochman and Parush (1998), however, found no correlation between kinesthesia-related tests and handwriting performance.

Visual motor integration appears to be an important factor in handwriting legibility. A great deal of research supports the assumptions that (a) visual motor integration is correlated with handwriting performance in good, as well as poor handwriters (Tseng & Chow, 2000; Tseng & Murray, 1994; Weil & Cunningham, 2000; Tseng & Chow, 2000; Tseng & Murray, 1994); (b) visual motor abilities are weaker in children with handwriting difficulties, across a wide range of ages, compared with children without handwriting difficulties (Cornhill & Case-Smith, 1996; Daly, Kelly, & Krauss, 2003; Rubin & Henderson, 1982; Tseng & Chow, 2000; Tseng & Murray, 1994); and (c) visual motor integration difficulties are a predictor of handwriting legibility (Cornhill & Case-Smith, 1996; Maeland, 1992; Tseng & Chow, 2000; Weintraub & Graham, 2000; Yochman & Parush, 1998). Visual motor integration may be particularly important in the acquisition of handwriting because visual motor abilities are used to acquire orthographic coding skills. Occupational therapists tend to view visual motor integration as underlying handwriting dysfunction and intervene using visual motor activities (Case-Smith, 2002). Despite this relative abundance of evidence confirming the relationships between visual motor integration and handwriting, there is as yet no evidence that remediating visual motor skills will result in enhanced handwriting output.

Handwriting intervention studies in the educational and motor learning literature focus on developing orthographic coding and using self-instruction methods for enhancing handwriting legibility and writing ability (Berninger et al., 1997; Graham et al., 2000; Hayes, 1982; Jones & Christensen, 1999; Jongmans et al., 2003; Karlsdottir, 1996). These studies provide good evidence that these approaches are effective in enhancing various aspects of handwriting legibility and speed and also the content of written work. Studies in occupational therapy are fewer in number than studies in education. Typically occupational therapy intervention studies integrate multiple theoretical perspectives and offer broad-based interventions encompassing biomechanical, multisensory, visual motor, fine motor, and handwriting-specific interventions (Case-Smith, 2002; Lockhart & Law, 1994; Peterson & Nelson, 2003). A range of outcomes which are not always related to handwriting legibility, speed, and content are evaluated. Two such broad-based studies (including one randomized controlled trial) reported significant improvement in handwriting; however, the specific components of the intervention that contributed
to the outcomes are undetermined (Case-Smith, 2002; Peterson & Nelson, 2003).

Computers and Handwriting

Children with significant disability or those who continue to have handwriting difficulties even after intervention may consider word processing as an alternative. There are a multitude of factors to consider in deciding whether keyboarding is an appropriate strategy for children to adopt. Just some of these factors are the keyboard configuration (e.g., laptop, PC); software (e.g., word prediction); transfer of data among home, school, and printers; the cognitive demands of managing files, academic subjects, and the facilities of multiple software packages; the physical demands of the task; and the suitability to the child. Further, it is necessary to predict whether a child will actually achieve quality written expression with adequate accuracy and speed compared with handwriting.

Keyboarding, like handwriting, is a complex skill and requires many hours of practice to achieve proficiency. Learners of keyboarding should progress through stages of learning the position of keys and the various movement patterns necessary to achieve correct key strokes. Proficiency, which relies largely on kinesthetic feedback and little on visual feedback, may be achieved with practice. It is interesting to contemplate whether handwriting and keyboarding have similar underlying abilities. If so, and if handwriting is a difficulty, then these same underlying abilities also may affect the development of proficiency at keyboarding. Studies indicate that different components underlie handwriting and keyboarding accuracy in typically developing students (Preminger, Weiss, & Weintraub, 2004; Rogers & Case-Smith, 2002). This information combined with Barrera, Rule, and Diemart’s (2001) finding that year 1 students wrote more words and sentences using a keyboard than handwriting gives us more confidence in using keyboarding as an option for children with handwriting difficulties.

Word processing and word prediction software can increase the legibility and spelling of written work in children with learning and handwriting difficulties (Handley-More et al., 2003). Studies do not concur as to whether keyboard instruction can result in keyboard speeds that are faster than handwriting (Rogers & Case-Smith, 2002). Indeterminate hours are spent learning and refining handwriting. The expectation should be that substantial effort goes into ensuring that the speed and accuracy of keyboarding is at least equivalent to handwriting to make it a viable alternative to handwriting. The secondary complications of poor handwriting (e.g., compositional difficulties, avoidance of handwriting, and loss of confidence) may be avoided if children can be offered word processing as a viable option to handwriting at an appropriate time (Rogers & Case-Smith, 2002).

This review of handwriting has discussed handwriting development and factors associated with skilled handwriting execution. The fact that handwriting underlies quality written output and thus that good handwriting instruction is essential has been emphasized.

Summary

The process and products of children’s drawing and handwriting have intrigued occupational therapists, as well as others interested in child development, for a number of years. It is clear from this chapter that, although we now have certain structures in place to understand the developmental transitions in children’s drawings, there is still much to understand. The same can be said for handwriting. There remain aspects of drawing and handwriting acquisition that still tantalize; this chapter concludes by pointing to some issues that still beg investigation.

Drawing is an important developmental experience for children. With the increasing use of computers by younger and younger children, some of the pencil and paper drawings with which we are most familiar are being accomplished using a computer. Are we able to translate our knowledge of paper-based outcomes to those on the screen?

Preliminary research has indicated that handwriting and keyboarding have differing underlying components. Thus we are unlikely to be able to translate our knowledge of handwriting directly to keyboarding. A greater understanding of word processing, as an alternative form of recording work, is necessary to match it to the individual needs of students. Using a motor learning framework, we understand that handwriting is a learned motor task requiring interplay among the writer, the task, and the environment. A key environmental factor in its acquisition is the quality of instruction received and amount of practice undertaken. However, even in the presence of adequate instruction there are a multitude of factors pertinent to an individual that may affect the child’s ability to develop handwriting. The association between some of these factors and handwriting has intrigued occupational therapists, as well as others interested in child development, for a number of years. It is clear from this chapter that, although we now have certain structures in place to understand the developmental transitions in children’s drawings, there is still much to understand. The same can be said for handwriting. There remain aspects of drawing and handwriting acquisition that still tantalize; this chapter concludes by pointing to some issues that still beg investigation.

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relationship of all these factors to handwriting and especially how these factors are manifesting in children with poor handwriting. It may be that a breakdown in any of these factors may impede a child’s acquisition of handwriting. Determining their relative effect on performance is essential if appropriate intervention is to be designed.

Developing proficient handwriting requires children to learn and apply a number of rules, as well as to develop motor programs for the efficient execution of script. We have established that the nature and extent of instruction are highly influential in proficient handwriting output. Part of handwriting instruction is knowing how to form individual letters and join them to manufacture words. One area that has not received much attention in the literature is the influence of different scripts in the attainment of proficient handwriting. The relative merits of learning print (ball and stick) and then moving on to learn cursive handwriting, as opposed to starting with a simple modified cursive script, also requires further investigation. Both approaches, in fact, are currently used in school systems throughout the world. We simply do not know which is more effective in optimizing handwriting development and outcomes.

Research in the area of implement grasp and manipulation suggests that the type of grip being used need not necessarily impede handwriting speed and legibility (Dennis & Swinth, 2001; Koziatek & Powell, 2003). This suggests that the mechanism for execution of handwriting is less important than the cognitive, perceptual, and planning components. Research is needed to clarify this relationship.

This review of the development of drawing and handwriting shows a field dotted with light and shade. Our knowledge of drawing and handwriting, grounded in research and founded on principles of motor learning, is the “light” we shed on our interactions with children with handwriting difficulties. The “shade” relates to areas in which knowledge is sparse. We should continue to seek knowledge that will shed light on the many “shaded” areas that currently exist in this area and will enable us to provide evidence-based and effective intervention for our clients.

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