# The Effectiveness of a Multisensory Approach compared to a Task-Oriented Approach on Handwriting Legibility amongst Elementary School Children

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**Introduction and Literature Review**

Handwriting is a complex activity that involves extensive training in order to master the required skills. Elementary age children spend a large part of their day participating in fine motor activities involving handwriting in subjects such as math, reading, spelling, social studies and science**.** The relevance of handwriting to a child's education is signified by the amount of in-class time spent in executing activities that require the skill of handwriting. For example, preschool students spend an average of 37% of their school day engaged in fine motor activities, of which 10% are paper-and-pencil tasks (Marr , Cermak, Cohn & Henderson, 2003). Kindergarten students spend up to 46% of their day completing fine motor activities, of which 42% are paper-and-pencil tasks (Marr et al., 2003). Evidently, handwriting-related activities start early in a child's education and increase in importance as the child advances in his or her basic education. Unfortunately, so do the difficulties associated with handwriting. Handwriting difficulties may affect up to 27% of school-age children, with up to 60% of the school day devoted to fine motor activities (McHale & Cermak, 1992). Therefore, the early identification and remediation of handwriting deficiencies before the child reaches middle and high school, when handwriting demands increase in complexity and intensity, can prevent difficulties associated with handwriting (Ste-Marie, Clark, Findlay, & Latimer, 2004).



Past and current research on handwriting supports the notion that handwriting is an essential skill involving a complex integration of several body systems, namely lower-level perceptual motor processes and higher-level cognitive processes. Perceptual-Motor processes rely on processing of information by the sensory systems and consist of perception of muscle sense (proprioception), visual (copying from text), tactile and or auditory information (dictation), fine motor coordination, motor planning, sensory, motor, perceptual, neuromuscular systems and

visual motor integration. Higher-level cognitive processes, often associated with task oriented approaches and motor learning theory in the literature, involve cognitive planning, working memory processes, orthographic coding, specific language processes such as reviewing and revising written text (Berninger & Swanson, 1994; Berninger et al. 1997; Graham & Weintraub, 1996; Jongmans, Linthorst-Bakker, Westerberg & Smits-Engelsman, 2003).

The contributions of higher-level and lower-level processes (i.e., performance skills, in the Occupational Therapy literature (AOTA, 2008) on handwriting have been extensively researched. The common assumption among therapists is that a causal relationship exists between these lower-level processes and handwriting performance and that remediation of these skills will result in improved handwriting. Therefore Occupational Therapists (OTs) typically analyze handwriting difficulties into its sensorimotor and perceptual components to identify the foundational performance skills that seem to be associated with the functional skill of handwriting. Therapists design activities, primarily using a multisensory approach to improve these delayed skills in the hopes that as they improve so will the child's handwriting and with the help of the OT and teacher will be able to generalize these new skills into the classroom (Cornhill & Smith, 1996). Performance skills traditionally associated with handwriting such as visual perception, visual motor integration, sensory processing, kinesthesia, fine motor and eye-hand coordination, motor planning, upper limb speed, accuracy and dexterity, in-hand manipulation, and cognitive planning have shown some evidence of this association (Case-Smith 2002; Case-Smith, Holland & Bishop, 2011; Cornhill & Case-Smith, 1996; Daly & Krauss, 2003; Humphries, Wright, Snider, & McDougal, 1992; Laszlo & Bairstow, 1983; Lust & Donica, 2011; Tseng & Murray, 1994; Tseng & Cermak, 1993) as well as sustained attention, proprioception and sensory awareness (Feder & Majnemer, 2007) when specifically targeted

during handwriting interventions. However, the contribution of these performance skills is not well understood, presenting a challenge to OTs as they evaluate and remediate handwriting difficulties (Feder, Majnemer & Synnes, 2000). A number of correlational studies have sought to identify the performance skills that are associated with handwriting. However, correlation does not mean causation, therefore remediation of these particular components may not necessarily result in improvement of handwriting since there are many other variables that may be unaccounted for. For example, if a child has perceptual motor issues, it's not clear whether this caused the poor handwriting or some other variable. The findings to date of these studies have been mixed and inconsistent with the exception of visual motor integration (VMI), which has been found to strongly correlate with poor handwriting across studies, gender, settings, and disability as well as with VMI scores from other assessments that measure VMI (Cornhill & Case-Smith, 1996; Daly & Krauss, 2003; Maeland, 1992; Sovik, 1981; Sovik, 1984; Tseng & Murray, 1994; Tseng & Cermak, 1993; Volman, van Schendel & Jongmans et al., 2006; Weil & Cunningham-Amundson, 1994). VMI has been found to consistently be a strong predictor of handwriting skill at a variety of ages. Specifically, the child's ability to copy the first nine forms on the VMI was also found to be associated with handwriting difficulties particularly letter construction (Cornhill & Case-Smith, 1996). The effects of kinesthesia as an individual component on handwriting performance has been researched by several researchers (Laszlo & Bairstow, 1983; Laszlo & Bairstow, 1984; Laszlo, Bairstow & Bartrip, 1988; Laszlo, Bairstow, Bartrip & Rolfe, 1988; Levin, Oberklaid & Meltzer, 1981; Maeland, 1992; Schneck, 1991; Sudsawad, Trombly, Henderson, & Tickle-Degnen, 2002; Ziviani, Hayes & Chant, 1990). All of these studies found reportable and significant findings on the effect of kinesthesia on

handwriting, with the exception of Sudsawad et al. (2002), who found no support for use of kinesthetic training to improve handwriting legibility in first grade students.

From a review of the handwriting literature, a number of approaches to address handwriting with children exist such as motor learning, perceptual-motor, sensory integrative, cognitive behavioral, and task oriented (Feder et al., 2000). While some OTs prefer to address specific performance skills, primarily using a multisensory approach, others also incorporate task-oriented approaches. The literature reveals that motor learning theory is a strong component of both these approaches. Additionally, commercially available handwriting programs used by many OTs and teachers may also address underlying performance skills, functional handwriting tasks, as well as incorporate practice, a key component of motor learning theory (Asher, 2006).



The use of multisensory approaches to treat handwriting difficulties is common practice amongst pediatric OTs (Feder et al., 2000; Woodward & Swinth, 2002) and dominate OT interventions (Zwicker & Hadwin, 2009; Woodward & Swinth, 2002). Ninety percent of Canadian OTs surveyed used sensorimotor approaches to remediate handwriting (Feder et al., 2000). Ninety-two percent of American school-based OTs survey used a multisensory approach (Woodward & Swinth, 2002). According to Woodward and Swinth (2002), a multisensory approach to handwriting involves "using a variety of sensory experiences, media, and instructional materials to control the sensory input and tap into the child's sensory systems, including the proprioceptive, vestibular, tactile, visual, auditory, olfactory, and gustatory senses" (p. 307). The multisensory approach is based on a sensorimotor model of practice, involving use of sensory experiences, media, and instructional materials (Amundson, 2005). Therapists using this approach hypothesize that "by providing various sensory opportunities, the child's nervous system may integrate information more efficiently to produce a satisfactory motor output e.g.

legible letters in a timely manner" (Amundson, 2005, p.601). Children with sensorimotor difficulties tend to experience difficulties with handwriting (Lockhart & Law, 1994). Children with sensorimotor difficulties lack the feedback from sensory systems necessary to visualize the formation of these "motor programmes," including letter production (Laszlo & Bairstow, 1985). According to Ayres (1985) children do not generalize learning from one motor program to another and require significant amounts of additional practice and "overlearning" for formation to become automatic. Oliver (1990) and Lockhart and Law (1994) support the idea that the use of effective multisensory writing programs which include the use of sensory modalities increases the potential for improvement of handwriting skills with children with sensorimotor difficulties, and they reported a significant improvement in scores on the Developmental Test of Visual Motor Integration after one year with special education students. Lockhart and Law (1994) together with Sovik (1981) and Sovik (1984) mentioned that cybernetic theory proposes that children receive more feedback during written instruction when input is provided through multiple sensory channels than through the visual system alone.



Research in the teaching of handwriting using a multisensory approach began approximately four decades ago, back in the early '70s. Several studies to date have attempted to assess the degree of influence of multisensory systems (including vision, tactile, proprioceptive and kinesthetic experiences) on handwriting as well as the effect of using a multisensory approach to improve handwriting (Case-Smith, 2002; Case- Smith et al., 2011; Denton, Cope & Moser, 2006; Lust & Donica, 2011; Erhardt & Meade 2005; Levine, 1987; Lockhart & Law 1994; Oliver, 1990; Peterson & Nelson, 2003; Vickery, Reynolds & Cochran, 2010; Schneck, 1991; Sudsawad et al., 2002; Tseng & Murray, 1994; Weil & Amundson, 1994; Ziviani, Hayes & Chant, 1990; Zwicker & Hadwin, 2009; Weintraub et al., 2009).

In general, though, OTs tend to use an eclectic approach offering a variety of intervention programs when addressing handwriting difficulties irrespective of years of experience or work setting (Feder et al., 2000). The eclectic approach has been advocated frequently in the handwriting literature (Amundson, 1992; Cermak, 1991). According to Amundson (1992) it is the flexibility of this approach that allows the OT to best meet the needs of the child. Within an eclectic approach to treat handwriting difficulties, sensorimotor components seem to be most frequently used (Feder et al., 2000). However, this approach can be divided into two main categories namely a process-oriented approach and a task-oriented approach. The process-oriented approach is most used by therapists who address the underlying performance skills that have been found to typically affect handwriting. The task-oriented approach is typically used by teachers or parents and focuses on direct teaching and generalization of the skill (Jongmans et al., 2003). The process approach focuses on impairments and the task-oriented approach focuses on the functional limitation (World Health Organization, 1997). According to Erhardt and Meade (2005) these approaches are not exclusive. As a result of the complex nature of handwriting, this leads professionals to use eclectic and multidisciplinary solutions. However, when using this approach there is not much consensus as to which strategies were the most effective (Feder et al., 2000).



Intervention focusing on higher-level processes employing a task-oriented approach includes the use of various strategies while teaching handwriting such as the use of visual cues (Berninger et al., 1997), self instruction strategies (Jongmans et al., 2003), self monitoring (Peterson & Nelson, 2003), and direct explicit instruction (Graham, Harris & Fink, 2000). These programs using a task-oriented approach are based on the assumption that handwriting acquisition requires direct instruction and practice in different tasks and environments (Jongmans

et al., 2003) and is often associated/combined with motor learning principles of practice opportunities and feedback (Feder et al., 2000). Motor learning is defined by Schmidt (2004) "as a set of processes associated with practice or experience leading to relatively permanent changes in the capability for responding" (p.346). The clinical application of motor learning includes feedback and practice, the two most important variables indicated by Schmidt as being in use by many OTs who may not be cognizant that they are using this approach as evident from the respondent survey during the interviews that were conducted by Feder et al. 2000. Often considered a framework that focuses on practice and feedback, motor learning is actually a much broader theory that looks at skill development through a dynamic systems lens. This dynamic approach takes into account a multitude of intrinsic (inherent to the student) and extrinsic factors (inherent to the task) that work together to influence a person's performance. For example, a student's skill with handwriting is a result of the interaction of intrinsic factors such as visual motor integration, body position, hand strength, motivation, orthographic coding and integration, perception and extrinsic factors such as shape and size of the writing utensil, paper, the desk, handwriting instructions (Kamm, Thelen, & Jensen, 1990). OTs evaluate these factors related to the task, person and environment to provide accommodations and modifications that are put in place to support the student in their handwriting. With that said, motor learning principles can and are inherently employed in many OT handwriting programs including those primarily using a multisensory or task-oriented approach.



Several studies looking at the effectiveness of handwriting approaches incorporating a task -oriented with a strong motor learning element have been completed (Berninger et al., 1997; Berninger et al., 2006; Case-Smith 2002; Case-Smith et al., 2011; Denton et al., 2006; Graham et al., 2000; Jongmans et al., 2003; Peterson & Nelson, 2003; Zwicker & Hadwin, 2009; Weintraub

et al., 2009). In addition to the task-oriented approach, Case-Smith (2002), Case-Smith et al., (2011); Peterson and Nelson (2003), and Weintraub et al., (2009) also incorporated cognitive strategies involving learning strategies of imitation, practice, self-evaluation and feedback.

In a practice analysis study conducted by the National Board for Certification in Occupational Therapy, NBCOT, (2008), it was reported that school systems are a primary practice area for 23% of all OTs in the United States. Additionally, it was also reported that 37% of individuals who receive OT services are children and youth. Across jurisdiction and settings, 1156 OTs completed this survey, reflecting a 90% response rate (NBCOT, 2008). OT services can be delivered in schools in the form of direct services and consultation and are instrumental in developing handwriting programs and curriculum impacting instruction.



On November 29, 1975, Occupational Therapy became an official school-based service as a result of the Education for All Handicapped Children Act (EHA) of 1975, public law 94-142. (US Department of Education). Since then the numbers of children that OTs work with in school systems addressing the difficulties with their participation as students, which includes handwriting, has continued to grow, and handwriting is still the number one referral for Occupational Therapy (OT) services in schools (Asher, 2006; Marr & Dimeo, 2006). As well a study conducted by Chandler (1994) that of 900 returned surveys from across the US found that the most common reason for OT referrals was handwriting problems. In addition, several studies (Barnes & Turner, 2001; Case-Smith 2002; Case-Smith et al., 2011; Lust & Donica, 2011, Wehrmann, Chiu, Reid & Sinclair 2006) have found changes in children's written communication and skill development through direct and indirect services in the classroom and consultative OT.

At the present, the OT practice lacks consensus on a definitive method founded on high-level evidence to remediate handwriting (Asher, 2006). As a result, it has become common practice for many school-based occupational therapists to use an eclectic range of strategies and approaches (Feder et al., 2000) to improve handwriting performance, including both multisensory and task-oriented approaches, which include but are not limited to the use of specific commercially available handwriting programs/curriculum as well as addressing performance skills of sensorimotor, visual perception, and motor planning activities, strengthening of hand skills, and improving hand function and fine motor skills.

While the findings from studying eclectic approaches seem favorable, it is difficult at best to discern which component of the intervention worked best to improve handwriting. It seems that handwriting interventions incorporating a task-oriented approach as well as a combination of task-oriented and multisensory approaches and higher-level cognitive components seem to be currently producing the most favorable results.



With the decrease in handwriting instruction in schools, and the increase in OT referrals to address handwriting, nationwide high-stakes testing, and regulations such as No Child Left Behind (NCLB) and Response to Intervention (RTI), OTs need to be using effective approaches and best practices when treating handwriting difficulties. Since multisensory and task-oriented approaches are frequently used by OTs, an evidence-based review was conducted to investigate their effects of these two approaches on handwriting among elementary school children.

## Methodology

### *Participants*

It was the original intent of this review to focus on the effectiveness of multisensory and task-oriented approaches on children in the elementary grades, but due to the sparseness and

methodological limitations of available studies that specifically targeted handwriting during this age period, necessitated broadening the scope of the included populations and levels of evidence. Related to the shortage of studies, studies that looked at the effectiveness of the combination of multisensory and task-oriented interventions rooted in motor learning theory on handwriting performance were also included.

A total of 32 studies were included in this review. Writing tools and surfaces also appear to be an important part of a multisensory approach to handwriting, as well as kinesthetic, visual and auditory tools, so studies that addressed these sensory areas were also included.

Of the included studies, 19 directly addressed the effectiveness of the multisensory approach on handwriting (Denton et al., 2006; Furner 1970; Guy, 2003; Halpin & Halpin, 2001; Harris & Livesey, 1992; Humphries et al., 1992; Krzesni, 1971; Lamme & Ayris, 1983; Laszlo & Bairstow, 1983; Lockhart & Law, 1994; Lust & Donica, 2011; Marr & Dimeo, 2006; Oliver, 1990; Robin, et al., 1975; Sovik 1981; Sovik, 1984; Sudsawad et al., 2002; Weintraub et al., 2006; Zwicker & Hadwin, 2009). Ten studies looked at the effectiveness of the task-oriented approach (Berninger et al., 1997; Berninger et al., 2006; Christensen, 2005; Denton et al., 2006; Graham et al., 2000; Jongmans et al., 2003; Ste-Marie et al., 2004; Sudsawad et al., 2002; Weintraub et al., 2009; Zwicker & Hadwin, 2009). Nine studies consisted of a combination of strategies based on multiple theoretical principles (biomechanical, sensorimotor, task-oriented, motor learning; Bazyk, et al., 2009; Berninger et al., 2006; Case-Smith 2002; Case-Smith et al., 2011; Erhardt & Meade, 2005; Graham, 1983; Jones & Christenson, 2005; Lust & Donica, 2011; Peterson & Nelson, 2003).



Across studies, participants included children from preschool through eighth grade. Boys and girls were included in all studies, which reflected the boy-to-girl ratio that is indicative of the

gender prevalence in handwriting concerns, with the exception of two studies (Lockhart & Law, 1994 and Guy, 2003) that included a total of four and five boys respectively. Lockhart and Law included boys who had been diagnosed with sensorimotor difficulties, one child had been placed in a self-contained class, all four had been diagnosed with a specific learning disability, and all four received OT prior to their involvement in the study, which was stopped during the study.

Most of the studies also included both left-handed and right-handed children. Three studies included children at risk for handwriting difficulties (Berninger et al., 1997; Berninger et al., 2006; Graham et al., 2000), and 10 included children receiving special education (Case-Smith, 2002; Case-Smith et al., 2011; Erhardt & Meade, 2005; Graham et al., 2000; Graham, 1983; Guy, 2003; Jongmans et al., 2003; Lockhart & Law, 1994; Marr & Dimeo, 2006; Oliver, 1990)



Reference to socio-economic background was noted by six studies (Berninger et al., 2006; Case-Smith et al., 2011; Donica & Lust, 2011; Graham et al., 2000; Jones & Christensen, 1999; Peterson & Nelson, 2003). Several studies included children who had received OT services or were receiving such services during the study as well as other special services such as speech therapy, physical therapy, and reading services (Berninger et al., 1997; Case-Smith, 2002; Case-Smith et al., 2011; Erhardt & Meade, 2005; Graham et al., 2000; Graham, 1983; Guy, 2003; Lockhart & Law, 1994; Marr & Dimeo, 2006; Oliver, 1990; Zwicker & Hadwin, 2009). All studies included children that had been identified as having poor handwriting either by teachers or by occupational therapists by use of standardized handwriting assessments, questionnaires, and visual analysis of handwriting samples.



*Interventions*

All of the studies in this review included a multisensory or a task-oriented approach as an intervention. Some studies included a comparison of these two approaches as well as a combination of these approaches but were still able to provide evidence in support of either approach. Several studies examined multisensory approaches that included a strong task-oriented, motor-learning component as part of the intervention program.

With regards to the task-oriented approach several studies were included in this review. Studies that included *direct instruction* (Berninger et al., 1997; Berninger et al., 2006; Case-Smith, 2002; Case-Smith et al., 2011; Denton & Moser, 2006; Lust & Donica, 2011; Erhardt & Meade, 2005; Furner, 1970; Graham et al., 2000; Graham, 1983; Guy, 2003; Jones & Christensen, 1999; Jongmans et al., 2003; Lockhart & Law, 1994; Marr & Dimeo, 2006; Oliver, 1990; Peterson & Nelson, 2003; Robin, Armel, & O'Leary, 1975; Ste-Marie et al., 2004; Sovik, 1984; Sovik, 1981; Sudsawad et al., 2002), *self instruction* (Case-Smith, 2002; Case-Smith et al., 2011; Denton, Cope & Moser , 2006; Graham, 1983; Erhardt & Meade, 2005; Furner, 1970; Jongmans et al., 2003; Robin et al., 1975) and *motor-learning theory* (practice and feedback) (Bazyk et al., 2009; Berninger et al., 1997; Case-Smith, 2002; Case-Smith et al., 2011; Christensen, 2005; Denton et al., 2006; Erhardt & Meade, 2005; Furner, 1970; Graham et al., 2000; Graham, 1983; Jones & Christensen, 1999; Lockhart & Law, 1994; Lust & Donica, 2011; Marr & Dimeo, 2006; Oliver, 1990; Petersen & Nelson, 2003; Ste-Marie et al., 2004; Sudsawad et al. 2002; Weintraub et al., 2009; Zwicker & Hadwin, 2009)



According to Amundson (1992) multisensory approaches to handwriting use a plethora of modalities and activities including visual instruction combined with tactile and kinesthetic experiences. The literature supports this notion that writing tools and surfaces appear to be an important part of a multisensory approach to handwriting, as well as kinesthetic, visual, and

auditory tools. Therefore several studies that examined the effects of traditional writing paper and writing tools on handwriting performance were also included. Halpin and Halpin (1976) looked at the effects of lined and unlined *paper*. Lamme and Ayris (1983) studied *writing tools*. Krzesni (1971) examined *tools and paper*. Harris & Livesey (1991) and Laszlo & Bairstow (1983) studied the effects of *kinesthetic training* on handwriting performance. Multiple studies were included that addressed multisensory approaches as a integral element of the intervention program (which included visual, auditory, tactile, proprioception, and kinesthetic activities; Bazyk et al., 2009; Case-Smith 2002, Case-Smith et al., 2011, Denton et al., 2006; Lust & Donica, 2011; Erhardt & Meade 2005; Furner, 1970; Humphries et al., 1992; Jones & Christensen, 2005; Lockhart & Law, 1994; Marr & Dimeo, 2006; Oliver, 1990; Peterson & Nelson 2003; Weintraub et al., 2009; Zwicker & Hadwin, 2009)



*Outcome Measures*



The included studies used a combination of measures to assess legibility as an outcome of handwriting performance and performance skills such as visual motor integration, proprioception, kinesthesia, and in-hand manipulation. One study used the Test of Written Language (TWOL), which provides a global picture of the child's writing legibility (Lockhart & Law, 1994). Nine studies developed their own rating scale based on specific criteria (Berninger et al., 1997; Christiansen, 2005; Guy, 2003; Halpin & Halpin, 2001; Jones & Christiansen, 1999; Krzesni, 1971; Lockhart & Law, 1994; Robin et al., 1975; Ste-Marie et al., 2004). The Test of Handwriting (THS) measures handwriting skills in five- to 11-year-olds (both manuscript and cursive) was used by Denton et al., (2006), and Peterson and Nelson (2003).

Case-Smith et al. (2011), Erhardt and Meade (2005), Guy (2003) and Peterson and Nelson (2003) used the Minnesota Handwriting Assessment (MHA). Handwriting speed and

legibility were measured using the Evaluation of Children's Handwriting (ETCH) (Case-Smith, 2002; Case-Smith et al., 2011; Marr & Dimeo, 2006; Zwicker & Hadwin, 2009; Sudsawad et al., 2002).

Berninger et al. (2006), Case-Smith et al. (2011), and Graham et al., (2000) used the Woodcock-Johnson Tests of Achievement (3rd ed.), subtests of writing fluency and writing samples, which measures academic achievement. The School Function Assessment (SFA) was used to evaluate the students' participation in school related activities (Case-Smith, 2002). Weintraub et al. (2009) used the Hebrew Handwriting Evaluation (HHE) that measures speed, overall legibility, spatial organization, and letter formation. Teacher Questionnaires developed by the researchers to obtain teachers judgments of the children's handwriting legibility were also used (Sudsawad et al., (2002).



Lust and Donica (2011) used The Handwriting without Tears Print Tool and Check Readiness Tool. This is a non-standardized tool used to show progress related to kindergarten readiness skills. It includes printing of letters, letter, and numbers recognition and copying shapes.



The Zaner Bloser Printing Evaluation Scale (measures of copying, quality and rate) and 10-point rating of printing readiness from the Basic Schools Skills Inventory (BSSI) was used by Humphries et al., (1992) and Lamme and Ayris, (1983). Guiding Growth in Handwriting Evaluation Scale (published by Zaner-Bloser) was used by Furner (1970). The Learning Accomplishment Profile, (3rd ed.; Lap-3 Prewriting Domain) assesses children ages 36-72 months in gross motor, fine motor, prewriting, cognitive, self-help, language, and personal and social skills. Only the prewriting domain was used in the study by Lust and Donica (2011).

The Developmental Test of Visual Perception (DTVP-2) measures visual perception (motor and motor-reduced formats) ages four- to 10-years-old was used by Denton et al., (2006) and Case-Smith (2002). Denton et al. (2006) also used the Test of Manual Pointing (TMP) which measures proprioception in children ages four- to 12-years-old and the In-Hand Manipulation (IHM), which measures rotation and translation skills in three- to seven-year-olds.

Case-Smith (2002), Lust and Donica (2011), and Humphries et al. (1992) used the Bruininks-Oseretsky Test of Motor Proficiency (BOTMP) that measures motor functioning of children ages four and a half to 14.5 years of age. The Fine Motor scale of the Peabody Developmental Motor Scales (PDMS-2) and the Observation Survey of Early Literacy Achievement (OSELA; three subtests of letter identification, concepts about print, hearing and recording sounds which involves actual writing of letters and sentences dictated orally) was used by Bazyk et al. (2009). The Developmental Test of Visual Motor Integration was a measure used by Bazyk et al., 2009, Erhardt and Meade, 2005, Humphries et al.1992, and Oliver (1990) Sudsawad et al. (2002) used the Kinesthetic Sensitivity Test (KST), which measures kinesthetic sensitivity of five -12yr olds; the Kinesthetic Acuity subtest (Runway task), the Kinesthetic Perception and Memory subtest (Pattern Task). Translation and rotation were also measured using the nine- hole peg test (Bazyk et al., 2009; Case-Smith, 2002).



Three studies used the Writing Speed and Accuracy Measure (Christensen, 2005; Graham et al., 2000; Jones & Christiansen, 1999). Berninger et al. (2006) also used the Process Assessment of the Learner (PAL) –test battery for reading and writing. Concise Assessment Scale for Children's Handwriting (known as the BHK) was used by Jongmans et al. (2003).

*Search Strategies*

A broad computer-aided search of online databases was undertaken to locate relevant research articles for review. Databases and sites searched included OVID, PsycINFO, EBSCOHost, Cochrane Database of Systemic Reviews, Journals@OVID full text, and OTSeeker. All of these databases provided *peer-reviewed* journals or summaries. Search terms and keywords included *handwriting, handwriting legibility, handwriting instruction, handwriting programs, multisensory, task oriented, cognitive approaches,* and *motor learning*. Search terms that were combined included *handwriting and legibility, handwriting and sensory, handwriting and task oriented, handwriting and occupational therapy.*

A manual search of the reference lists of found articles was also completed. Articles identified as relevant to the topic were then obtained.

*Inclusion and exclusion criteria for the search*



All studies included used either a multisensory approach, a task-oriented approach, or combination of the two approaches as an intervention. Handwriting legibility was the outcome sought in all the studies. Due to the limited amount of published research and high levels of evidence used in these areas, studies using combined interventions were included as well as children above elementary grade level. Articles that contained only exert opinion were excluded.



*Data Collection and Analysis*

All the studies included used quantitative data. Twelve studies were randomized control trials (Berninger et al., 1997; Berninger et al., 2006 [study 4]; Christensen, 2005; Denton et al., 2006; Furner, 1970; Graham et al., 2000; Humphries et al., 1992; Peterson & Nelson, 2003; Robin et al., 1975; Sudsawad et al., 2002; Weintraub et al., 2009; Zwicker & Hadwin 2009). Several of these studies used a randomized blinded three-group pre-posttest experimental design (Denton et al., 2006; Robin, et al., 1975; Humphries, et al., 1992; Sudsawad et al., 2002;

Weintraub et al., 2009; Zwicker & Hadwin, 2009). Four used a randomized comparison two-group design (Christensen, 2005; Graham et al., 2000; Laszlo & Bairstow, 1983 [study 2, stage 1]; Peterson & Nelson, 2003). Three studies used randomized comparison group designs without a control group (Berninger et al., 2006 [studies 1-3]; Harris & Livesey, 1992; Ste-Marie et al., 2004). Two studies used a quasi-experimental case control design (Jongmans et al., 2003 [study 2]; Lust & Donica, 2011). Four studies used a single group pre-post study design (Bazyk et al., 2009; Case-Smith et al., 2011; Jongmans et al., 2003 [study 1]; Marr & Dimeo, 2006). Six studies used nonrandomized comparison group designs (Case-Smith, 2002; Halpin & Halpin, 2001; Jones & Christensen, 2005 [study 1]; Krzesni, 1971;Oliver, 1990; Laszlo & Bairstow, 1983 [study 1, stage 2]). One study used a single case with multiple baselines across behaviors design (Lockhart & Law, 1994) and one study used a case report design (Erhardt & Meade, 2005). Graham (1983) used a multiple-baseline-across-subjects design, which consisted of three phases (A-B-C).



Eight studies gathered follow-up data after the completion of the intervention and looked at long-term treatment effects (Case-Smith, 2002; Case-Smith et al., 2011; Erhardt & Meade, 2005; Graham, 1983; Graham et al., 2000; Lockhart & Law, 1994; Sudsawad et al., 2002; Weintraub et al., 2009).

Eleven studies reported incorporated blinding into study designs to reduce bias (Berninger et al., 2006; Denton et al., 2006; Harris & Livesey, 1992; Humphries et al., 1992; Graham, 1983; Guy, 2003; Peterson & Nelson, 2003; Robin et al., 1975; Sudsawad et al., 2002; Weintraub et al., 2009; Zwicker & Hadwin, 2009).

The included studies used a variety of methods for analyzing data. A multivariate analysis of covariance (MANOVA) was used by several studies to test for significant different

between means and each dependent measure between control and intervention groups. (Christensen, 2005; Humphries et al., 1992; Jones & Christensen, 1999; Peterson & Nelson, 2003). Analysis of variance (ANOVA's) were used to determine statistical significance of scores between groups of students (Berninger et al., 1997; Graham et al., 2000; Humphries et al., 1992;Jongmans et al., 2003; Lamme & Ayris, 1983; Krzesni, 1971; Robin et al., 1975; Ste-Marie et al., 2004; Zwicker & Hadwin, 2009). Two-way analysis of variance (ANOVA) was used by Bazyk et al., (2009), Case-Smith, (2002), Harris and Livesey, (1992), and Lamme and Ayris, (1983). Repeated measures ANOVA was performed on different scores (posttest-pretest; Denton et al., 2006; Weintraub et al., 2009). Specifically, a two-way repeated ANOVA was used by Sudsawad et al., (2002). Chi Square was used to show statistical difference between conditions (Berninger et al., 1997; Furner, 1970; Graham et al., 2000; Zwicker & Hadwin, 2009). Follow-up univariate analyses were used to indicate significant main effects in each group on all variables (Christensen, 2005).



Post hoc testing using Turkey's honestly significant difference (HSD) was used to determine differences between groups at pre and posttest (Christensen, 2005; Halpin & Halpin, 2001; Humphries et al., 1992; Jones & Christensen, 1999; Ste-Marie et al., 2004). Post hoc analysis were also performed using a Bonferroni test used by Case-Smith et al., (2011), Jongmans et al., (2003), Peterson & Nelson, (2003), and Weintraub et al., (2009). Case-Smith (2002), Lust and Donica (2011), and Marr and Dimeo (2006) used *t* -*t*ests comparing pretest and posttest scores, which were computed to determine the level of change made by the students. To determine clinical significance, Bazyk et al., (2009) calculated the Proportional Change Index (PCI) for tests yielding age equivalent scores (PDMS-2 and VMI).

Twelve studies also used descriptive statistics to analyze and interpret data (Bazyk et al., 2009; Case-Smith et al., 2011; Erhardt & Meade, 2005; Graham, 1983; Guy, 2003; Halpin & Halpin, 2001; Jongmans et al., 2003 [study 1]; Krzesni, 1971; Marr & Dimeo, 2006; Oliver, 1990; Lamme & Ayris, 1983; Laszlo & Bairstow, 1983). Lockhart and Law (1994) used descriptive statistics as well as a test of ranks (Rn).

**Results**

Twelve studies examining the multisensory approach to improve handwriting have provided significant results in support of this approach (Case-Smith, 2011; Furner, 1970; Harris & Livesey, 1992; Laszlo & Bairstow, 1983; Lockhart & Law, 1994; Lust & Donica, 2011; Marr & Dimeo, 2006; Oliver, 1990; Robin et al., 1975; Sovik, 1981; Sovik, 1984; Weintraub et al., 2009). Harris and Livesey (1992) found that kinesthetic sensitivity practice produced an improvement in handwriting performance, with the older group showing the greatest benefit, which interestingly was not found with the handwriting practice group alone. The findings of Laszlo and Bairstow support the use of kinesthetic sensitivity practice to improve handwriting performance. Sudsawad et al., (2002), however, found no significant improvement in handwriting legibility with the use of kinesthetic practice. Findings of a three-year longitudinal study by Furner (1970) demonstrated support of the use of a method that used multisensory stimuli and verbalization of procedures. Robin et al. (1975) compared the effectiveness of a self-instructed multisensory program with direct training and no training in 30 children in kindergarten. The multisensory group performed significantly better than the direct training group and both groups were significantly better than no treatment group. The results of Sovik's research (1981; 1984) support the use of what he had referred to as cybernetic theory (whereby children receive more sensory feedback during writing instruction when visual input occurs in

conjunction with kinesthetic and tactile input rather than on its own). Oliver (1990) demonstrated that multisensory training improved the writing readiness of children who differed by 15 points or more in their verbal and performance intelligence quotient scores but not for children with average intelligence quotients scores or children with special education classes. Oliver also found significant improvement in VMI scores after one year with special education students. Although Lockhart and Law (1994) showed improvement of cursive writing of all four children following a multisensory handwriting program, only one child showed significant improvement in letter quality. Both of these studies were limited by very small sample sizes. In a single case study, Erhardt and Meade (2005) demonstrated the effectiveness of addressing underlying sensorimotor and perceptual performance skills to improve handwriting legibility. Marr and Dimeo (2006) demonstrated the effectiveness of using a multisensory program, namely Handwriting without Tears, with significant changes in writing legibly of both upper and lower case alphabets over the duration of the summer. Weintraub et al. (2009) compared interventions using executive functions (task- oriented) with sensorimotor activities and a control group. Both interventions used higher-level cognitive skills, namely, mnemonics. Both groups showed better legibility than the control, and both improved significantly in legibility and letter formation. In a more recent two-group controlled study conducted by Lust and Donica (2011) looking at the effectiveness of a handwriting readiness program (Handwriting without Tears-Get Set for School [HWT-GSS] by Jan Olsen) in one Head Start classroom, both experimental and control group made significant improvements in their handwriting readiness. Additionally, the study also found improvement in fine motor ability after multisensory intervention, consistent with Case-Smith (2002) findings. The HWT-GSS program is a multisensory-based program that includes making letters with wooden pieces, singing songs with coordinated actions, rolling modeling clay into

letter shapes, tracing letters with a magnetic stylus, and using chalk and a wet sponge for writing letters on a small chalkboard (Lust & Donica, 2011). Lust and Donica (2011) and Woodward and Swinth (2002) both provide evidence in support of a multisensory approach to improving handwriting. In addition to the multisensory intervention, both Marr and Dimeo and Oliver included supplementary programs that incorporated motor learning and task-oriented approaches.

The following studies have provided evidence that the multisensory intervention made some difference based on small to medium size effects, teacher reports, visual analysis of pretest and posttest writing samples, but no significant results were reported (Guy, 2003; Humphries et al., 1992; Sudsawad et al., 2002; Zwicker & Hadwin, 2009). Guy (2003) demonstrated changes on visual analysis after using a proprioceptive intervention in addition to the HWT program. No improvement on visual analysis was shown for the HWT intervention alone. This study was limited by a very small sample size and one gender. Denton et al. (2006) compared sensorimotor to motor learning (i.e., practice) with a group of six- to 11-year-olds, and found that the group who received the therapeutic practice improved significantly more than those who received sensorimotor interventions alone. Denton et al., found that selected children's sensorimotor performance skills improved but handwriting performance itself declined after a sensorimotor invention. Humphries et al. (1992) found that motor planning (a component of sensory integrative therapy) was the only skill found to strongly correlate with a change in academic performance, namely, printing readiness, but no significant treatment difference in printing readiness could be attributed to sensory integrative therapy. Zwicker and Hadwin (2009) in a randomized control trial of 72 first and second graders compared a cognitive, and a multisensory intervention with a control group. No significant differences were found between pre- and posttest in handwriting legibility for participants in both the cognitive and multisensory groups.

Although multisensory intervention produced better results with first graders, first graders improved their legibility regardless of intervention received, including no intervention, which indicates that classroom instruction was just as effective as direct individual intervention, questioning the need for direct OT services compared to inclusive practices. No intervention and multisensory intervention showed any improvement in handwriting legibility of second graders. However, second graders demonstrated improved legibility with cognitive intervention. This finding suggests that second graders and first graders respond differently to intervention and that the type of intervention matters (Zwicker & Hadwin, 2009). It also suggests that a cognitive approach may be more effective than a multisensory approach for improving handwriting legibility in second graders.

Evidence supporting the use of sensory tools and paper was not favorable. Both Krzesni (1971) and Halpin and Halpin (2001) found no difference in performance using special types of paper. Krzesni found that both spelling and story-writing tasks indicated no significant difference in performance between using lined and unlined paper. Halpin and Halpin specifically looked at paper with varying spaces and width, and found that this did not make a difference in handwriting performance. Lamme and Ayris (1983) found that writing tools do not influence legibility.



Nine studies have provided strong data supporting the use of the task-oriented approach incorporating motor learning theory to improve handwriting skills (Berninger, 1997; Christensen, 2005; Denton et al., 2006; Graham, 2000; Jongmans et al., 2003; Ste-Marie et al., 2004; Sudsawad et al., 2002; Zwicker & Hadwin, 2009; Weintraub et al., 2009).

Berninger et al. (1997) concluded that handwriting requires memory representation, which relies on visual cueing and memory retrieval for writing to become automatic (i.e., fluent).

Christensen (2005) demonstrated significant results when comparing participants in a handwriting practice group compared to a journal-writing group. Christensen found that the handwriting practice group scored higher in both letter formation (orthographic motor integration) as well as composition (length and quality of text). Graham et al. (2000) looked at the relationship between learning handwriting and learning to write and found that students who received handwriting instruction—including those with disabilities—were able to write more fluently. Graham et al. found that in 27 15-minute sessions involving handwriting instruction and practice, compositional fluency was raised by 0.4 of a standard deviation at posttest and 0.6 of a standard deviation six months later. Improvements in handwriting and writing were noted in both children with and without disabilities. According to Graham et al. if the intervention was provided over a longer time, it may be possible to raise performance even more. Jongmans et al. (2003) studied the effectiveness of a task-oriented self-instruction handwriting method using motor learning principles and found that the intervention group improved significantly in handwriting quality when compared to the control group.



In a study looking at the effects of sensorimotor intervention versus therapeutic practice on improved handwriting performance conducted by Denton et al. (2006), therapeutic practice was found to have an impact on handwriting after a relatively short period of intervention. These results support those of Ste-Marie et al. (2004) that demonstrated therapeutic practice had a beneficial effect on handwriting performance. According to Ste-Marie et al., practicing/repetition alone of letters is not sufficient. Random practicing as opposed to blocked practicing alone leads to enhance performance of handwriting skills. Additionally, based on the premise that cognitive processing is a key feature in motor learning (Lee, Swinnen, & Serrien, 1994, as cited in Ste-Marie et al., 2004), random scheduling of practicing letters results in more effortful processing

because the child needs to constantly execute a variety of different motor patterns. This provides a more challenging learning environment (high contextual) as opposed to blocked practice schedule where the child simple had to repeat the same letter (same motor demands) over again. The results of this study by Ste-Marie et al. indicate that random presentation (high contextual interference) of different letters to write (practice) within a number of trials is better for improvement of handwriting skills. In comparing sensorimotor with task-oriented inventions, Weintraub et al. (2009) found that statistically significant gains in handwriting performance were noted in both intervention groups but not in the control group. Both intervention groups included higher-level cognitive components such as mnemonics, self-evaluation and transfer. The task-oriented group scored significantly higher than the control group in overall legibility. In the long term (four months after intervention) significant gains were also noted in both groups. This suggests that handwriting performance of students in both groups continued to improve after formal intervention was terminated. These findings support those of Jongmans et al. (2003), who found that children who participated in a task-oriented group combined with higher-level functions (self instruction) performed better than their peers in the no-intervention control group. These results differ from Denton et al. (2006), who showed that students in therapeutic practice group combined with higher-level functions perform better than their peers in a sensorimotor intervention that did not include higher-level components. Weintraub et al. found neither program to have an advantage and suggested that higher-level functions therefore seem to be more effective than interventions that do not include them in supporting and enhancing handwriting performance. Sudsawad et al. (2002) compared kinesthetic training, handwriting practice and no interventions. They reported no significant improvement of handwriting legibility in any of the groups. Zwicker and Hadwin (2009) compared multisensory to cognitive

(task-oriented) intervention and found no significant differences in participants in both intervention groups. However findings that were worth mentioning were that first graders responded better to multisensory intervention, which had little to no effect on the second graders, who showed sizeable improvement in legibility after receiving the cognitive intervention.

Of the studies that looked at the effectiveness of combined approaches (of which multisensory, biomechanical, task-oriented, and motor learning were strong elements) supporting the commonly used eclectic approach, all found significant results. Graham (1983) demonstrated the effectiveness of a multisensory procedure coupled with practice, self-instruction and self-monitoring for improving and maintaining the letter formation skills of learning disabled students with writing deficiencies. Berninger et al. (2006) completed four studies that investigated the effects of neurodevelopmental training combined with direct handwriting practice, motor and orthographic training, direct handwriting and reading instruction, explicit instruction in composition respectively. The neurodevelopmental activities included multisensory activities that were designed to improve hand strength, kinesthetic awareness, eye-hand coordination, dexterity and motor planning. Neurodevelopmental processes combined with handwriting practice in Study one were found to contribute to accurate, letter formation. Self Instruction, direct instruction combined with visual cues and memory delay strategies and opportunities to practice was found to be effective in improving legibility, composition as well as reducing reversals. Jones and Christensen (1999) investigated the effects of an intervention designed to improve orthographic integration of students with handwriting difficulties. The intervention consisted of direct instruction of letter formations and activities for promoting speed and accuracy. Teacher modeling and guided and independent practice were included as well as color coding, rainbow letters, visual association strategies, drawing in the air (sky writing),

kinesthetic, perceptual and gross motor practice. Jones & Christensen found significant improvement in handwriting, which resulted in a comparable improvement in written expression and automaticity. Case-Smith (2002) investigated the effectiveness of school-based OT on handwriting, and found that students increased an average of 14% in letter legibility, and 15 out of 29 students who had poor legibility in the beginning of the year (>85% total letter legibility) showed good legibility at the end of the school year (>90% total letter legibility) after receiving OT intervention using an eclectic approach. OT intervention included multisensory approaches (vibration, resisted writing and writing on chalkboard and vertical surfaces), behavioral and motor learning techniques (shaping, stimulus fading, verbalizing description of letter formation and self monitoring), developmental and behavioral approaches (letter formation, alignment, spacing, and sizing), and teacher consultation, all of which that were aimed at improving students' individual and unique handwriting problems. Bazyk et al. (2009) demonstrated effectiveness after children with and without disabilities participated in an embedded OT literacy curriculum emphasizing biomechanical, sensorimotor and teacher-learning approaches. Case-Smith et al. (2011) conducted a single-group pretest-posttest designed pilot study with one class of 19 students investigating the effectiveness of an integrated handwriting program (Write Start) for first grade students. Large gains were made in handwriting legibility and speed that were maintained throughout the end of the school year. The Write Start program is an embedded classroom intervention that uses a co-teaching model in which OT and teacher collaborate to provide handwriting and writing instruction. The researchers mention that the gains made by participants in this study were greater than those in comparable studies such as Denton et al. (2006) and Zwicker and Hadwin (2009). The researchers state several reasons for their significant results including use of the co-teaching model, an inclusive model of service delivery

whereby OT services are integrated into the classroom, consistency in the method use to teach handwriting, use of tools and multisensory strategies (kinesthetic, visual motor integration, manipulation and motor planning) provided by the OT, a task-oriented approach providing a meaningful context for learning handwriting linking it to writing, and the use of evidence-based strategies such as specific instruction in letter formation, practice (motor learning) at each session, activities to promote motor learning and visual motor skills, student self evaluation, frequent visual cueing and monitoring of performance with immediate feedback (Case-Smith et al., 2011). Peterson and Nelson (2003) incorporated biomechanical, multisensory approaches (vibration, resisted writing, and writing on chalkboard and vertical surfaces), task-oriented and motor learning techniques (shaping, stimulus fading, verbalizing description of letter formation, alignment, spacing, and sizing, practice, and self monitoring) to explore the effectiveness of OT intervention on the printing skills of 59 first graders. They found that students from an economically disadvantaged background improved in legibility after receiving handwriting instruction that included five min of sensorimotor (i.e., heavy work) activities, a 20-minute session of motor planning and letter formation, and five minutes of handwriting practice.



**Discussion and Clinical Implications**

Handwriting affects the academic performance of many school age children. A variety of interventions exist consisting of individual to combined methods as well as a variety of underlying theoretical underpinnings exist to treat handwriting difficulties. Moreover, several studies have been done to date that demonstrate that handwriting interventions with male and female, left and right-handed children with and without disabilities as well as at-risk children can improve handwriting performance. However, none of these studies is clear as to which intervention works best and with which children.

In support of the task-oriented approach and the multisensory approach in improving handwriting, there were more studies that reported significant results, as compared to the few that did not. Results of studies show that neither method has an advantage over the other in terms of their unique components. Studies addressing the multisensory approach that included task-oriented activities such as instruction and practice produced significant results. Interestingly though, it seems that a task-oriented approach carefully and systematically structured and implemented using motor learning principles seems to be effective in improving handwriting without any obvious multisensory components (Asher, 2006; Cahill, 2009; Denton et al., 2006; Ste-Marie et al., 2004). Higher-level cognitive components seem to have been instrumental in producing significant results in both approaches (Weintraub et al., 2009; Zwicker & Hadwin, 2009). Surprisingly, more substantial and rigorous evidence exists supporting the eclectic use of both approaches that include interventions that incorporate activities that address lower-level performance skills and higher-level cognitive strategies such as mnemonics, self instruction and monitoring (Case-Smith, et al., 2011; Furner, 1970; Graham, 1983; Jones & Christensen, 1999; Petersen & Nelson, 2003; Robin et al., 1975; Weintraub et al., 2009) and parent involvement (Case-Smith, 2002; Case-Smith et al., 2011; Christensen, 2005; Erhardt & Meade, 2005; Marr & Dimeo, 2006; Oliver, 1990; Weintraub et al., 2006). Despite the evidence in support of the eclectic approach, there is still not much consensus and insufficient evidence as to which program based on approaches that focus on higher level or lower level functions or a combination of the two is the most effective in remediating handwriting performance (Asher, 2006; Feder et al. 2000). It is also difficult to discern from an eclectic approach which components of the intervention contributed to the improvement of handwriting (Zwicker & Hadwin, 2009). According to Yack (1983), an OT clinical intervention that typically consists of

combined techniques and methods to tailor the treatment to the child's unique needs is considered ecologically valid and represents a truer picture of OT intervention. Treatment based on combination of methods compared to individual ones will continue to require further investigation.

Due to methodological limitations and differences, lack of consensus with definitions, inconsistency with treatment protocols, particularly with the multisensory approach, and a variety of outcome measures used that may not have been sensitive enough to provide definitive results, not all studies examining either approach yielded positive and or significant results. The findings support either approach but are still preliminary. Hence, a lack of consensus still remains as to which method works best. At the present, the more typical, ecologically valid, eclectic approach seems to be showing more promise. However, more evidence is still needed in this area to support this approach.



*Implications for Consumers*

Significant results have been found using both approaches. It seems that using a multisensory approach alone without task-oriented elements incorporating motor learning does not deliver as promising results as a task-oriented approach has shown on its own. Consistency in handwriting instruction methods is imperative as well as writing in a meaningful context following handwriting letter formation practice. Consumers need to be careful that outcomes for either approach are variable and depend on individual differences of the children, age of the child, and context/environment in which the intervention occurs.

*Implications for Practitioners*

One common finding amongst the studies is that children of different ages and ability seem to respond differently to intervention. Zwicker and Hadwin (2009) suggest that while first

graders are still receiving handwriting instruction, direct OT intervention may not be needed and additional practice may be all that is needed. They also recommend that future studies use motor learning principles to examine the amount and type of practice needed to learn letter formations at this age. This finding has important implications for the type and level of OT service delivery. In fact, this could help to decrease the OT caseload in the school setting. All researchers using motor learning principles suggest that sufficient practice is necessary to be able to produce legible script at a level of automaticity. Christensen (2005) recommends written expression rather than "copy book" script or simply focusing on meaningful learning in lieu of handwriting practice.

Regardless of whether practitioners choose to use a task-oriented or multisensory approach, the best results have been found when OT service addressing handwriting is embedded in the classroom curriculum, includes parent involvement, supplementary programs (similar to homework), higher-level components (mnemonics, frequent visual cueing, self instruction, and a combination of theories sensorimotor, biomechanical, motor learning, task-oriented), as well as a consistent method of instruction linking handwriting to functional writing so that students have a meaningful context for learning writing (Case-Smith et al., 2011). Assessment and treatment of performance skills that seem to be impacting handwriting particularly visual-motor integration skills, need to be addressed and should form an important part of any comprehensive evaluation and intervention plan.



*Implications for Researchers*

A need exists for further high-level research to determine the effects of the multisensory and the task oriented approach on handwriting using clearly defined operational definitions and consistent treatment protocols/ interventions that are systematically implemented in terms of

frequency and intensity. Treatment based on combination of methods compared to individual ones will continue to require further investigation. The role of higher-level cognitive components, supplementary programs and parent involvement must be evaluated in both approaches. Future studies are needed to examine the amount and type of practice needed to learn letter formations. Studies with larger samples, more sensitive outcome measures, and methodological rigor are required.

*Recommendations for Best Practice*

The general consensus is that handwriting must be taught and that the methods used must be consistently implemented. Teachers should also focus on improving handwriting skills instead of replacing them with a different method with its own challenges and limitations. Occupational Therapists must continue to accurately measure outcomes to determine the best intervention strategies for each client. OT service addressing handwriting needs to be embedded in the classroom curriculum.



*Summary and Conclusion*

A thorough review of the literature pertaining to handwriting does not indicate that there are any handwriting programs or tools that are superior in remediating handwriting problems (Asher, 2006). In a national survey, Woodward and Swinth found that 92 % of OTs uses the multisensory approach and in discovered that there are 114 types of multisensory activities used by OTs to improve the skill of handwriting (Harris & Livesey, 1992; Lockhart & Law, 1994; Oliver, 1990). Therapists who use this approach are not systematic about the actual modalities and activities that they use. Despite the evidence in support of the eclectic approach, there is still not much consensus and insufficient evidence as to which program based on approaches that focus on higher-level or lower-level functions or a combination of the two is the most effective

in remediating handwriting performance (Asher, 2006; Feder et al. 2000). It is also difficult to discern from an eclectic approach which components of the intervention contributed to the improvement of handwriting (Zwicker & Hadwin, 2009). According to Yack (1983), an OT clinical intervention that typically consists of combined techniques and methods to tailor the treatment to the child's unique needs is considered ecologically valid and represents a truer picture of OT intervention. Treatment based on combination of methods compared to individual ones will continue to require further investigation.

While the findings from studying eclectic approaches seem favorable, it is difficult at best to discern which component of the intervention worked best to improve handwriting. It seems that handwriting interventions incorporating task-oriented approaches combined with higher-level cognitive components as well as a combination of task-oriented and multisensory approaches with higher-level cognitive components seem to be currently producing the most favorable results. Additionally, the best results have been found when OT service addressing handwriting is embedded in the classroom curriculum, includes parent involvement, supplementary programs ( similar to homework), higher-level components (frequent visual cueing, mnemonics, self instruction, self monitoring) and a combination of theories (sensorimotor, biomechanical, motor learning, task-oriented) have been used. Addressing underlying performance skills particularly visual-motor integration, needs to be part of any handwriting intervention. Further, learning handwriting requires direct, explicit instruction which does not focus on just one factor but rather a more balanced approach that appreciates the relationship between the student's capacity, the task and the environment. An example of a handwriting program that includes these critical elements is the Size Matters Handwriting Program (SMHP) designed by Dr Beverly Moskowitz (Moskowitz, 2012).

References

Amundson, S. J. (1992). Handwriting: Evaluation and intervention in school settings. In: J. Case-Smith & C. Pehoski (Eds.), Development of hand skills in children (pp. 63–78). Rockville, MD: American Occupational Therapy Association.

Amundson, S. J. (2005). Prewriting and handwriting skills. In J. Case-Smith (Ed.). *Occupational therapy for children* (5th ed.) pp. 587-614. St. Louis, MO: Mosby.

AOTA, (2008). Occupational therapy practice framework: Domain and process. (2nd ed.) *American Journal of Occupational Therapy*, 62, *(6)* 625-683.

Asher, A. V. (2006). Handwriting instruction in elementary schools. *American Journal of Occupational Therapy, 60,* 461–471.

Ayres, A.J. (1985). *Sensory integration and the child.* Los Angeles: Western Psychological Services.

Barnes, K. J., & Turner, K.D. (2001). Team collaborative practices between teachers and occupational therapists. *American Journal of Occupational Therapy, 55,* 83-89.

Bazyk, S, Michaud, P., Goodman, G., Papp, P., Hawkins, E., & Welch, M.A. (2009). Integrating occupational therapy services in a kindergarten curriculum: A look at the outcomes. *American Journal of Occupational Therapy , 63,* 160-171. doi: 10.5014/ajot.63.2.160

Berninger, V. W., & Swanson, H. L. (1994). Modifying Hayes and Flower's model of skilled writing to explain beginning and developing writers. In J. S. Carlson (Series Ed.) & E. C. Butterfield (Vol. Ed.), *Advances in cognition and educational practice: Vol. 2 Children's writing: Toward a process theory of the development of skilled writing* (pp. 57–81). Greenwich, CT: JAI.

Berninger, V. W. , Vaughan, K.B., Abbott, R. D., Abbott, S.P., Rogan, L. W., Brooks, A., et al. (1997). Treatment of handwriting problems in beginning writers: Transfer from handwriting to composition. *Journal of Educational Psychology, 89,* 652-666. doi: 10.1037/0022-0663.89.4.652

Berninger, V. W., Rutberg, J. E., Abbott, R. D., Garcia, N., Anderson-Youngstrom, M., Brooks, A. & Fulton, C. (2006). Tier 1 and Tier 2 early intervention for handwriting and composing. *Journal of School Psychology, 44,* 3-30.

Birch, H.G. & Lefford, A. (1967). Visual Differentiation, intersensory integration and voluntary motor control. *Monographs of the Society for Research in Child Development, 32,* 2.

Cahill, S.M. (2009). Where does handwriting fit in ? *Intervention in School and Clinic, 44,* 223-228. doi: 10.117/1053451208328826



Case-Smith, J. (2002). Effectiveness of school-based occupational therapy intervention on handwriting. *American Journal of Occupational Therapy, 56,* 17-25.



Case-Smith, J., Holland, T., & Bishop, B. (2011). Effectiveness of an integrated handwriting program for first grade students: A pilot study. *American Journal of Occupational Therapy, 65,* 670-678. doi: 10.5014/ajot.2011.000984

Cermak, S. (1991). Somatodyspraxia. In A. Fisher, E. Murray, & A. Bundy (Eds.), *Sensory integration: Theory and practice* (pp. 138–170). Philadelphia: F. A. Davis.

Chandler, B. (1994). The power of information: School based practice survey results, *OT Week, 18,* 24.

Cornhill, H., & Case-Smith, J. (1996). Factors that relate to good and poor handwriting. *American Journal of Occupational Therapy, 50,* 732–739.

Christensen, C. (2005). The role of orthographic-motor integration in the production of creative and well-structured written text for students in secondary school. *Educational Psychology, 25,* 441-453.

Daly, C.J., Kelley, G.T., & Krauss, A. (2003). Brief Report-Relationship between visual-motor integration and handwriting skills of children in kindergarten: A modified replication study. *American journal of Occupational Therapy, 57,* 459-462.

Dennis, J. L., & Swinth, Y. (2001). Pencil grasp and children's handwriting legibility during different-length writing tasks. *American Journal of Occupational Therapy, 55*, 175–183.

Denton, P. L., Cope, S., & Moser, C. (2006). The effects of sensorimotor-based intervention versus therapeutic practice on improving handwriting performance in 6- to 11-year-old children. *American Journal of Occupational Therapy, 60,* 16–27.



Donica, D. (2010). A historical journey through the development of handwriting instruction (Part 1): The historical Foundation. *Journal of Occupational Therapy, Schools, & Early Intervention, 3,* 11-31. doi: 10.1080/19411241003683904

Donica, D. (2010). A historical journey through the development of handwriting instruction (Part 2): The occupational therapist's role. *Journal of Occupational Therapy, Schools and Early Intervention, 3,* 32-53. doi: 101.1080/19411241003683995

Erhardt, R.P., & Meade, V. (2005). Improving handwriting without teaching handwriting: The consultative clinical reasoning process. *Australian Occupational Therapy Journal, 52,* 199-210. doi: 10.1111/j.1440-1630.2005.00505.x

Feder, K., Majnemer, A., & Synnes, A. (2000). Handwriting: Current trends in occupational therapy practice. *The Canadian Journal of Occupational Therapy, 67 (*3), 197 -204.

Feder, K. P., Majnemer, A., Bourbonnais, D, D, Blayney, M., & Morin, I. (2007). Handwriting

performance on the ETCH-M of students in grade one regular education program. *Physical and Occupational Therapy in Pediatrics, 27,* 43-62

Furner, B.A. (1970). An analysis of the effectiveness of a program of instruction emphasizing the perceptual-motor nature of learning in handwriting. *Elementary English, 47,* 61-69.

Graham, S., & Weintraub, N. (1996). A review f handwriting research: Progress and prospects from 1980-1994. *Educational Psychology Review, 8,* 7-87. doi: 10.1007/BF01761831

Graham, S., Berninger, V., Weintraub, N., & Schafer, W. (1998). The development of writing fluency and legibility in grades 1 through 9. *Journal of Educational Research, 92,* 42-52.

Graham, S., Harris, K. R., & Fink-Chorzempa, B. (2000). Is handwriting causally related to learning to write? Treatment of handwriting problems in beginning writers. *Journal of Educational Psychology, 92,* 620-633. doi: 10.1037/0022-0663.92.4.620



Graham, S. (1983). The effect of self-instructional procedures on LD students' handwriting performance. *Learning Disability Quarterly, 6,* 231-234



Graham, S., Harris, K. R., Mason, L., Fink-Chorzempa, B., Moran, S. & Saddler, B. (2008). How do primary grade teachers teach handwriting? A national survey. *Reading and Writing, 21,* 49-69. doi: 10.1007/s11145-007-9064-z

Guy, Jodie M. (2003). Effect of proprioceptive input combined with "Handwriting without Tears" on the handwriting of children with learning disabilities. Masters Thesis. Western Michigan University.

Harris, S. J., & Livesey, D. J. (1992). Improving handwriting through kinesthetic sensitivity practice. *Australian Occupational Therapy Journal, 39,* 23–27.

Humphries, T., Wright, M., Snider, L., & McDougall, B. (1992). A comparison of the

effectiveness of sensory integrative therapy and perceptual-motor training in treating children with learning disabilities. *Journal of Developmental and Behavioral Pediatrics, 13*, (1), 31–40.

Halpin, G., & Halpin, G. (1976). Special paper for beginning handwriting: An unjustified practice? *Journal of Educational Research, 69,* 267–269.

Jones, D., & Christensen, C.A. (1999). Relationship between automaticity in handwriting and students' ability to generate written text. *Journal of Educational Psychology, 91,* 44-49.

Jongmans, M. J., Lint horst-Bakker, E., Westerberg, Y., & Smits-Engelsman, B. C. M. (2003). Use of a task –oriented self-instruction method to support children in primary school with poor handwriting quality and speed. *Human Movement Science, 22,* 549-566. doi: 10.1016/j.humov.2003.09.009



Kamm, K., Thelen, E., & Jensen J. (1990). A dynamic systems approach to motor development. *Physical Therapy, 70,* 763-775.



Krzesni, J. S. (1971). Effect of different writing tools and paper on performance of the third grader. *Elementary English, 7*, 821–824.

Lamme, L. L., & Ayris, B. M. (1983). Is the handwriting of beginning writers influenced by writing tools? *Journal of Research and Development in Education, 17,* 32–38.

Laszlo, J. I. & Bairstow, P.J. (1983). Kinesthesis: Its measurement, training and relationship to motor control. *Quarterly Journal of Experimental Psychology, 35*, 411-421.

Laszlo, J L, Bairstow, P. J, &. Bartrip, J (1988). A new approach to treatment of perceptual-motor dysfunction: Previously called 'clumsiness' *Support/or Learning,* 3(1), 35-40.

Laszlo, J L, Bairstow, P J, Bartrip, J., &. Rolfe, U (1988) Clumsiness or perceptuo-motor

dysfunction? In A. M. Colley &J. R. Beech (Eds,), *Cognition and action in skilled behavior* (pp. 293-312). New York: Elsevier.

Laszlo, J.I. & Bairstow, P.J. (1985). Perceptual-motor behavior: Developmental assessment and therapy. London: Holt, Saunders & Winston.

Laszlo, J. I., & Bairstow, P. J. (1984). Handwriting: Difficulties and possible solutions. School Psychology International, 5, 207–213.

Levine, M, D., Oberklaid, F, & Meltzer, L (1981). Developmental Output failure: A study of low productivity in school-aged children. *Pediatrics*, 67, 1b-25.

Lockhart, J., & Law, J. (1994). The effectiveness of a multisensory writing programme for improving cursive writing ability in children with sensorimotor difficulties. *Canadian Journal of Occupational Therapy, 61*, 206–210.



Lust, C.A., & Donica, D.K. (2011). Effectiveness of a handwriting readiness program in Head Start: A two-group controlled trial. *American Journal of Occupational Therapy, 65*, 560-568. doi: 10.5014/ajot.2011.000612



Maeland, A. F. (1992). Handwriting and perceptual-motor skills in clumsy, dysgraphic and "normal" children. *Perceptual and Motor Skills, 75*, 1207–1217.

Marr, D., Cermak, S., Cohn, E., & Henderson, A. (2003). Fine motor activities in Head Start and kindergarten classrooms. *American Journal of Occupational Therapy, 57*, 550–557.

Marr, D., & Dimeo, S. B. (2006). Outcomes associated with a summer handwriting course for elementary students. *American Journal of Occupational Therapy, 60*, 10–15.

McHale, K., & Cermak, S.A. (1992). Fine motor activities in elementary schools. Preliminary findings and provisional implications for children with fine motor problems. *American Journal of Occupational Therapy, 46,* 898–926.

Moskowitz, B. (2012). The size matters handwriting program: Instruction manual. Retrieved May, 19th, 2012 from http://realotsolutions.com/products/smhp-instruction.html

National Board for Certification in Occupational Therapy. (2008). *Executive summary for the practice analysis study: NBCOT 2008 practice analysis.* Retrieved February 24, 2012, from www.nbcot.org/pdf/Exectuive-Summary-for-the-Praxctice-Analysis-Study-OTR.pdf

Oliver, C. E. (1990). A sensorimotor program for improving writing readiness skills in elementary-age children. *American Journal of Occupational Therapy, 44,* 111–116.

Peterson, C. Q., & Nelson, D. (2003). Effect of an occupational intervention on printing in children with economic disadvantages. *American Journal of Occupational Therapy, 57,* 152–160.



Reis, E. M. (1990). Multisensory approaches for teaching handwriting to learning disabled children. *Journal of Instructional Psychology, 17(4),* 190–193.



Rutherford, L. H. (1991). For sweet success, use multisensory approaches to teach writing. *Social Studies,* 243–244.

Robin, A.L., Armel, S & O'Leary, D.K. (1975). The effects of self-instruction on writing deficiencies. *Behavior Therapy, 6,* 178-87.

Schmidt, R. A., & Wrisberg, C. A. (2004). *Motor learning and performance: A problem-based learning approach* (3rd ed.). Champaign, IL: Human Kinetics.

Schneck, C M. (1991). Comparison of pencil-grip patterns in first graders with good and poor writing skills. *American Journal of* Occupational *Therapy, 45,* 701-706.

Sovik, N. (1975). Developmental cybernetics of handwriting and graphic behavior.

Oslo: Universitestsforlaget

Sovik, N. (1981). An experimental study if individualized learning/instruction in copying, tracking, and handwriting based on feedback principles. *Perceptual and Motor Skills, 53,* 192-215.

Sovik, N. (1984). The effects of a remedial tracking program on writing performance of dysgraphic children. *Scandinavian Journal of Educational Research, 28,* 129-147.

Ste-Marie, D. M., Clark, S. E. Findlay, L. C., & Latimer, A. E. (2004). High levels of contextual interference enhance handwriting skill acquisition. *Journal of Motor Behavior, 36*(1), 115-126.

Sudsawad, P., Trombly, C., Henderson, A., & Tickle-Degnen, L. (2002). Testing the effect of kinesthetic training on hand- writing performance in first-grade students. *American Journal of Occupational Therapy, 56,* 26–33.



Tseng, M. H., & Cermak, S. A. (1993). The influence of ergonomic factors and perceptual-motor abilities on handwriting performance. *American Journal of Occupational Therapy, 47,* 919–926.



Tseng, M. H., & Murray, E. A. (1994). Differences in perceptual-motor measures in children with good and poor handwriting. *Occupational Therapy Journal of Research, 14,* 38–52.

Vickery, K. S., & Cochran, S. W. (1987). Multisensory teaching approach for reading, spelling and handwriting, Orton- Gillingham based curriculum, in a public school setting. *Annals of Dyslexia, 37,* 189–200.

Volman, M. J. M., van Schendel, B. M., & Jongmans, M. J. (2006). Handwriting difficulties in primary school children: A search for underlying mechanisms. *American Journal of Occupational Therapy, 60,* 451–460.

Yack, E. (1989). Sensory integration: A survey of its use in the clinical setting. *Canadian Journal of Occupational Therapy, 56,* 229-235.

Ziviani, J., & Elkins, J. (1984). An evaluation of handwriting performance. *Educational Review 38,* 247-257.

Ziviani, J., Hayes, A., & Chant, D. (1990). Handwriting: A perceptual motor disturbance in children with myelomeningocele *Occupational Therapy Journal of Research, 10, 12-26.*

Zwicker, J. G., & Hadwin, A.F. (2009). Cognitive versus multisensory approaches to handwriting intervention: A randomized controlled trial. *OTJR: Occupation, Participation and Health, 29,* 40-48. doi: 10.3928/15394492-20090101-06

US Department of Education, Office of Special Education. (n.d.). History: 25 years of progress in education children with disabilities through IDEA. Retrieved March 10th, 2012, from :http://www2.ed.gov/policy/speced/leg/idea/history.html



Wehrmann, S., Chiu, T., Reid, D., & Sinclair, G. (2006). Evaluation of occupational therapy school-based consultation service for students with fine motor difficulties. *Canadian Journal of Occupational Therapy, 73,* 225-235.



Weil, M., & Cunningham Amundson, S. J. (1994). Relationship between visuo- motor and handwriting skills of children in kindergarten. *American Journal of Occupational Therapy, 48,* 982–988.

Weintraub, N., Yinon, M., Hirsch, I. B.-E., & Parush, S. (2009). Effectiveness of sensorimotor and task-oriented handwriting intervention in elementary school-aged students with handwriting difficulties. *OTJR: Occupation, Participation and Health, 29,* 125-134. doi: 10.3928/15394492-20090611-05

Woodward, S., & Swinth, Y. (2002). Multisensory approach to handwriting remediation:

Perceptions of school-based occupational therapists. *American Journal of Occupational Therapy, 56,* 305–312.

World Health Organization. (1997). ICIDH-2: *International classification of impairments, activities, and participation.* Geneva, Switzerland: WHO