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A STUDY OF THE HANDWRITING SPEED AND
VISUAL MOTOR INTEGRATION
OF SCHOOL-AGED CHILDREN
WITH DEVELOPMENTAL COORDINATION DISORDER
IN HONG KONG

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2004
To my God,

who showed me the path of life

and made me bold with strength in my soul;

and

to my parents,

who love and support me with all their hearts
ABSTRACT

Abstract of dissertation entitled:
A Study of the handwriting speed and visual motor integration of school-aged children with Developmental Coordination Disorder in Hong Kong
submitted by Kwok Ching Yee, Alice
for the degree of MSc in Health Care (Occupational Therapy)
at the Hong Kong Polytechnic University in December, 2004.

The purpose of the present study was to investigate the problem of handwriting speed and visual motor integration in school-aged children with Developmental Coordination Disorder (DCD) in Hong Kong. The relationship between visual motor integration and Chinese and English handwriting speed was also examined. Evidence of content validity and inter-rater reliability of the Developmental Test of Visual Motor Integration (VMI, Beery, 1997) for use with the present study was first established. The content validity was established by means of expert panel review and inter-rater reliability was analyzed using Intraclass Correlation (ICC) approach. The results of content validity showed that above 85% agreement was obtained for cultural relevance and representativeness as well as equivalence of semantic meaning of the Chinese translation of VMI. A high ICC ranging from 0.89 to 0.98 was obtained for inter-rater reliability of VMI between two experienced raters. Following that, the Handwriting Assessment Tool – Speed Test (HATS, Chow et al, 2003) and VMI were administered to 24 children with DCD and 24 children without DCD, aged between 6 to 10 years 11 months of age and attending grade 1 to 4 of primary schools in Hong
Kong. Performances on these measures were analyzed using multivariate analysis of variance, Pearson Product-Moment Correlation analysis and regression analysis. The results showed that children with DCD as a group wrote significantly slower in both languages (For Chinese, $F = 6.67$, $p < 0.05$; for English, $F = 5.69$, $p < 0.05$), and obtained a significantly lower VMI score ($F = 46.31$, $p < 0.001$) than children without DCD, though individual differences were noted. A moderate but significant correlation was found between VMI and Chinese copying speed only in both groups (for DCD group, $r = 0.65$, $p < 0.01$; for control group, $r = 0.48$, $p < 0.05$). Years of schooling was found to be a significant predictor of Chinese and English handwriting speed for both groups (for DCD group, Chinese: adjusted $R$ square was 0.70, $p < 0.01$, English: adjusted $R$ square was 0.42, $p < 0.01$; for control group, Chinese: adjusted $R$ square was 0.83, $p < 0.01$, English: adjusted $R$ square was 0.62, $p < 0.01$). On the other hand, VMI scores (for DCD group, Chinese: $p = 0.119$, English: $p = 0.212$; for control group, Chinese: $p = 0.470$, English: $p = 0.423$) and gender (for DCD group, Chinese: $p = 0.324$, English: $p = 0.264$; for control group, Chinese: $p = 0.127$, English: $p = 0.425$) were not. In conclusion some children with DCD have handwriting speed problem in both Chinese and English. Difficulties in writing proficiently is only moderately related to the integration of visual processing and motor execution processes, in which children with DCD showed a clear weakness.
ACKNOWLEDGEMENTS

I would like to express my gratitude to my academic supervisor, Dr. Susanna Chow, Assistant Professor of the Department of Rehabilitation Sciences of the Hong Kong Polytechnic University. Dr. Chow provided me valuable advice and guidance during the process of completing my dissertation. In addition, her expertise in the area has given me much enrichment and inspiration on how to apply the knowledge in my clinical practice.

I would also like to express my gratitude to all the children and parents who participated in my study. Thanks for their support and cooperation which made my study successfully completed.

I would like to express my thankfulness to the school principals and teachers who kindly provide me with special arrangement to facilitate my process of data collection.

I would like to give special thanks to my co-workers in the department of Occupational Therapy of Kowloon Hospital, and in particular, Ms Sally Choy, my team leader, for helping me in data collection. She has always given me great support, encouragement and opportunity to develop my clinical expertise.

I would also like to give special thanks to Mr. Chan Ka Yan, Mrs. Jenny Ma, and Ms Janet Yu, who gave me great help in liaising with the school principals.

Last but not least, I would like to thank my fiancé, my parents and my sisters, who always support me, especially at times when I was stressed with work and study.
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1. Introduction

1.1 Background of the Study

Handwriting remains an essential occupational skill for school-aged children despite the advances of word processors and augmentative communication systems (Amundson & Weil, 1996). McHale and Cermak (1992) found that 31% to 60% of the children’s school day consisted of fine motor activities. Of those fine motor tasks, 85% of the time consisted of paper and pencil tasks. To be able to write competently, integration of a number of performance components is required. That includes visual perceptual skills (Meulenbroek & van Galen, 1990; Maeland, 1992; Weil & Cunningham-Amundson, 1994), motor planning, initiation and execution (Castiello & Stelmach, 1993) and language processing (Abbott & Berninger, 1993).

Proficiency in handwriting is especially essential as many of the written works have to be completed within a time limit. Slow rate of handwriting hinders higher order writing processes such as composing, because thoughts were being forgotten as they were not being written down fast enough (Graham & Weintraub, 1996). Slow handwriting speed would also have a negative impact on a child’s motivation for writing, and poor academic performance may become a consequence of deficient
handwriting speed (Berninger et al., 1992). In fact, remediation of this aspect of handwriting difficulty has been an important concern to Occupational Therapists due to the high frequency of referrals for children with handwriting problems (Reisman, 1991).

Children in Hong Kong are expected to learn both Chinese and English even from kindergarten years. Yet, the orthographic script of Chinese and the alphabetic script of English are two distinct writing systems. The Chinese script relies on semantic processing (Hoosain & Osgood, 1983), whereas the English script relies on the phonological processing (Lesch & Pollatsek, 1993). Therefore, to be able to write two distinctively different scripts proficiently poses a challenge for children in Hong Kong. This also presents a challenge for local Occupational Therapists to develop intervention of slow handwriting speed in both languages as most of the studies on handwriting came from Western countries.

There were studies investigating how the performance components of handwriting in relating to English handwriting difficulties. For example, handwriting was found to be related to kinaesthetic perception (Laszlo & Bairstow, 1983; Ziviani et al., 1990), finger dexterity (Levine et al., 1981) and in-hand manipulation (Sovik et
al, 1982). However, few examined Chinese handwriting difficulties. One study by Tseng and Chow (2000) was identified which examined the perceptual motor functions of school-aged children with slow handwriting speed. They found that visual sequential memory and visual motor integration as measured by the Developmental Test of Visual Motor Integration (VMI, Beery, 1997), among other perceptual motor functions, were best predictors of Chinese handwriting speed of slow writers.

As will be reviewed later in chapter 2, children with Developmental Coordination Disorder (DCD) present with very slow handwriting speed and poor legibility clinically. Yet, there were few studies investigating the handwriting speed problem of children with DCD and most of these studies were done on children from Western countries. Only one study on Chinese children with DCD (Chui, 2000) was found. In Chui’s study, it was shown that children with DCD in HK wrote much slower than children without DCD. However, the study only assessed the handwriting speed of Chinese and it did not examine how handwriting speed is related to the underlying performance components.

Various studies attempted to investigate the underlying deficits associated with
the difficulties in motor skills such as handwriting, experienced by children with DCD. Some studies showed that children with DCD had perceptual motor difficulties (Lord & Hulme, 1987; O’Brien et al., 1988, Wilson & McKenzie, 1998). One of the perceptual motor difficulties identified was the visual motor integration. The studies of O’Brien et al (1988) and Dewey and Wilson (2001) revealed that children with DCD scored below average in tests assessing the performance of visual motor integration and their scores were significantly lower than the control group. Although significant correlation has been consistently found between both Chinese and English handwriting legibility and visual motor integration, no study was identified which investigated if there would be a relationship between the impairment found in visual motor integration and the handwriting speed problem in children with DCD.

In order to develop effective intervention on the handwriting difficulties of children with DCD, a clearer understanding of the problem of slow handwriting speed faced by these children is needed. Therefore, the present study aimed at investigating the handwriting speed of children with DCD in Hong Kong, and determining if visual motor integration would be in association with their slow handwriting speed.
1.2 Objectives of the Study

The objectives of the study are to determine if children with DCD in Hong Kong do have slow Chinese and English handwriting; and poorer performance in visual motor integration, and to investigate if there is a significant relationship between visual motor integration and both Chinese and English handwriting speed.

1.3 Hypotheses of the Study

The null hypotheses of the present study are:

1. There will not be a significant difference in Chinese and English handwriting speed, and the performance in visual motor integration between children with and without DCD.

2. There will not be a significant correlation between the Chinese and English handwriting speed and visual motor integration.

The alternative hypotheses of the present study are:

1. There will be a significant difference in Chinese and English handwriting speed, and the performance in visual motor integration between children with and without DCD.

2. There will be a significant correlation between the Chinese and English handwriting speed and the visual motor integration.
2. Literature Review

2.1 Developmental Coordination Disorder

2.1.1 Introduction

There had been debates over the appropriate terminology for the particular group of children who have exceptional difficulties with tasks requiring motor coordination (Henderson & Henderson, 2001). These children have normal intelligence and do not have any obvious neurological or pervasive developmental disorders, and they do not have deficient educational opportunities. Over the years, different terms had been used to denote the movement difficulties in these children, including “clumsiness”, “dyspraxia”, “poor coordination”, “minimal brain damage”, etc (Henderson & Barnett, 1998). The competing labels reflect the variations observed among these children in the severity and pattern of their problems. Through continued discussions and studies, the term “Developmental Coordination Disorder” (DCD) was finally being universally adopted (Polatajko et al, 1995). According to the fourth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV, American Psychiatric Association, APA, 1994, p.53-55), DCD is defined as a marked impairment in the development of motor coordination, which cannot be attributed to a general medical condition (e.g. cerebral palsy, muscular dystrophy), and the criteria
are not met for Pervasive Developmental Disorder. Additional criteria includes that if mental retardation is present, the motor difficulties are in excess of those usually associated with it. In addition, the diagnosis is made only if this impairment interferes with academic achievement or activities of daily living.

Prevalence of DCD among children aged 5 to 11 years ranges between 6% and 10% (APA, 1994). Some studies found a higher prevalence of DCD in boys than in girls (Taylor, 1990; Missiuna, 1994). A local study by Chan et al (2004) found that of the 94 children who were diagnosed as DCD within a ten-month period at Child Assessment Centres in Hong Kong, 56% of them were between 6 to 7 years of age, and the boys to girls ratio was 6.5 to 1. However, some population studies report a more equal distribution (Cermak et al, 2002). The conflict may be attributed by gender differences and cultural influences (Cermak et al, 2002).

2.1.2 Subtypes and Comorbid Conditions

It has been noted that children with DCD form a heterogeneous group (Lord & Hulme, 1987). Various studies suggested the existence of different subtypes of DCD, reflecting varying motor dysfunction in these children. (Dewey & Kaplan, 1994; Hoare, 1994; Chan et al, 2004; Macnab et al’s study, 2001; Miyahara, 1994; Wright &
Sugden, 1996a). These studies used different outcome measuring tools to assess the children's motor and/or perceptual skills, thereby to establish the possible subgroups. On the whole, there was little agreement amongst the subtypes proposed by these studies. However, some commonalities were identified. Most studies identified a group with severe deficits in all areas of motor ability (Dewey & Kaplan, 1994; Hoare, 1994; Macnab et al., 2001; Miyahara, 1994; Wright & Sugden, 1996a). Subgroups of children with DCD who were characterized by general visual-perceptual difficulties were also identified (Hoare, 1994; Macnab et al., 2001). In addition, Dewey and Kaplan (1994) and Miyahara (1994) identified subgroups of children who showed good performance of static balance. In a local study by Chan et al. (2004), three subgroups of DCD were identified among the 94 children who were diagnosed with DCD within a ten-month period. Based on the Gross Motor and Fine Motor Composite score of the Bruinicks-Oseretsky test of Motor Proficiency (BOTMP, Bruininks, 1978), 35% of children with DCD belonged to the subgroup with poor gross motor functions only, 34% belonged to the subgroup with poor fine motor functions only; and 31% belonged to the group with poor functions in both. However, the validity of defining the subtypes based on the result of the composite scores the BOTMP is questionable. The result of factor analysis of this test showed that most of the items in the fine motor subtests clustered together with other gross motor items
(Bruininks, 1978). Therefore, a child obtaining a low fine motor composite score in BOTMP only may not indicate that he or she does not have any gross motor problems.

Henderson and Henderson (2001) further argued that there was no persuasive evidence to suggest that the subtypes identified form cohesive and contrasting clusters. That was due to lack of general theories in the motor domain that delineate important processes required by a task. They contended that the features of DCD were not clearly distinguishable from the features of other developmental disorders. In addition, different outcome measures of motor and/or perceptual skills were used in different studies, yielding different patterns of skills and deficits. Besides, different investigators had different perspectives or approaches in analyzing the problems. That might lead to biased interpretation of the results.

DCD may occur in isolation, although it frequently coexists with a variety of other learning and behavioral problems, including learning disabilities, speech or language deficits and attention deficits (Kaplan et al, 1998; Cermak et al, 2002). Chan et al (2004) found that a significant percentage of children who were diagnosed with DCD were associated with co-morbid conditions, in which 43% were associated with
attention deficits and hyperactivity disorders, 32% were associated with dyslexia, 6.4% were associated with emotional problems, and 17% associated with multiple co-morbidities of DCD, dyslexia and attention deficits.

In summary, DCD is heterogenic in nature. A comprehensive assessment is indicated in order to investigate the wide-ranging problems experienced by children with DCD.

2.1.3 Mechanism Underlying DCD

A range of underlying perceptual and motor control deficits associated with DCD has been reported. Perceptual processing deficits identified include visual perception (Hulme et al., 1982; Hulme et al., 1984; Lord & Hulme, 1987; Parush et al., 1998), kinesthetic perception (Bairstow & Laszlo, 1981; Laszlo & Bairstow, 1983; Laszlo et al., 1988), and cross-modal perception (or the transfer of information between sensory modalities) (Newnham & McKenzie, 1993). However, Schoemaker et al. (2001), found that no significant differences in visual, proprioceptive and tactile information processing among children with and without DCD, except for items involving visual motor skills. In fact, the performance of these children varied across tasks. Two out of 19 children performed well on all 17 tests; whereas two children failed almost half of
the tests. The remaining children performed well on majority of the tests, yet failed on one to five tests.

Motor control deficits identified in children with DCD include inappropriate selection of motor response (van Dellen & Geuze, 1988), motor programming difficulties (Smyth, 1991), slow reaction time in response to visual stimulus and slow movement time (Henderson et al., 1992; Williams et al., 1998). However, Smyth et al. (2001) found that children with DCD tended to make movement more quickly comparing to control subjects, in reaching for object in response to reduced visual information.

The sample sizes in these studies of investigating the underlying deficits of children with DCD varied, ranging from 16 to over 100, which may therefore contribute to difference in results between studies. In addition, the use of different outcome measures might yield different results.

Wilson and McKenzie (1998) conducted a meta-analysis in which a total of 50 studies were included. The results showed that children with DCD were inferior on most measures of information processing. The most pronounced deficit was found in
visual-spatial processing, regardless of whether or not the tasks involved a motor component, though deficit was greater in tasks requiring a motor response. Parush et al (1998) also showed that children with DCD performed significantly more poorly than controls, on visual perceptual skills in both motor and motor-free tasks. In addition, they also found that there was a moderate and significant relationship between the performance on visual perceptual test and visual motor test in children with DCD. However, such relationship was not found in the control group. In view of its significant contribution of the underlying deficit in children with DCD, and the possible non-separable functions of visual processing and motor control in children with DCD, the skill of visual motor integration was therefore examined in the present study, to determine if there would be any relationship between handwriting speed and visual motor integration.

2.1.4 Assessment for DCD

As mentioned earlier, children with DCD do not form a homogeneous group. Although various tests or checklists have been developed for screening and initial identification of DCD, there is no gold standard assessment instrument for the identification of children with DCD (Crawford et al, 2001). Larkin and Cermak (2002) commented that motor proficiency tests such as Movement Assessment Battery for
Children Test (Henderson & Sudgen, 1992) and the Bruininks Oseretsky Test of Motor Proficiency (BOTMP, Bruininks, 1978) were generally adequate for identification of DCD.

While some advocated for the use of motor proficiency tests in identifying DCD, Dewey & Wilson (2001) proposed the inclusion of the independent examination of participation in school and daily activities as they represent two distinct functional issues. Wright and Sudgen (1996b) suggested a two-step procedure for the identification of children with DCD. They first used the Movement ABC Checklist which was administered by school teachers to identify children with functional difficulties in daily living. It was followed by the use of Movement ABC test which was administered by the author to those children to diagnose the children with DCD. Therefore, the Movement-ABC test and checklist together provide both quantitative and qualitative information on child's motor performance, thereby, giving a more comprehensive picture of child's functioning.

In addition, the presence of academic difficulties raised the concern of the inclusion of this aspect in the assessment of children with DCD as some argued that these academic difficulties are a manifestation of DCD, instead of just consequences.
(Rodger et al, 2003). In view of the frequent handwriting problem experienced by children with DCD, Chow and Henderson (2004) mentioned the assessment of handwriting skill in association with the assessment of global motor impairment. In fact, both the commonly used motor proficiency tests, Movement-ABC and BOTMP, do not include handwriting as a subtest.

Moreover, as mentioned earlier, DCD have a negative impact on children’s self-confidence in physical abilities, social competence and social-emotional well-being, and decreased leisure and playground participation (Hay & Missiuna, 1998; Rasmusseen & Gillberg, 2000). However, Rodger et al (2003) argued that more specific skill manifestations regarding these aspects of functioning were not reported in most of the motor proficiency tests.

In summary, given the diverse and varied nature of motor skills and the fact that DCD often presents itself differently in different situations, different tests assessed by different persons, in different contexts contributed to a better understanding, and therefore a clearer identification of children with DCD. Therefore, a comprehensive assessment was indicated to investigate the wide-ringing problems experienced by children with DCD in order to facilitate clinician to develop effective intervention for
these children. As the present study aims at comparing the handwriting and VMI performance between children with and without DCD, a quick screening rather than a detailed assessment would be most appropriate to screen out children with DCD in the control group. As previously mentioned, The Movement-ABC was found to be the best screening tool for DCD, it was used in the present study.

2.1.5 Prognosis

Quite a number of studies investigated the long term effects of DCD on children, which reveal differing and sometimes conflicting results. In a ten-year follow-up study by Losses et al (1991) have found children who were diagnosed in the early years carried an increased risk of learning difficulties at school age. In Cantel et al’s longitudinal study (1994) also found that children who were diagnosed with DCD at age 5 and had extreme motor difficulties would have the poorest social and educational outcomes. In addition, Losses et al also suggested that if the difficulties of DCD include social and emotional problems, these problems would continue into later school life. Moreover, they suggested that temperament of the children and the support of the family are critical factors in the outcome of these children. In contrast, Gillberg et al (1989) found that 70% of children at age 7 who were diagnosed as DCD in their study, were no longer having motor problems at age 13. However, 84% of
these children were found to have either behavioral or academic problems at age 13.

The reason behind the different findings of the studies on motor competence may be found in the testing procedures, with a lack of validated and well-standardized tests being available for teenagers (Losses et al, 1991).

2.2.1 Performance Components of Handwriting

Handwriting is a complex skill which encompasses various skills. Most studies focus on how the various perceptual motor performance components of handwriting affect handwriting legibility (Cornhill & Case-Smith, 1996; Harris & Livesey, 1992; Maeland, 1992; Tseng & Murray, 1994; Ziviani et al, 1990). The possible perceptual motor performance components identified include visual motor integration, visual perception, fine motor skills and kinesthetic perception. However, few studies examined the aspect of handwriting speed. Levine (1987) stressed the importance of adequate kinesthetic perception for developing mature pencil grip for proficient handwriting. However, this implies that kinesthetic perception affects pencil grip, but not directly on handwriting speed. Tseng and Chow (2000) found that one of the subtests of the Test of Visual Perceptual Skills (non-motor, TVPS), which assesses the visual sequential memory, was a significant predictor for the handwriting speed of the 35 slow handwriters aged 7 to 11 years. However, it only accounted for 13% of the
variance. Besides, visual sequential memory is only one out of seven subtests of the TVPS. It is questionable if it can conclude that visual perception on a whole is significantly correlated with handwriting speed. In addition, the above study only examined the Chinese handwriting speed. It is unclear that if there is a significant relationship between visual perception and English handwriting speed. In the same study, it was found that upper limb speed and dexterity, an aspect of fine motor skills, as measured by BOTMP, was a significant predictor of handwriting speed of normal speed handwriters, but not slow speed handwriters among a group of school-aged children. In a local study by Lam (2001), it was found that there was a significant correlation between in-hand manipulation which is another aspect of fine motor skills, and English handwriting speed, but not Chinese handwriting speed. The difference of the findings may be due to the fact that two studies investigated different aspects of fine motor skills, one was assessed with time constraints and the other was not. In addition, when assessing the upper limb speed and dexterity in Tseng and Chow's study, a strong component of visual demand was involved, but not so much as in the assessment of in-hand manipulation. Therefore, it is unclear that if fine motor skills on a whole, significantly relates to handwriting speed. Besides the perceptual motor components, cognitive function is also considered to be one of the important factors of handwriting readiness (Amundson & Weil, 1996). A child must have achieved a
level of cognitive maturity that allows him to put together the sub-skills and abstract concepts needed to produce words on paper.

2.2.2 Relationship of Visual Motor Integration and Handwriting Speed

Visual motor integration, one of the visual motor skills, is defined as the ability to integrate visual image with appropriate motor responses (Berry, 1997). In copying, similar processes are involved as one must visualize the letter or character form, assign a meaning to the form, and then manipulate a writing tool to reproduce the same letter (Cornhill and Case-Smith, 1996). Therefore, visual motor integration seems to be one of the important variables to a child's handwriting skill, particularly when copying or transposing from printing material to writing. The relationship between visual motor integration and handwriting legibility has been examined by various studies, and significant correlation was found in most of these studies (Daly et al, 2003; Maeland, 1992; Rubin & Henderson, 1982; Weil & Cunningham, 1994). Significant correlation was also found between visual motor integration and Chinese handwriting legibility (Tseng & Murray, 1994; Weng, 1998). It was recommended that children should not be taught how to write until they could copy the eighth item on the VMI as it was found that VMI scores were significantly correlated with handwriting readiness (Beery, 1997; Weil & Cunningham, 1994). However, the extent
of correlation of these studies was consistently found to be only moderate, ranging from \( r = 0.47 \) to 0.55. In addition, they only implied that visual motor integration and handwriting legibility are associated, rather than causal relationship.

Only one study was identified which investigated the relationship between visual motor integration and Chinese handwriting speed. Tseng and Chow (2000) conducted a study on 34 slow handwriters and 35 normal speed handwriters, studying grade two to six. It was found that VMI did not correlate significantly with handwriting speed for both groups of handwriters \( (r = 0.29) \). On the other hand, VMI was found to be a significant predictor of handwriting speed for slow handwriters \( [F (3, 30) = 16.2997, p < 0.0001] \). However, VMI was only the third best predictor, and the extent of variation it accounted for was small (6.5% of variance). In addition, VMI was not found to be a significant predictor for fast handwriters. Therefore, it is unclear that if visual motor integration associates significantly with handwriting speed of children in both languages. Therefore, the relationship of both Chinese and English handwriting speed with visual motor integration in children with and without DCD would be investigated in the present study.
2.3 Analysis of English and Chinese Handwriting

2.3.1 Analysis of English Handwriting

The English writing system consists of 26 basic units which are called letters. Each letter, or combination of letters, corresponds to an individual phonemic unit. The 26 letters exist in two forms, the upper and lower case letters. Combinations of one or more of the 26 letters form a word with a specific meaning. There are two different scripts in the English handwriting system, the manuscript and cursive script. The present study focused on the manuscript as the cursive script is usually taught not until primary three or four students in Hong Kong.

A letter is comprised of discrete strokes, continuous and curve lines. According to Alston and Taylor (1987), there are six basic strokes in forming the manuscript of 26 letters. They are the horizontal, vertical, backward circle, forward circle, slant right, and slant left. For all letters, strokes are drawn from top to bottom, except for letter “e” and “d”. For lower case letters, strokes are continuous, except for dots and crossbars. For upper case letters, strokes are usually discrete. Alston and Taylor (1987) further divided the lower case of 26 letters into four groups according to their common movement patterns as shown in table 2.1.
Table 2.1: Patterns found in lower case letters

<table>
<thead>
<tr>
<th>Patterns</th>
<th>Letters</th>
</tr>
</thead>
<tbody>
<tr>
<td>The round patterns</td>
<td>a, c, d, e, f, g, o, q, s</td>
</tr>
<tr>
<td>The hump patterns</td>
<td>b, h, m, n, p, r</td>
</tr>
<tr>
<td>The straight line and cup patterns</td>
<td>i, j, l, t, u</td>
</tr>
<tr>
<td>The zigzag patterns</td>
<td>k, v, w, x, y, z</td>
</tr>
</tbody>
</table>

(Adapted from: Alston & Taylor, 1987, p.101)

2.3.2 Analysis of Chinese Handwriting

Chinese characters are logographic in nature and are more complex than English letters (Chan, 1993; Tseng, 1993). A Chinese character can be comprised of one or more radicals (部首), and each radical is comprised of different strokes. Conventionally, there are eight types of basic strokes: dot (點），horizontal line (横一), vertical line (直 | ), left curve (撇 丿), right curve (捺 乚), tick (趯 乀), turn (折 乿), and hook (鉤 ㇇) (Weng, 1998). However, besides the basic strokes, there are other more complicated strokes of Chinese characters, for example, the strokes“辶” of the character 考, and the stroke“辰” of the characters 迷, 遊.

Hwang (cited in Curriculum Development Council, 1996) classified all basic strokes into 28 types (please refer to Appendix 17). There are ten types of horizontal lines, seven types of vertical lines, three types of slanting lines, and one type of down stroke to the left, one type of dot, two types of up strokes to the right, and four types of curves.
Besides the variation in strokes, there are also different formats in assembling the radicals into a character. There are thirteen formats in assembling radicals into a character (Psychological Services Section of Education Department, 2002) (please refer to Appendix 18).

Given the complexity of Chinese characters, writing Chinese proficiently is more difficult than that of English as it demands more visual discrimination of the fine difference in the forms and position of strokes (Huang, 1984); and the spatial organization ability in order to write the characters legibly with appropriate positioning of strokes and proportioning of radicals (Chan, 1993). In addition, Chinese handwriting involves constant pen lifting action as it contains mostly discrete strokes; whereas for English handwriting which contains mostly circular strokes. The intermittent pen lifting actions when writing Chinese characters lead to increase in writing pressure (Tseng, 1998), and may increase the motor demand. Therefore, in the present study, the difference in the copying speed of both Chinese characters and English letters, in the DCD and control group was examined, and the degree of their difference between copying Chinese and English would also be determined.
2.4 Handwriting Problems in Children with DCD

2.4.1 Slow Handwriting Speed

Miller et al (2001) have showed that children with DCD are typically referred to Occupational Therapist in the early school years with handwriting difficulties. However, not all studies reported handwriting speed problems in children with DCD. Rubin and Henderson (1982) did not find any difference in handwriting speed between the DCD and the control group. O'Hare and Brown (1989) also reported both very slow and very fast handwriting speed in children with DCD. On the other hand, Sovik et al (1987), Henderson (1992) and Chui (2000) found that children with DCD wrote much slower than children without DCD. However, most of these studies were conducted at time when DCD were not yet the formal diagnosis; therefore, subjects recruited might not be truly DCD. In addition, most of the studies were done on children from Western countries. In Chui's study (2000), 23 Hong Kong children with DCD were compared to 23 controls studying in primary 1 to 4, on their handwriting speed. It was found that children with DCD wrote significantly slower, with an average of three characters per minute less than the control group (p < 0.05). However, the study only assessed the copying speed of Chinese script only. In Hong Kong, both Chinese and English are taught in school and children are required to learn how to write both scripts at an early age. Therefore, it is important to examine the copying
speed of both Chinese and English.

2.4.2 Problem in Visual Motor Integration

Some studies found that children with DCD had difficulties with visual motor integration. O’Brien et al (1988) found that 13 children who had learning disabilities and clumsiness scored significantly lower than the control group of 22 children in VMI. Dewey and Wilson (2001) also found similar result on 137 children with DCD and 155 children without DCD, in which the DCD group scored one standard deviation below the norm on VMI. However, Rodger et al’s study (2003) on 20 children with DCD showed that their performance on VMI was within average range based on the converted standard scores. The different findings may be due to the great difference in the number and age of children recruited in the above studies. Rodger et al’s study only recruited 20 children of a narrower age range (between 4 to 7 years). In addition, Rodger et al’s study did not include a control group for comparison. Schoemaker et al (2001)’s study on 19 children with DCD and 19 sex-matched controls found that children with DCD performed significantly more poorly on the visual motor subtest, of the Developmental Test of Visual Perception (Hamill et al, 1993), and in which, 42% of the children with DCD obtained scores in the clinical range. However, the subtest measures visual motor speed rather than visual motor
integration as it does not involve copying of forms and it is performed under time constraint. Therefore, it seems that there is stronger evidence for the presence rather than absence of deficits in visual motor integration found in children with DCD.

As previously mentioned, visual motor integration has been found to be significantly associated with handwriting ability. Would the deficits in visual motor integration account for the difference in handwriting speed found in between children with and without DCD? One of the objectives of the present study was to investigate this possible relationship.

2.5 Assessment of Handwriting Speed

2.5.1 Instruments of Measuring Handwriting Speed

Different handwriting assessment tools have been developed to evaluate the handwriting performance of children. In Hong Kong, children start learning to write both Chinese and English during kindergarten. However, most of the handwriting tests commonly used only assess proficiency of writing one language. For example, Tseng and Hsueh's Chinese Handwriting Speed Test (1997) is a test commonly used by Occupational Therapists in Hong Kong which only assesses the Chinese handwriting speed of school-aged children. The text used came from a textbook used
by children from first grade in Taiwan. Characters learnt in higher grades are therefore not included. In addition, the characters from the text do not include all the strokes and structures. Therefore, that may weaken the representativeness of the assessment.

For English handwriting tests such as the most recent Handwriting Speed Test of Wallen, et al (1996), they were normed against children from the Western countries.

In order to truly assess the handwriting speed of children in Hong Kong, the Handwriting Assessment Tool – Speed Test (HATS) developed by Chow et al (2003), which assesses both Chinese and English Handwriting Speed, was used in the present study. The Chinese writing material selected for the test contains characters which include all the strokes based on the stroke classification of Chow (2000). The characters selected are frequently incorrectly written as identified by teachers (Choy & Mui, 2000). The English writing material is a sentence which contains all the 26 letters. In addition, it was normed against local children studying in primary schools. Therefore, HATS was used in the present study for its better representativeness. The test was further elaborated in chapter 4.1.2.

2.5.2 Other Factors Affecting Handwriting Speed

Not only handwriting is a complex skill, there are different factors which may play a role in affecting handwriting performance. The factors of age, gender, school
teaching method, school location and parents’ education were discussed in this section.

*Age and Grade*

Meulenbroek and van Galen (1986) suggested that the coordination of handwriting movements improves with increasing age and years of schooling. The results of various overseas and local studies (Chow et al, 2003; Tseng and Hsueh, 1997; Wallen et al, 1996) were consistent with the above suggestion and revealed significant age effect in the handwriting speed of school-aged children.

*Gender*

Studies examining the gender effect on handwriting performance showed contradicting results. Alston and Taylor (1987), Tseng and Murray (1994) and Opper (1996) revealed that there was a significant gender effect in the handwriting performance of children. They found that boys were in general, had poorer abilities in managing handwriting tasks. Tseng and Hsueh (1997) also showed that there was a significant interaction between grade and gender, in which, girls wrote significantly faster than boys in grades three, four and five. However, Chow and her colleagues (2003) revealed that there was no significant difference in the copying speed between
170 boys and 163 girls of grade one to three. Weng (1999) also did not find significant gender difference in the handwriting performance of 128 pre-school aged children in Hong Kong.

*School Teaching Method*

Chan (1993) showed that children studying in the preparatory types of kindergarten which focuses on developing readiness and pre-writing skills, had better writing skills than children studying in the conventional types of kindergarten which focuses on frequent practices of copying and writing. However, no local study has conducted to investigate the handwriting performance of children studying in different types of primary schools. In the present study, only children studying from the traditional types of primary schools were recruited, as most of the mainstream primary schools in Hong Kong adopt traditional types of teaching.

*School Location*

Opper (1996) showed that children studying in pre-schools of different locations in Hong Kong had significantly different performance in pre-writing skills. However, the direction of the difference was not clear.
Parents' Education

Previous studies revealed that parents' level of education had an impact on children's writing competence (Dunsmuir & Blatchford, 2004) and overall developmental attainment (To et al, 2004). However, there is no local study investigating the relationship between handwriting performance and parents' education among school-aged children.

In summary, there are various possible factors associated to handwriting performance of children. In the present study, since the age, grade and gender of the participants were matched, effect of school location and parents' education in relation to handwriting performance were investigated.

2.6 Assessment of Visual Motor Integration

2.6.1 Instrument of Measuring Visual Motor Instrument

Various kinds of assessment tools which evaluate the performance of visual motor integration were developed. One of that is the Bender-Gestalt Test (Bender, 1938), which is a paper and pencil test which assesses the ability of children from age 4 years 6 months to 8 years 5 months in copying six designs. Although the test shows good inter-rater reliability and test-retest reliability, and local norm is available (Chan, 2001), the test only assesses children of a limited age range. In addition, the test is
mostly accessible to use by psychologists only. The Developmental Test of Visual-Motor Integration (VMI, Beery, 1997) is regarded as one of the most valid and reliable instruments for the assessment of visual-motor integration (Preda, 1997). It is also accessible to use by different professionals, including Occupational Therapists.

As mentioned earlier in chapter 2.2.1, a number of studies, including both overseas and local, revealed a significant relationship between VMI scores and handwriting. Therefore, VMI was used in the present study to examine the visual motor skills of the participants and to evaluate the relationship between handwriting speed and visual motor integration.

2.6.2 Validity and Reliability Issues on Local Use of Instruments Measuring Visual Motor Integration

Since no validation study of VMI has conducted on local school-aged children, evidence of validity and reliability of VMI would need to be established before use for assessing Hong Kong children on their performance of visual motor integration in the present study.

Validity indicates the extent to which an instrument measures what it is intended to measure (Portney & Watkins, 2000). Clinical judgments are strongly influenced by the validity of the assessment instruments that provide the data on which the
judgments are based (Haynes, Richard & Kubany, 1995). Validity is divided into three categories, including content validity, criterion-referenced validity, and construct validity (Dunn, 1989). Content validity is an important component of construct validity as it affects the clinical inferences that can be drawn from the obtained data (Haynes, Richard & Kubany, 1995). According to Haynes, Richard & Kubany (1995), content validity is defined as the degree to which elements of an assessment instrument are relevant to and representative of the targeted construct for a particular assessment purpose. Crocker and Aligna (1986) defined that content validation as the process of assessing whether items of an assessment instrument adequately represented a main domain or construct of targeted interest. A commonly adopted approach in establishing content-related evidence is to construct a panel review in which relevance and representativeness of the test items can be examined (Crocker and Aligna, 1986). As content validity could be changed across population (Marsella & Kameoka, 1989); therefore, the content-related evidence of validity of VMI for use with Hong Kong school-aged children was first established in the present study.

Reliability has been defined as the consistency or stability of empirical indicators between raters or from one measurement to another, as the extent to which measurement is free of random error, and as the ratio of true score variance to
observed score variance (Ottenbacher & Tomchek, 1993). Reliability was fundamental to all aspects of clinical research as the information gathered from the assessment instruments need to be reliable in order for interpretation to be made (Kerlinger, 1986). Reliability studies in rehabilitation commonly include examining of test-retest, inter-rater reliability and internal consistency (Ottenbacher & Tomchek, 1993). When a study involves the comparison of pre-test and post-test in order to examine the effectiveness of an intervention, establishing test-retest reliability of the instrument is important. This is to ensure that the change in scores reflects the impact of the intervention, rather than as a result of time. When the instrument comprises of sub-items that are consolidated to derive sub-skills scores, it is important to establish the reliability of internal consistency. On the other hand, when subjective judgment is involved, establishing of the inter-rater reliability is indicated. Despite the inclusion of scoring guidelines in the manual, the scoring of VMI, to a certain extent still involves subjective judgment of the rater. As VMI only has a total score and the present study did not aim at comparing scores before and after an intervention, only inter-rater reliability of VMI was evaluated in the present study. In the 1996 norming study of VMI (Beery, 1997), two independent raters scored 100 VMI tests of a random sample of the norming group of age 3 to 17. The resulting inter-rater reliability was 0.94, which was considered to be good. However, Renkin and Stokes (1998) argued that
reliability studies which used Pearson Product-Moment correlation coefficient $r$, which was the case in the norming study of VMI, only measured the covariation between raters, rather than measuring the estimates of agreement between or among raters. Therefore, the Intraclass Correlation approach, which uses analysis of variance (ANOVA) to estimate true variance and error variance associated with measurement, was adopted in the present study to determine the inter-rater reliability of VMI.

2.7 Summary

From the literature review, it is clear that children with DCD is a heterogeneous group, experiencing different extent of difficulty in motor coordination and handwriting performance. However, there is a lack of consistent finding in the handwriting speed problem in children with DCD. Although various perceptual motor skills were identified as the possible performance components of handwriting, it was unclear that if these visual perceptual skills identified relate to slow handwriting speed due to limited number of study found. Visual motor integration, on the other hand, appeared to demonstrate more clear relationship to handwriting speed, yet, it is unclear if it relates to both Chinese and English handwriting speed, given the great difference in these two scripts. With strong evidence of deficits of visual motor integration found in children with DCD, it is unclear that if that relates to the slow
handwriting speed found in children with DCD. Therefore, the present study aimed at exploring the extent of handwriting speed problem found in children with DCD and its possible relationship with visual motor integration.
3. Validity and Reliability Study

In this chapter, evidence of validity and reliability of VMI for use with Hong Kong school-aged children was established. This chapter consisted of two parts. In section 3.1, evidence of content validity of VMI was examined. In section 3.2, evidence of reliability of VMI was examined.

3.1 Content – related evidence of validity of VMI

3.1.1 Introduction

According to Crocker and Aligna (1986), content validity is usually established by conducting a panel review, in which the relevance and representativeness of the test items are examined. This section consisted of two parts. The first part (chapter 3.1.2) consisted of the translation of the instructions of VMI into Chinese. The second part (chapter 3.1.3) consisted of the evaluation of the equivalence of the translated instructions, and the evaluation of the relevance and representativeness of VMI in the assessment of the performance of visual motor integration in HK school-aged children, by the expert panel.
3.1.2 Translation of the Test Instructions of VMI into Chinese

Participants

A qualified translator, with a Bachelor Degree in East Asian Studies and a Master Degree of Philosophy in Bilingual Studies, whose native language was Chinese, was invited to participate in the present study. Previously without any knowledge of VMI, the translator forward translated the English verbal instructions of VMI into Chinese. Upon the completion of the forward translation, a primary school teacher was invited to conduct the backward translation. She had a Bachelor Degree in the English Cultural Studies and whose native language was Chinese. The backward translator also did not have any knowledge of VMI.

Instruments

Developmental Test of Visual Motor Integration (VMI, Beery, 1997) is a standardized copy forms-type test which is used primarily as a screening tool to assess proficiency in the integration of visual and motor abilities of children aged from 2 to 15. It contains 24 geometric forms of ascending order of complexity, to be copied in sequence from a test booklet (sample of test items in Fig. 3.1). The participants are required to use HB-pencil to complete the test. They are asked to copy the form on the test booklet and they are not allowed to use eraser to correct the copied form. In the
fourth edition, two supplementary tests, VMI Visual Perception and VMI Motor Coordination are included to compare individual's VMI results with his or her pure visual and motor performances. Since the present study aims at examining the integration of visual and motor skills of DCD children, the two supplementary tests were not utilized.

Fig. 3.1 Sample of test forms: Form 13 to 15

VMI can be administered individually or to a group in about 10 to 15 minutes. Therefore, there are instructions for both individual and group administration. In VMI, the first three test items are for younger children aged below 6 who show difficulty in copying the forms. They are asked to imitate the first three forms before copying the forms. In the present study, the children being administered the test were all school-aged children, children therefore would not be asked to imitate the geometric forms of item one to three. For the instructions for individual administration, they
directed the child to copy the geometric forms printed on the top of the page to the space provided on the space below the printed geometric forms. The child was also guided to start with item four and to try his or her best to copy every form, which include both easy and difficult ones, until three consecutive failures. The child was reminded that there was only one trial for each form. The instructions for group administration were similar to that for individual administration. Additional instructions were provided to remind children not to start the test before the examiner told them to do so. The children were also guided in how to place the test booklet on the table.

Each form is awarded either “1” for pass or “0” for failure. Detailed scoring criteria is included in the test manual for each form to be copied. An example of the scoring criteria of one of the forms was shown in table 3.1.

**Table 3.1: Scoring Criteria of Form 14 (Three-Line Cross)**

<table>
<thead>
<tr>
<th>Scoring Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Three intersecting lines</td>
</tr>
<tr>
<td>2. Intersection gap no more than 1/8” in height</td>
</tr>
<tr>
<td>3. over 1/2 of horizontal line within 15° correct</td>
</tr>
<tr>
<td>4. over 1/2 of both diagonals more than 10° from vertical</td>
</tr>
</tbody>
</table>

The points for each successive, correctly copied from are added to the child’s
score. Scoring was discontinued after three consecutive failures. Age equivalents, percentile and standard scores for VMI raw scores by chronological age levels are provided for comparisons of one’s performance to those of the US normative population.

VMI is regarded as one of the most valid and reliable instruments for the assessment of visual-motor integration (Preda, 1997). VMI was normed in 1996 on 2614 children of age 3 to 18, from five areas of the United States. A total of 26 child care, preschool, public and private school settings participated in the norming study. The inter-rater reliability of two raters on 100 children ranged from $r = 0.58$ to 0.99. The test-retest reliability on 122 children was $r = 0.87$ for an interval of three weeks. For the internal consistency, the odd-even split-half correlation was 0.88, and the coefficient alpha was 0.82.

*Data Collection Procedures and Analysis*

The original instructions were sent to the translator for forward translation and were returned to the author through e-mail. The translated instructions were then submitted to the school teacher for backward translation, which was sent back to the author through e-mail. The two different versions of translation were compared to the
original version of VMI to examine if there was any marked discrepancy in the semantic meaning, and to make any amendment to the test instructions if necessary.

Results and Discussions

The original instructions of VMI, the forward and backward translation of the instructions were shown in appendix 1, 2 and 3. No marked discrepancy was found between the forward translation and the backward translation. Most of the wordings in the backward translations were the same as the original version. Therefore, modification of the translated instructions of VMI was not needed.

3.1.3 Evaluation of the Equivalence of the Translated Instructions, Relevance and Representativeness of VMI by Panel Review

Participants

Potential expert panel members who had over three years of experience working in pediatric setting and at least two years of administering VMI were contacted by the author through telephone. The nature and purpose of the expert panel were explained to the potential panel members on phone. After obtaining verbal consent, formal invitation letter (Appendix 5), which explained the purpose of the study, a content validity questionnaire (Appendix 6), and a consent form (Appendix 7) were sent to the invited panel members.
Eight local Occupational Therapists working in the pediatric setting returned the signed consent forms and the completed questionnaires to the author by mail. The demographic description of the expert panel members were shown in table 3.2. Their experience of working in the pediatric setting ranged from 3.5 to over 15 years. Two experts worked in the out-patient department under the Hospital Authority (HA). Two experts worked in the Non-Government Organizations (NGO). Two experts worked in the Child Assessment Centres (CAC). One expert worked in a Special School for physically handicapped children (PHS). One expert worked in private setting (PS). All expert panel members were female, and had experience administrating VMI, ranging from two to ten years. The frequency of administration of VMI ranged from zero to over fifteen times per month.

**Table 3.2: Demographic Description of the Expert Panel (N = 8)**

<table>
<thead>
<tr>
<th>Expert</th>
<th>Work setting</th>
<th>Years of experience in</th>
<th>Years of experience in</th>
<th>Frequency of administering VMI in a month</th>
</tr>
</thead>
<tbody>
<tr>
<td>One</td>
<td>HA</td>
<td>3.5</td>
<td>3.5</td>
<td>3 - 4</td>
</tr>
<tr>
<td>Two</td>
<td>HA</td>
<td>12</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>Three</td>
<td>NGO</td>
<td>15</td>
<td>10</td>
<td>3 - 5</td>
</tr>
<tr>
<td>Four</td>
<td>CAC</td>
<td>15</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>Five</td>
<td>PHS</td>
<td>6</td>
<td>2</td>
<td>1 - 2</td>
</tr>
<tr>
<td>Six</td>
<td>NGO</td>
<td>10</td>
<td>3</td>
<td>0 - 1</td>
</tr>
<tr>
<td>Seven</td>
<td>CAC</td>
<td>&gt;15</td>
<td>&gt;5</td>
<td>&gt;15</td>
</tr>
<tr>
<td>Eight</td>
<td>PS</td>
<td>11</td>
<td>4</td>
<td>&lt;1</td>
</tr>
</tbody>
</table>

Instruments

A questionnaire was designed, which consisted of questions to evaluate the fluency and semantic equivalence of the translated instructions in comparison to the original instructions; the relevance and representativeness of VMI for use in assessing the ability of visual integration in Hong Kong school-aged children. The questionnaire is shown in Appendix 6. The questions were rated in a 4-point Likert Scale, with “1” indicating strongly disagree; “2” indicating disagree; “3” indicating agree; and “4” indicating strongly agree. In addition to the quantitative rating, space was reserved for each question in the questionnaire for any comments and recommended modifications to the translated instructions and the test items to improve the relevance and representativeness of VMI. An open-ended question was also included in the questionnaire for any other comments or recommended modifications to the Chinese version of VMI.

Data collection Procedures

The purpose of the study, the test construct, the testing procedure and the scoring method of the questionnaire were introduced to the panel members. The panel members were given two weeks to complete the questionnaire. They were asked to return the completed questionnaire and the signed consent forms to the author by
sending them in the attached stamped envelopes.

*Data Analysis*

The mean, standard deviation (SD), and percentage of agreement were calculated. As the questionnaire adopted a 4-point Likert Scale, a mean score at or above 3 indicated that the panel members agreed the equivalence of the translated instructions (in terms of fluency and semantic meaning), the relevance or the representativeness of VMI for use with HK school-aged children. A mean score below 3 indicated that the panel members disagreed the equivalence of the translated instructions, the relevance or the representativeness of VMI. The percentage of agreement reflected the consistency among the panel members. The formula for computing the percentage of agreement for item i and domain k, is equal to the number of judges assigning item i to domain k divided by the total number of judges. Any item reaching 70% agreement was regarded as good items; whereas items below 70% agreement would need to be reviewed for revision (Chan, 1999; Tong, 1999). In addition to the quantitative analysis, the comments of the experts were being analyzed qualitatively to evaluate the equivalence (in terms of fluency and semantic meaning) of the translated instructions, the relevance and representativeness of VMI.
Results

a. Fluency and semantic meaning of the translated instructions of VMI

Table 3.3 summarized the ratings of the fluency of the translated Chinese instructions of VMI. The mean ratings ranged from 2.75 (SD = 0.46) to 3.50 (SD = 0.53). Only the mean rating of section 1 (mean = 2.75, SD = 0.46) and 3 (mean = 2.88, SD = 0.64) of the translation for group administration were below 3. The mean rating of all other sections of the translation for group administration (section 2 and 4) and the translation for individual administration (section 5) were above 3. From the data of cumulative percentage, both the translation for group and individual administration had a satisfactory percentage of agreement on fluency, which ranged from 75% to 100%.

Table 3.3: Ratings of the fluency of the translated Chinese instructions of VMI (N = 8)

<table>
<thead>
<tr>
<th>Instructions</th>
<th>Min.</th>
<th>Max.</th>
<th>Mean</th>
<th>SD</th>
<th>% Strongly</th>
<th>%</th>
<th>%</th>
<th>% Strongly</th>
<th>Cum. %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Disagree</td>
<td></td>
<td></td>
<td>Disagree</td>
<td>Agree</td>
</tr>
<tr>
<td>Section 1</td>
<td>2</td>
<td>3</td>
<td>2.75</td>
<td>0.46</td>
<td>0</td>
<td>25</td>
<td>75</td>
<td>0</td>
<td>25</td>
</tr>
<tr>
<td>Section 2</td>
<td>2</td>
<td>4</td>
<td>3.00</td>
<td>0.53</td>
<td>0</td>
<td>12.5</td>
<td>75</td>
<td>12.5</td>
<td>12.5</td>
</tr>
<tr>
<td>Section 3</td>
<td>2</td>
<td>4</td>
<td>2.88</td>
<td>0.64</td>
<td>0</td>
<td>25</td>
<td>62.5</td>
<td>12.5</td>
<td>25</td>
</tr>
<tr>
<td>Section 4</td>
<td>3</td>
<td>4</td>
<td>3.25</td>
<td>0.46</td>
<td>0</td>
<td>0</td>
<td>75</td>
<td>25</td>
<td>0</td>
</tr>
<tr>
<td>Section 5</td>
<td>3</td>
<td>4</td>
<td>3.50</td>
<td>0.53</td>
<td>0</td>
<td>0</td>
<td>50</td>
<td>50</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 3.4 summarized the ratings of the equivalence of the semantic meaning of the Chinese instructions of the VMI. The mean ratings ranged from 3.25 (SD = 0.53)
to 3.50 (SD = 0.76). All the mean rating of translated instructions for both group and individual administration were above 3. The cumulative percentage of agreement on the equivalence of semantic meaning of the translated instructions of VMI was above 80%, which ranged from 87.5% to 100%.

Table 3.4: Ratings of the equivalence of the semantic meaning of the Chinese instructions of the VMI (N = 8)

<table>
<thead>
<tr>
<th>Instructions</th>
<th>Min.</th>
<th>Max.</th>
<th>Mean</th>
<th>SD</th>
<th>% Strongly Disagree</th>
<th>% Disagree</th>
<th>% Agree</th>
<th>% Strongly Agree</th>
<th>Cum. % &lt; 3</th>
<th>≥ 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section 1</td>
<td>2</td>
<td>4</td>
<td>3.25</td>
<td>0.71</td>
<td>0</td>
<td>12.5</td>
<td>50</td>
<td>37.5</td>
<td>12.5</td>
<td>87.5</td>
</tr>
<tr>
<td>Section 2</td>
<td>2</td>
<td>4</td>
<td>3.25</td>
<td>0.71</td>
<td>0</td>
<td>12.5</td>
<td>50</td>
<td>37.5</td>
<td>12.5</td>
<td>87.5</td>
</tr>
<tr>
<td>Section 3</td>
<td>3</td>
<td>4</td>
<td>3.50</td>
<td>0.53</td>
<td>0</td>
<td>0</td>
<td>50</td>
<td>50</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Section 4</td>
<td>2</td>
<td>4</td>
<td>3.50</td>
<td>0.76</td>
<td>0</td>
<td>12.5</td>
<td>25</td>
<td>62.5</td>
<td>12.5</td>
<td>87.5</td>
</tr>
<tr>
<td>Section 5</td>
<td>3</td>
<td>4</td>
<td>3.50</td>
<td>0.53</td>
<td>0</td>
<td>0</td>
<td>50</td>
<td>50</td>
<td>0</td>
<td>100</td>
</tr>
</tbody>
</table>

Some experts gave other comments on the translations. Two experts recommended Cantonese translation of the instructions and one expert commented that the Chinese translation was not close to “everyday spoken language”. Some experts suggested amendment on some of the wordings of the instructions to make them more fluent. Examples of suggestion of the Chinese translation and change of wordings of the instructions were presented in table 3.5.
Table 3.5: Suggestions of the Chinese Translation

<table>
<thead>
<tr>
<th>Original Chinese Translation</th>
<th>Suggested Chinese Translation</th>
</tr>
</thead>
<tbody>
<tr>
<td>在我未作出指示之前，不可打開冊子。把印有一隻手掌(指尖向上)的一面</td>
<td>在我未作出指示之前，不可打開冊子。把印有一隻手掌(指尖向上)的一面向自己。</td>
</tr>
<tr>
<td>懶向自己。在第 4 頁，最上端的方格內有一些圖案，像這樣子。請你記得，每個圖形你只可以畫一次，你也</td>
<td>懶向自己。在第 4 頁，最上端的方格內有一些圖案，好像這樣。請你記住，每個圖形你只可以畫一次，你也不可以擦掉再畫。</td>
</tr>
<tr>
<td>不可以擦掉再畫。</td>
<td></td>
</tr>
</tbody>
</table>

Further revision of the translation of the instructions was done by the author, which involved change of some of the wordings. The finalized translated instruction was shown in Appendix 4.

b. Relevance of the test items of VMI for use with HK School-Aged Children

A shown in Table 3.6, the mean rating on relevance was 3.13 (SD = 0.35) and the percentage of agreement was 100%, indicating that all the experts rated “3” or above. Therefore they all agreed that all items of the VMI were culturally relevant for use to assess the performance of visual motor integration of children for the present study.
Table 3.6: Ratings of the Relevance of VMI to assess the performance of Visual Motor Integration of Hong Kong School-Aged children (N = 8)

<table>
<thead>
<tr>
<th>Raters</th>
<th>Min.</th>
<th>Max.</th>
<th>Mean</th>
<th>SD</th>
<th>% Strongly Disagree</th>
<th>% Disagree</th>
<th>% Agree</th>
<th>% Strongly Agree</th>
<th>Cum. %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 4 4 3 3 4 3 3</td>
<td>4</td>
<td>3.13</td>
<td>0.35</td>
<td>0</td>
<td>0</td>
<td>87.5</td>
<td>12.5</td>
<td>0</td>
<td>100</td>
</tr>
</tbody>
</table>

Two experts gave other comments on the relevance of VMI. One expert suggested that it would be more relevant to include the ratings of the relative size and position of the geometric form copied in the space provided on the booklet. Her suggestion was based on the justification that Chinese handwriting requires such visual motor skills. Another expert suggested that local norm was needed for VMI as she argued that Hong Kong children was much ahead in handwriting skills than the children in United States, on whom the norming study was conducted. Although the comments made by the experts were very valid, they would not affect the use of VMI in the present study as the raw scores, instead of standard scores were collected and used in data analysis.

c. Representativeness

Table 3.7 summarized the mean ratings on the representativeness. The mean rating was 3.25 (S.D. = 0.71) and the percentage of agreement was 87.5 %, which was considered satisfactory.
Table 3.7: Ratings of the Representativeness of VMI to assess the performance of Visual Motor Integration of Hong Kong School-Aged children (N = 8)

<table>
<thead>
<tr>
<th>Raters</th>
<th>Min.</th>
<th>Max.</th>
<th>Mean</th>
<th>SD</th>
<th>% Strongly</th>
<th>%</th>
<th>% Strongly</th>
<th>Cum.%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Disagree</td>
<td>Disagree</td>
<td>Agree</td>
<td>Agree</td>
</tr>
<tr>
<td>1 2 3 4 5 6 7 8</td>
<td>2 4</td>
<td>4</td>
<td>3.25</td>
<td>0.71</td>
<td>0</td>
<td>12.5</td>
<td>50</td>
<td>37.5</td>
</tr>
</tbody>
</table>

One expert suggested to have the children copy all the 24 geometric forms and the rater should rate all the items instead of rating up to three consecutive failures, as stated in the scoring procedures in the test manual. She argued that the difficulty level of the test items would be different for Hong Kong children.

Discussion

The content validity study result reflected that VMI was a relevant and representative test to assess the ability of visual motor integration of Hong Kong school-aged children. Although some experts suggested the use of Cantonese translation instead of the Chinese translation, Chinese instruction was used in order to make the instructions applicable to Chinese children whose mother's tongue may be of different dialect. The suggestions provided by the experts for improving the semantic equivalence were useful and the translation was therefore revised by the author.
Despite some experts commented that Hong Kong children were ahead in their visual motor skills, no item was suggested to be deleted or added to the test. Since all test forms were arranged in order of ascending complexity, any addition or deletion of an item might change the scoring system and the interpretation of the scores in comparison with the normative population. In addition, one expert suggested rating all items instead of up to three consecutive failures as she argued that the difficulty level of the test might not reflect the ability of Hong Kong children. That again would involve change of scoring instructions, which would be beyond the scope of the present study. Therefore, all the test items remained unchanged and the original scoring instruction was preserved.

3.2 Study of Inter-rater Reliability of VMI

Participants

a. Children Participants

With use of the statistical software PASS, by setting alpha to 0.05 and power to 0.80, the number of participants needed for establishing inter-rater reliability was calculated and 22 children participants would be needed. To obtain 22 children participants, parents of children who completed a VMI test in the last year at the Out-patient Occupational Therapy Department of Kowloon Hospital were approached
by the author. They were explained the purpose of the study when attended the therapy session at the department. A copy of the invitation letter (Appendix 8) was also given to the parents. Upon obtaining verbal consent, they were asked to sign the written consent form (Appendix 9). A photocopy of the signed consent form was given to the parents.

As group homogeneity and variability of subjects’ scores would be factors affecting the reliability coefficient (Portney & Watkins, 2000), the only other inclusion criterion was that children should have similar diagnosis, but with a range of performance level on the VMI to avoid the chance of the scores falling within a restricted range. Twenty-two children participants were subsequently recruited and they were all previously tested with VMI by the author. The demographic description of the children participants was presented in table 3.8.
Table 3.8: Demographic Descriptions of the Children Participants (N=22)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Number of subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td></td>
</tr>
<tr>
<td>6-7</td>
<td>10</td>
</tr>
<tr>
<td>8-9</td>
<td>8</td>
</tr>
<tr>
<td>10-11</td>
<td>4</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>19</td>
</tr>
<tr>
<td>Female</td>
<td>3</td>
</tr>
<tr>
<td>Diagnosis</td>
<td></td>
</tr>
<tr>
<td>DCD</td>
<td>2</td>
</tr>
<tr>
<td>SLD</td>
<td>6</td>
</tr>
<tr>
<td>Fine motor and handwriting problem</td>
<td>14</td>
</tr>
<tr>
<td>VMI raw score</td>
<td></td>
</tr>
<tr>
<td>10-12</td>
<td>3</td>
</tr>
<tr>
<td>13-15</td>
<td>5</td>
</tr>
<tr>
<td>16-18</td>
<td>6</td>
</tr>
<tr>
<td>19-21</td>
<td>6</td>
</tr>
<tr>
<td>22-24</td>
<td>2</td>
</tr>
</tbody>
</table>

b. Raters

The VMI performance of the children participants recruited were scored by two raters independently. The first rater was the author, an occupational therapist who has four years experience of working in pediatric setting and the administration of VMI. The second rater was an occupational therapist, who has worked in pediatric setting for twelve years and has experience in administering VMI for eight years.

Data Collection Procedures

The VMI performance of the 22 children participants were scored independently
by the two raters, according to the scoring criteria in the test manual. Ruler and projector were used by both raters for more accurate scoring which involved measuring of length and the angle of the geometric forms drawn by the examinees. The second rater was given two weeks to return the scored test booklets to the author.

Data Analysis

The Intraclass Correlation (ICC) approach, which estimates the true variance and error variance associated with measurement, has become the most frequently used approach with continuous data (Ottenbacher & Tomchek, 1993). It was used for establishing the inter-rater reliability of the VMI in the present study. Two-way random effect model was used as generalization of result was being aimed at (Portney & Watkins, 2000). Absolute agreement method was adopted as the study aimed at investigating the agreement between the two raters on scoring of the performance by subjects on VMI. By using the SPSS, the ICC value was calculated, with 95% of confidence interval. According to Portney and Watkins (2000), ICC values above 0.75 are indicative of good reliability, and those below 0.75 poor to moderate reliability.

Result and Discussion

Table 3.9 presented the ratings of VMI of 22 children by the two raters. The ICC
of the inter-rater reliability computed by SPSS, was 0.95 (lower: 0.89; upper: 0.98; F
= 40.5315; p < 0.001), which therefore, indicated high level of agreement between the
two raters.

Table 3.9: Ratings of VMI (4th ed) (N = 22)

<table>
<thead>
<tr>
<th>Subjects</th>
<th>1st rater</th>
<th>2nd rater</th>
<th>Subjects</th>
<th>1st rater</th>
<th>2nd rater</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>21</td>
<td>19</td>
<td>12</td>
<td>19</td>
<td>19</td>
</tr>
<tr>
<td>2</td>
<td>18</td>
<td>19</td>
<td>13</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>3</td>
<td>15</td>
<td>16</td>
<td>14</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>4</td>
<td>19</td>
<td>17</td>
<td>15</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>5</td>
<td>12</td>
<td>12</td>
<td>16</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>6</td>
<td>18</td>
<td>17</td>
<td>17</td>
<td>19</td>
<td>20</td>
</tr>
<tr>
<td>7</td>
<td>12</td>
<td>12</td>
<td>18</td>
<td>16</td>
<td>17</td>
</tr>
<tr>
<td>8</td>
<td>16</td>
<td>15</td>
<td>19</td>
<td>20</td>
<td>21</td>
</tr>
<tr>
<td>9</td>
<td>17</td>
<td>17</td>
<td>20</td>
<td>14</td>
<td>15</td>
</tr>
<tr>
<td>10</td>
<td>15</td>
<td>15</td>
<td>21</td>
<td>21</td>
<td>22</td>
</tr>
<tr>
<td>11</td>
<td>26</td>
<td>24</td>
<td>22</td>
<td>21</td>
<td>21</td>
</tr>
</tbody>
</table>

Although the scoring of VMI involved subjective judgment by the raters, the
high level of agreement between the raters as reflected by the high ICC value of
inter-rater reliability revealed that the scoring criteria of the manual was useful in
guiding the raters to score on the VMI performance. It also showed that VMI was a
reliable instrument in assessing the visual motor integration for the purpose of the
present study.
3.3 Conclusion

In summary, the present study showed that the Chinese translation of VMI, in general, has satisfactory fluency and semantic equivalence. It also showed that VMI is relevant and representative in assessing the performance of visual motor integration of Hong Kong children. In addition, it also showed good inter-rater reliability when it involves two experienced raters. Therefore, it revealed preliminary evidence to support the use of VMI in assessing the visual motor integration for the purpose of the present study.
4. Study of Handwriting Speed and Visual Motor Integration

In this chapter, the handwriting speed and the visual motor integration performance of children with and without DCD were examined. The objective of this study was to compare the handwriting speed and visual motor integration performance of school-aged children with and without DCD. In addition, the relationship between visual motor integration and the handwriting speed was also explored. First, the methodology of the study was presented. That was followed by the presentation of the result. The result will be discussed in the following chapter.

4.1 Methodology

4.1.1 Participants

Based on the results (mean scores and SD) of a previous study (Chui, 2000), with use of the statistical software PASS, setting alpha to 0.05 and power to 0.80, it was calculated that a total of 48 participants (24 in each group) would be needed. The following inclusion criteria were applied in the recruitment of the participants:

For both DCD and control group, children should:

- be aged between 6-0 to 10-11 months old, studying in primary one to four
- not have any formal diagnosis of or identifiable behavioral problems such as
Attention Deficit Disorder and Oppositional Defiant Disorder

- not have any formal diagnosis of or identifiable problems in sensory functions
- not have any visual impairment not correctable by wearing of visual aids
- not have repeated the same class
- use Cantonese as their first language
- attend a school or preschool in Hong Kong in the previous two years to equalize handwriting exposure
- have parental consent to participate in the research

For the DCD group, children should:

- have an established diagnosis of DCD made at Child Assessment Centres
- not have any cognitive dysfunctions

For the Control group, children should:

- score above 30th percentile on Movement-ABC, which indicated a normal range of motor coordination ability
- not have special educational needs, or history of receiving remedial or tutorial services from school or Education and Manpower Bureau
Sampling Procedures – DCD Group

Convenient sampling method was adopted to recruit subjects with DCD. Parents of potential children participants with DCD were approached by the author when they attended the out-patient Occupational Therapy Department of Kowloon Hospital. The purpose of the study, the nature and procedures of the assessments were explained. A formal invitation letter (Appendix 10) was also given to them. Upon receiving verbal consent, a written consent form (Appendix 11), and a supplementary information form (Appendix 12) were given to the parents. The parents were asked to sign the consent forms and completed the supplementary information form before assessment of handwriting speed and visual motor integration performance. Only children who met the inclusion criteria described above were recruited in the DCD group. A photocopy of the signed consent form was given to the parents of the subjects.

Sampling Procedures – Control Group

The subjects recruited in the control group were individually matched to the DCD group according to age (within six-month difference), grade, gender, and present school teaching approach i.e. traditional or activity approach.
A list of primary schools in Hong Kong was downloaded from the website of the Education and Manpower Bureau. In the list, the primary schools were categorized into different sections according to the district the schools located in. A number was randomly drawn from the list, and the school which was listed under that number was selected. The school principal was then approached by the author through telephone. The purpose of the study; the nature and the procedures of the assessments were explained to the school principals. Upon receiving verbal consent from the school principal, the invitation letter to the school principal (Appendix 13), the invitation letter to the parents (Appendix 14), the consent form (Appendix 15), and the supplementary information form (Appendix 16) were faxed to the school principal. Copies of invitation letter to the parents, consent forms, and supplementary information forms were sent to the school principals for distribution to the parents of potential children participants. The school principal was instructed to randomly select a class in each grade of primary one to four. In the selected class, a number of boys and girls were randomly selected according to their assigned student number. The number of boys and girls selected in the particular grade was matched with the number of boys and girls recruited DCD subjects. The parents of the randomly selected potential subjects were given the invitation letter, the consent form, and the supplementary information form. The parents who agreed to have their children
participate in the study, were asked to sign the consent forms and completed the supplementary information forms, and returned them to the class master or mistress. The signed consent forms and the completed supplementary information forms were collected by the author from the class masters or mistresses of the selected school on the day of assessment. Only students who met the criteria described above and matched with the DCD group subjects according to the age, grade, gender, and school teaching approach were recruited in the control group. A photocopy of the signed consent form was given to the parents of the children. Since not all the participants recruited from the first school selected matched the inclusion criteria and the demographic variables of the DCD subjects, two other schools were selected and approached by the author in the same way to recruit the required number for the control group.

4.1.2 Instruments

Developmental Test of Visual-Motor Integration (VMI)

The same instrument together with the Chinese instructions were used in the validation study presented in section 3.1.2.

Handwriting Assessment Tool – Speed Test (HATS, Chow, 2003)

HATS was a standardized test that assesses Chinese and English handwriting
speed of children (number of characters and number of letters copied per minute). It consisted of a Chinese and an English test item. The test started with a practice item, in which 30 seconds were given for the children to copy a simple character. It was followed by the Chinese item, in which five minutes were given for the children to copy nine two-character phrases. A sample of the Chinese item was presented in Fig. 4.1. Lastly, children were given three minutes to complete the English item, in which they were asked to copy the sentence “The quick brown fox jumps over the lazy dog”. The sentence contained all 26 alphabets. The whole test lasted for about 10 minutes. The participants were required to use HB-pencil without erasers to complete all tests. They were asked to write as quickly and legibly as possible and not to stop for correcting mistakes.

Fig. 4.1 Sample of Chinese item of HATS
Scoring followed standardized scoring criteria which was listed in table 4.1. The validation study (Chow et al, 2003) showed that the test has good inter-rater reliability between two independent raters (0.95 on Chinese items, and 0.99 on English item), test-retest reliability over one-week interval (0.94 on Chinese items, and 0.89 on English item). Inter-item correlation coefficient was 0.87, which indicated that the test has good internal consistency. HATS also significantly correlated with the Chinese Handwriting Test ($r = 0.91$) (Tseng & Hsueh, 1997) and with Handwriting Speed Test ($r = 1.00$) (Wallen et al, 1996). Norming study based on 333 children from grade one to three was conducted, in which the test showed the presence of grade effect, indicating that handwriting speed increased with grade level.

Table 4.1: Scoring Criteria for the HATS

<table>
<thead>
<tr>
<th>A. Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. All recognizable characters/letters produced regardless of their legibility, accuracy, placement, or case (in English). This includes repetition or substitution by another recognizable character/letter or those that have been crossed out.</td>
</tr>
<tr>
<td>2. Two or more characters/letters overlapped (such as correction on top of the original) are counted as one.</td>
</tr>
<tr>
<td>3. Characters/letters that were crossed out are counted but not the crossing-out mark itself.</td>
</tr>
<tr>
<td>B. Do not count</td>
</tr>
<tr>
<td>1. Spaces or punctuation marks.</td>
</tr>
<tr>
<td>2. Character/letters that have two or more strokes added or omitted.</td>
</tr>
<tr>
<td>3. Final character/letters that are not completed.</td>
</tr>
</tbody>
</table>

(Chow et al, 2003)
**Movement Assessment Battery for Children (Movement-ABC)**

In order to make sure the participants recruited in the control group did not have DCD, Movement-ABC was used as a screening instrument in the present study. Movement-ABC is a standardized test which assesses three main areas: manual dexterity, ball skills, static and dynamic balance on children aged 4 to 12. Participants were to complete eight sets of assigned tasks according to their age, including three items of manual dexterity, two items of ball skills, one item of static balance, and two items of dynamic balance. The whole test lasted for about 30 minutes. The description of each item was listed in table 4.2.

**Table 4.2: Description of the items of Movement-ABC**

<table>
<thead>
<tr>
<th>Test Area</th>
<th>4 to 6 years</th>
<th>7 to 8 years</th>
<th>9 to 10 years</th>
<th>11 to 12 years</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Manual Dexterity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Posting coins</td>
<td>Placing pegs</td>
<td>Shifting pegs</td>
<td>Turning pegs</td>
<td></td>
</tr>
<tr>
<td>Threading beads</td>
<td>Threading lace</td>
<td>Threading nuts on bolt</td>
<td>Cutting out elephant</td>
<td></td>
</tr>
<tr>
<td>Bicycle trail 5 mm</td>
<td>Flower trail 3 mm</td>
<td>Flower trail 2.5 mm</td>
<td>Flower trail 1 mm</td>
<td></td>
</tr>
<tr>
<td><strong>Ball Skill</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Catching bean bag</td>
<td>One-hand bounce and catch</td>
<td>Two-hand catch</td>
<td>One-hand catch</td>
<td></td>
</tr>
<tr>
<td>Rolling ball</td>
<td>Throwing beanbag into box</td>
<td>Throwing beanbag into box</td>
<td>Throwing at wall target</td>
<td></td>
</tr>
<tr>
<td><strong>Static and Dynamic Balance</strong></td>
<td>One-leg balance</td>
<td>Stork balance</td>
<td>One-board balance</td>
<td>Two-board balance</td>
</tr>
<tr>
<td>Jumping over cord</td>
<td>Jumping in squares</td>
<td>Hopping in squares</td>
<td>Jumping over cord and clapping</td>
<td></td>
</tr>
<tr>
<td>Walking heels raised</td>
<td>Heel-to-toe walking</td>
<td>Walking while balancing ball</td>
<td>Walking backwards</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The child's performance on the test is scored in several ways. Raw scores, such as the number of seconds taken to complete a test, the number of catches made, or the number of deviations made when completing a trail are recorded. The raw scores are then converted into scaled scores for comparison with the normative sample. The total impairment score is determined by adding up all the scaled scores. From the total impairment score, one can determine at what percentile the child's performance falls into. According to the test manual, total impairment scores falling below the fifth percentile is indicative of a definite motor problem, while scores falling between the fifth and the fifteen percentile suggests borderline motor difficulty. The norms of the Total Impairment Scores of different age bands were established in 1992, on 1234 children of aged 4 to 12 from the United States (Henderson & Sugden, 1992).

It was found that the Total Impairment Scores of the Movement-ABC correlated well to the composite score of BOTMP, with the correlation coefficient of 0.53. Studies had also showed that Movement-ABC could successfully differentiate children with and without motor difficulties (Mutch et al, 1992; Marlow et al, 1989; Levene et al, 1992). The test-retest reliability was examined and the results were 97% agreement for age 5, 91% agreement for age 7 and 73% agreement for age 9.
Movement-ABC has also found to be reliable for Hong Kong children. In Chow, Barnett and Henderson's study (2001) on 255 Hong Kong children, it was found that the inter-rater reliability of the Chinese version of Movement-ABC was 0.98; and the test-retest reliability was 0.78. In Chow et al's study (2003) on 225 Taiwan and 741 US school-aged children, cross-cultural difference was found in the performance between US and HK children, in which HK children were found to have better performance in bimanual dexterity tasks, whereas the US children performed better in uni-manual dexterity tasks and projectile tasks.

Although in most of the research studies, a cut-off point of 15th percentile was usually used in screening for DCD according to the review by Geuze et al (2001), 30th percentile was set as the cut-off point in the present study. This was based on the rationale that discrepancy in performance was found between children in Hong Kong and US. In order to ensure that the participants selected for the control group did not have any motor impairment, the cut-off point was set at the 30th percentile instead of the 15th percentile in the present study.

Supplementary Information Form

Supplementary information (please refer to Appendix 12 and 16) was collected
from parents of the children participants of both groups. For the DCD group, the information needed to be completed include the child’s sex, date of birth, grade, school location, hand dominance, ability of speaking fluent Cantonese, history of repeating the same class, history of schooling in Hong Kong, presence of other developmental disabilities, and parents’ education level. For the control group, the information needed to be completed include the child’s sex, date of birth, grade, school location, hand dominance, ability of speaking fluent Cantonese, history of repeating the same class, history of schooling in Hong Kong, history of receiving school remedial service, presence of any developmental disabilities, and parents’ education level.

4.1.3 Data Collection Procedures

DCD Group

On the day of assessment, the participants were tested individually with the HATS by the author. The Chinese items were administered first, followed by the English items. After completing the handwriting test, the participants were tested individually by the author with VMI for 15 minutes. The HATS scores (number of Characters and number of letters copied per minute) and the VMI raw score of each participant were recorded. The HATS and VMI results of five participants were
randomly chosen and scored again by the author a month later to ensure reliability of scoring. The supplementary information form was collected before commence of assessments to rule out participants not meeting the inclusion criteria.

**Control Group**

On the day of assessment, the supplementary information forms were collected before commence of assessments. Those meeting the inclusion criteria were first tested individually with Movement-ABC by the author. Only children who scored above 30th percentile on the test were then tested with HATS, followed by VMI. The administration of the HATS and VMI followed the same procedures as that in the DCD group, except that the control participants were tested in groups, with participants of the same grade forming a group. The size of the group ranged from two to four. The HATS scores and the VMI raw score of each participant were recorded. The HATS and VMI results of five participants were randomly chosen and scored again by the author to ensure reliability of scoring.

**4.1.4 Data Analysis**

In order to examine the differences between the handwriting speed of children in the DCD and control group, therefore testing the hypothesis of the presence of
significant difference in handwriting speed and visual motor integration of children with and without DCD, Chi-square test was performed to determine if school location and parents' education was found to be related to the HATS scores and VMI raw scores. MANOVA test was then performed to examine if there was a significant difference in the handwriting speed and visual motor integration performance between the participants in the DCD and control group. Comparison was made between the handwriting speed of children with DCD in the present study and the handwriting speed of the children in Chow et al's study (2003).

In order to test the hypothesis of the presence of significant relationship between handwriting speed and visual motor integration, the Pearson Product-Moment Correlation Analysis was performed. According to Portney and Watkins (2000), value of $r$ between 0.00 to 0.25 reveals little relationship; 0.25 to 0.69 moderate relationships; 0.90 to 1.00 strong relationships. The relationship was further examined through the regression analysis to determine if VMI raw score, among other factors including gender and grade was a significant predictor of the handwriting speed of the participants in the two groups. Another regression analysis was also performed to investigate if the difference in VMI raw scores between the two groups would significantly predict the difference in handwriting speed between the two groups.
4.2 Result

In this section, the result of the comparison of the handwriting speed and the performance of VMI between the DCD and control group was presented. In addition, the relationship of handwriting speed and visual motor integration through the use of correlation and regression analysis was also presented.

4.2.1 Analysis of Difference in the Handwriting Speed and VMI Performance between DCD and Control Groups

Demographic data of the DCD and control group was summarized in table 4.3. All control participants recruited achieved above 30\textsuperscript{th} percentile in the Movement-ABC test. Eight participants from grade one, six participants from grade two, five participants from grade three and five participants from grade four were recruited from each group. The age of the participants ranged from 6.08 to 10.58 years (8.30 ± 1.20). The mean age of the DCD group was 8.21 (SD = 1.24); whereas the mean age of the control group was 8.40 (SD = 1.19). Most of the participants were boys, only three girls were recruited in each group. All participants went to schools which adopted traditional method of teaching. The schools of the DCD group located in Kowloon (n = 20) and the New Territories (n = 4). The school of the control group located in all three main areas of Hong Kong, with nine located in Hong Kong Island, eleven located in Kowloon and four located in the New Territories. The parents'
education level varied among the participants in both groups. In the DCD group, two parents of the participants had primary school level; fifteen parents of the participants attained secondary school level; and seven parents of participants attained university level. In the control group, six parents of the participants had primary school level; fourteen parents of the participants attained secondary school level; and four parents of participants attained university level.

Table 4.3: Demographic data of the DCD and control group (N = 48)

<table>
<thead>
<tr>
<th></th>
<th>DCD (n=24)</th>
<th>Control (n=24)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>8.21</td>
<td>8.40</td>
</tr>
<tr>
<td>S.D.</td>
<td>1.24</td>
<td>1.19</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>21</td>
<td>21</td>
</tr>
<tr>
<td>Female</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>School location</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hong Kong Island</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>Kowloon</td>
<td>20</td>
<td>11</td>
</tr>
<tr>
<td>New Territories</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>School teaching method</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traditional approach</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td>Activity approach</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Parents' education level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Secondary</td>
<td>15</td>
<td>14</td>
</tr>
<tr>
<td>University</td>
<td>7</td>
<td>4</td>
</tr>
</tbody>
</table>
Group Differences

From the results of the Chi-Square test (please refer to table 4.4), it revealed that school location and parents’ education did not associate with Chinese and English handwriting speed, and VMI scores.

Table 4.4 Results of Chi-Square Test

<table>
<thead>
<tr>
<th></th>
<th>Characters copied per minute</th>
<th>Letters copied per minute</th>
<th>VMI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>School location</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pearson’s chi-square</td>
<td>59.72</td>
<td>92.23</td>
<td>29.42</td>
</tr>
<tr>
<td>Significance level</td>
<td>0.63</td>
<td>0.30</td>
<td>0.29</td>
</tr>
<tr>
<td><strong>Parents’ education</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pearson’s chi-square</td>
<td>63.97</td>
<td>85.34</td>
<td>44.71</td>
</tr>
<tr>
<td>Significance level</td>
<td>0.48</td>
<td>0.50</td>
<td>0.13</td>
</tr>
</tbody>
</table>

Descriptive statistics (mean and SD) of the HATS scores (number of character and number of letter copied per minute) and the VMI raw score for both the DCD and the control group was summarized in table 4.5. MANOVA results revealed significant differences between the DCD and control groups in Chinese handwriting speed ($F = 6.67, p<0.05$); English handwriting speed ($F = 5.69, p<0.05$); and VMI raw scores ($F = 46.31, p<0.001$).
Table 4.5: Descriptive Statistics of the HATS scores and VMI raw scores and between group effect on handwriting speed and VMI performance

<table>
<thead>
<tr>
<th></th>
<th>DCD</th>
<th>Control</th>
<th>Between groups effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characters copied/minute</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M (SD)</td>
<td>7.23 (2.73)</td>
<td>9.42 (3.15)</td>
<td>6.67</td>
</tr>
<tr>
<td>Letters copied/minute</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M (SD)</td>
<td>42.10 (15.12)</td>
<td>52.12 (13.96)</td>
<td>5.69</td>
</tr>
<tr>
<td>VMI raw scores</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M (SD)</td>
<td>17.04 (2.60)</td>
<td>21.79 (2.23)</td>
<td>46.31</td>
</tr>
</tbody>
</table>

*p < 0.05   **p < 0.01

The control group on average, had a faster copying speed of Chinese characters and English letters, and had higher VMI scores than the DCD group. For the DCD group, the mean number of characters copied per minute was 7.23 (SD = 2.73); whereas the mean number of characters copied per minute was 9.42 (SD = 3.15) for the control group; with a difference of 2.19 characters per minute. When comparing the English handwriting speed, the DCD group copied 42.1 letters per minute (15.12); whereas the control group copied 52.12 letters per minute (SD = 13.96); with a difference of 10.02 letters per minute. The DCD group had a mean VMI raw score of 17.04 (SD = 2.60), whereas the control group had a mean VMI raw score of 21.79 (SD = 2.60); with a difference of 4.75. The standard deviation of the number of letters copied per minute were quite large in both groups, when comparing to that of the Chinese handwriting speed and the VMI raw scores.
Grade Differences

The difference of Chinese handwriting speed between the DCD and the control group was greater in higher grades (with a difference of 1.20 characters/min in grade three and 4.10 characters/min in grade 4) than lower grades (with a difference of 0.40 character/min in grade one and 1.90 character/min in grade two). Whereas for English handwriting speed, the difference between the DCD and the control group increased from 6.79 letters/min in grade one, to 15.40 letters/min in grade three. However, the difference dropped drastically to 3.96 letters/min in grade four. The handwriting speed at each grade of the two groups is presented in fig. 4.2.

Fig. 4.2 Handwriting Speed at each Grade of the DCD and Control Group

According to table 4.6, the difference in the VMI raw scores between the two groups at each grade was quite close which ranged from 4.2 to 5.17.
Table 4.6 Comparison of VMI Raw Scores of the DCD and Control Group

<table>
<thead>
<tr>
<th>Grade</th>
<th>n</th>
<th>Mean raw score (SD)</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8</td>
<td>15.00 (1.77)</td>
<td>19.88 (1.81)</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>17.33 (2.07)</td>
<td>22.50 (1.87)</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>18.00 (2.83)</td>
<td>22.20 (1.64)</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>19.00 (2.35)</td>
<td>23.60 (1.82)</td>
</tr>
</tbody>
</table>

Individual Differences

Individual differences were noted. Two children of the DCD group wrote faster in Chinese than their matched controls and the difference in speed ranged from 0.2 to 0.4 characters/min. Six children of the DCD group wrote faster in English than their matched controls and the difference in speed varied from 2 to 27.3 letters/min. For the performance in VMI, except one participant who had the same VMI raw scores as the matched control, all other participants in the DCD group obtained lower VMI raw scores than their matched controls. The difference on VMI raw scores between the groups ranged from 1 to 8. The HATS scores and the VMI raw scores of each individual paired DCD-control are presented in table 4.7.
Table 4.7: HATS scores and the VMI raw scores of each individual paired DCD-control subject

<table>
<thead>
<tr>
<th>Pair</th>
<th>Gender</th>
<th>Grade</th>
<th>Chinese</th>
<th>English</th>
<th>VMI</th>
<th>Pair</th>
<th>Gender</th>
<th>Grade</th>
<th>Chinese</th>
<th>English</th>
<th>VMI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DCD</td>
<td>1</td>
<td>6.6</td>
<td>32.0</td>
<td>13</td>
<td>13</td>
<td>DCD</td>
<td>2</td>
<td>5.6</td>
<td>30.3</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>girl</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>boy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Control</td>
<td>1</td>
<td>6.0</td>
<td>32.0</td>
<td>20</td>
<td>14</td>
<td>Control</td>
<td>2</td>
<td>8.2</td>
<td>47.0</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>boy</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>boy</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>DCD</td>
<td>1</td>
<td>5.6</td>
<td>32.0</td>
<td>17</td>
<td>15</td>
<td>DCD</td>
<td>3</td>
<td>11.0</td>
<td>58.3</td>
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<tr>
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</tr>
<tr>
<td>4</td>
<td>Control</td>
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<td>33.7</td>
<td>14</td>
<td>16</td>
<td>Control</td>
<td>3</td>
<td>9.9</td>
<td>42.7</td>
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<td>5</td>
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<td>41.7</td>
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<td>DCD</td>
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<td>74.0</td>
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</tr>
<tr>
<td>6</td>
<td>Control</td>
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<td>37.0</td>
<td>19</td>
<td>18</td>
<td>Control</td>
<td>3</td>
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<td>55.7</td>
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</tr>
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<td>7</td>
<td>DCD</td>
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<td>6.2</td>
<td>37.7</td>
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<td>19</td>
<td>DCD</td>
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</tr>
<tr>
<td>8</td>
<td>Control</td>
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<td>5.8</td>
<td>32.7</td>
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<td>20</td>
<td>Control</td>
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<td>9.8</td>
<td>61.3</td>
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<td>35.7</td>
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<td>Control</td>
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<td>75.7</td>
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<td>41.7</td>
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<td>Control</td>
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<td>11.0</td>
<td>78.0</td>
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<tr>
<td>13</td>
<td>DCD</td>
<td>2</td>
<td>5.6</td>
<td>35.7</td>
<td>18</td>
<td>25</td>
<td>DCD</td>
<td>4</td>
<td>9.2</td>
<td>58.3</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>boy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>boy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Control</td>
<td>2</td>
<td>8.6</td>
<td>46.7</td>
<td>25</td>
<td>26</td>
<td>Control</td>
<td>4</td>
<td>12.4</td>
<td>51.0</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>boy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>boy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>DCD</td>
<td>2</td>
<td>6.8</td>
<td>39.7</td>
<td>14</td>
<td>27</td>
<td>DCD</td>
<td>4</td>
<td>8.8</td>
<td>70.0</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>boy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>boy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Control</td>
<td>2</td>
<td>7.2</td>
<td>54.3</td>
<td>20</td>
<td>28</td>
<td>Control</td>
<td>4</td>
<td>14.5</td>
<td>57.7</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>boy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>boy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>DCD</td>
<td>2</td>
<td>8.2</td>
<td>37.3</td>
<td>18</td>
<td>29</td>
<td>DCD</td>
<td>4</td>
<td>7.6</td>
<td>33.7</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>boy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>boy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Control</td>
<td>2</td>
<td>8.6</td>
<td>41.3</td>
<td>23</td>
<td>30</td>
<td>Control</td>
<td>4</td>
<td>13.2</td>
<td>58.7</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>boy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>boy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>DCD</td>
<td>2</td>
<td>7.2</td>
<td>39.7</td>
<td>20</td>
<td>31</td>
<td>DCD</td>
<td>4</td>
<td>13.0</td>
<td>33.0</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>boy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>boy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Control</td>
<td>2</td>
<td>8.4</td>
<td>61.0</td>
<td>24</td>
<td></td>
<td>Control</td>
<td>4</td>
<td>13.2</td>
<td>74.7</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>boy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>boy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comparison of the Handwriting Speed of the Chow et al's study (2003) and the Present Study

According to table 4.8, it was found that the children with DCD from grade one and two in the present study had a faster Chinese handwriting speed than the group of children of the same grade in Chow et al's study; whereas the children with DCD
from grade three had a slower handwriting speed than the group of children of the same grade in Chow et al’s study. For the English handwriting speed, children with DCD from grade one in the present study wrote faster, but children from grade two and three wrote slower than the group of children of the same grade in Chow et al’s study.

Table 4.8 Comparison of the Handwriting Speed of the Chow et al’s study (2003) and the Present Study

<table>
<thead>
<tr>
<th>Grade</th>
<th>Chow et al’s Study (2003)</th>
<th>Present Study</th>
<th>Chow et al’s Study (2003)</th>
<th>Present Study</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N = 333</td>
<td></td>
<td>Control Group</td>
<td>DCD Group</td>
</tr>
<tr>
<td></td>
<td>Chinese</td>
<td>English</td>
<td>Chinese</td>
<td>English</td>
</tr>
<tr>
<td></td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
</tr>
<tr>
<td></td>
<td>Characters/min</td>
<td>Letters/min</td>
<td>Characters/min</td>
<td>Letters/min</td>
</tr>
<tr>
<td>1</td>
<td>4.32 (1.40)</td>
<td>30.19 (5.44)</td>
<td>8</td>
<td>6.53 (1.17)</td>
</tr>
<tr>
<td>2</td>
<td>8.19 (2.18)</td>
<td>34.66 (13.62)</td>
<td>6</td>
<td>9.00 (2.52)</td>
</tr>
<tr>
<td>3</td>
<td>10.63 (2.78)</td>
<td>66.97 (13.72)</td>
<td>5</td>
<td>10.64 (1.23)</td>
</tr>
<tr>
<td>4</td>
<td>/</td>
<td>/</td>
<td>5</td>
<td>14.14 (1.97)</td>
</tr>
</tbody>
</table>

"/" Not available in Chow et al’s Study

4.2.2 Analysis of the Relationship between Handwriting Speed and Visual Motor Integration

4.2.2.1 Correlation Analysis

The Pearson Product-Moment Correlation Analysis as presented in table 4.9, revealed moderate but significant relationships between VMI performance and Chinese handwriting speed ($r = 0.62$, $p < 0.001$); and VMI performance and English handwriting speed ($r = 0.41$, $p < 0.01$) in all children. When examining at group level,
moderate but significant relationships between VMI performance and Chinese handwriting speed were also found in the DCD group ($r = 0.65, p < 0.01$) and the control group ($r = 0.48, p < 0.05$). However, the relationship between the VMI performance and the English handwriting speed was not significant in both the DCD group ($r = 0.22, p = 0.302$) and control group ($r = 0.32, p = 0.126$).

<table>
<thead>
<tr>
<th>Table 4.9: Result of Pearson Product-Moment Correlation Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>VMII:Chinese.</td>
</tr>
<tr>
<td>--------------------------------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>DCD group (n = 24)</td>
</tr>
<tr>
<td>Control group (n = 24)</td>
</tr>
</tbody>
</table>

*p < 0.05; **p < 0.01

4.2.2.2 Regression Analysis

The result of the regression analysis of the Chinese and English handwriting speed of the DCD and control group, as presented in table 4.10, revealed that the VMI raw score and gender were not significant predictors of the both the Chinese and English handwriting speed for both the DCD and control group. However, grade was a significant predictor of the Chinese and English handwriting speed for the DCD group, accounting for 62.2% ($p < 0.05$) of the variation. Grade was found to be a significant predictors of the both the Chinese and English handwriting speed for both the DCD and the control group, accounting for 70% ($p < 0.01$) of the variation in the
Chinese handwriting speed in the DCD group, and 83% (p < 0.01) in the control group; and 42% (p < 0.01) of the variation in the English handwriting speed of the DCD group, and 62% (p < 0.01) in the control group.

Table 4.10: Result of Regression Analysis of Chinese and English Handwriting Speed

<table>
<thead>
<tr>
<th></th>
<th>Chinese handwriting speed</th>
<th>English handwriting speed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DCD</td>
<td>Control</td>
</tr>
<tr>
<td>VMI raw scores</td>
<td></td>
<td></td>
</tr>
<tr>
<td>p</td>
<td>0.119</td>
<td>0.470</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>p</td>
<td>0.324</td>
<td>0.127</td>
</tr>
<tr>
<td>Grade</td>
<td></td>
<td></td>
</tr>
<tr>
<td>p</td>
<td>0.001**</td>
<td>&lt;0.01**</td>
</tr>
<tr>
<td>Adjusted R Square</td>
<td>0.70</td>
<td>0.83</td>
</tr>
</tbody>
</table>

When performing the regression analysis to determine the relationship of the difference in VMI between the DCD and the control group and the difference in handwriting speed between the two groups, it was found that difference in VMI was not able to significantly predict the difference in handwriting speed between the two groups. The result is presented in table 4.11.
Table 4.11 Result of Regression Analysis of the Difference in Handwriting Speed

<table>
<thead>
<tr>
<th></th>
<th>Difference in Chinese handwriting speed</th>
<th>Difference in English handwriting speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Difference in VMI raw scores</td>
<td></td>
<td></td>
</tr>
<tr>
<td>p</td>
<td>0.377</td>
<td>0.182</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>p</td>
<td>0.873</td>
<td>0.203</td>
</tr>
<tr>
<td>Grade</td>
<td></td>
<td></td>
</tr>
<tr>
<td>p</td>
<td>0.107</td>
<td>0.576</td>
</tr>
<tr>
<td>Adjusted R Square</td>
<td>0.114</td>
<td>0.035</td>
</tr>
</tbody>
</table>

4.2.3 Summary

The present study showed that there was a significant difference in Chinese and English handwriting speed, and the VMI performance between children in the DCD and control group. In addition, a moderate but significant relationship was found between the VMI performance and the Chinese handwriting speed, but not English handwriting speed of the participants. Grade was a significant predictor of both the Chinese and English handwriting speed in both DCD and control group. However, neither did VMI nor gender was found to be a significant predictor for the handwriting speed in both groups. The difference in VMI raw scores between the two groups was also not a significant predictor of the difference of handwriting speed between the two groups. The result was discussed in chapter five.
5. Discussions

5.1 Comparison of Handwriting Speed of Children with and without DCD

*Do children with DCD have a slower handwriting speed?* Although the results of the present study showed that as a group, children with DCD wrote significantly slower than children without DCD, which support the findings of other studies (Chui, 2000; Henderson, 1992; Sovik et al, 1987), individual differences were found. According to table 4.5, two children of the DCD group wrote faster in Chinese than their matched controls, and six children of the DCD group wrote faster in English than their matched controls. In addition, when comparing the present study to the Chow et al's study (2003), it showed that children with DCD from grade one and two in the present study actually wrote slightly faster than the group of children of the same grade in Chow et al's study. One of the reasons might be due to the heterogenic nature of DCD. As mentioned earlier, some studies found children with DCD present with different subtypes (Dewey & Kaplan, 1994; Hoare, 1994; Macnab et al, 1999; Miyahara, 1994; Wright & Sugden, 1996a). Some of them may not have fine motor problems, which has been found to be associated with handwriting problems (Cornhill & Case-Smith, 1996; Lam, 2001). In fact, a local study by Chan et al (2004) found that 35% of children with DCD diagnosed at the Child Assessment Centre within a
period presented with gross motor problems only. These children may not have fine motor problem, they therefore would not have slow handwriting speed.

Another reason accounting for the faster handwriting speed noted in individual participants with DCD is the issue of trading of legibility for speed. When reviewing the handwriting output of the participants, it was found that there was a great discrepancy of handwriting legibility and accuracy between children with and without DCD. For those in the DCD group who wrote faster than the matched controls, their handwriting was generally less legible and less accurate. The handwriting problems found included poor stroke formation, proportioning of radicals, alignment of strokes and radicals, addition and omission of strokes (please refer to Fig. 5.1 for an example). Therefore, the children with DCD may trade off legibility and accuracy for speed. If this is in fact the case, this is consistent with the Fitts' Law (Maruff et al, 1999), one of the most robust phenomena in motor control. It describes a logarithmic relationship between the speed and accuracy of movement. It states that the time required to complete a movement is constrained by the required accuracy of the movement. Therefore, instead of trading speed for accuracy, children may trade off accuracy for speed.
A third reason accounting for the faster handwriting speed in some children with DCD is that the handwriting speed problem might not be very prominent, or even might be hidden in lower grades, as compared to higher grades. Although children with DCD from grade one and two in the present study wrote faster than children of the same grade in Chow et al's study (2003), children with DCD from grade three in the present study wrote slower than children of the same grade from Chow et al's
study. As children reach higher grades, those with DCD may lag behind their peers in their handwriting speed. Chui (2000) found that in her study, children with DCD from grade one and two wrote only about 1 to 2 characters slower per minute than the control group, as against 4 to 5 characters slower in children from grade three and four. This may reflect the fact that the handwriting speed problem when comparing to their peers, would become more prominent and evident as they grow older. However, this assumption is very speculative for two reasons. First, the present study did not recruit children of older than grade four. Therefore, whether or not the difference of handwriting speed would become greater in grade five and six is unknown. In addition, the present study examined only cross-sectional data rather than longitudinal ones.

5.2 Other Factors affecting Handwriting Speed

The present study is consistent with the findings of previous studies that years of schooling as reflected in the grade that the child enrolled in, is a significant predictor of the handwriting speed of children with and without DCD (Chow et al, 2003; Meulenkoek & van Galen, 1986; Tseng & Chow, 2000; Tseng & Hsueh, 1997; Wallen et al, 1996).
Although significant gender difference on handwriting speed was found in previous studies (Tseng & Hsueh, 1997; Wallen et al., 1996), the present study did not find gender to be a significant factor or predictor of the handwriting speed of the participants. This may be due to the fact that only a small number of girls were recruited in the present study as reflected by a much higher prevalence of DCD in boys than in girls. However, similar findings were also noted in other studies (Chow et al., 2003; Man & Chan, 2000). Chow and her colleagues argued that a lack of gender difference might due to the early start of handwriting training in preschools in Hong Kong. With repetitive practice of handwriting, the pre-existing gap between boys and girls might be equalized.

School location and parents' education were not found to be related to the handwriting speed of participants in the present study. As Hong Kong is a small city with great mobility of the population, different location of schools may not be significant enough to affect the handwriting performance of children. Since the distribution of the parents' educational level was also uneven among the children recruited, the result cannot be considered as conclusive.

Another factor that might affect handwriting speed is the attention of the child.
As mentioned earlier, children with DCD from lower grades in the present study wrote faster than children of the same grade in Chow et al's study. In the present study, the children were assessed individually for the DCD group, and in a group of two to four children for the control group. In contrast, children of the selected class in Chow et al's study were assessed together in a group. With fewer children present, children would less likely to be distracted by other children, therefore, would be able to maintain better attention during assessment. Inadequate attention has been shown to have a strong relationship with slow handwriting speed (Levine et al, 1981; Tseng & Chow, 2000). Therefore, attention would likely be a factor affecting the handwriting speed of children. However, this must be examined in the future.

5.3 Comparison of the VMI Performance between Children with and without DCD

Do children with DCD have a poorer performance in VMI? The results of the present study revealed that children with DCD, as a group performed significantly poorer than children without DCD on visual motor integration. In addition, consistent marked difference in VMI scores was found across grades (ranged from 4.2 to 5.17). Previous studies also found similar results. O'Brien et al (1988) conducted a study on 22 children with learning disabilities and 22 children without learning disabilities, aged between 5 to 8 years old. The children with learning disabilities were further
divided into the clumsy and non-clumsy group based on the scores on the Test of Motor Impairment (Stott, Moyes, & Henderson, 1984). It was found that there was a significant difference in the VMI scores between clumsy and non-clumsy children with learning disabilities (F = 3.59; p, 0.05). However, the study was conducted at the time when DCD was not yet the formal diagnosis, therefore, children in the "clumsy" group might not be truly DCD. In a later study by Dewey and Wilson (2001), 137 children, who were formally diagnosed with DCD and 144 children without DCD were assessed with VMI, it was found that the DCD group scored significantly lower than the control group in VMI. This further supports that children with DCD have problem in visual motor integration.

5.4 Relationship between Visual Motor Integration and Handwriting Speed

Is there a relationship between visual motor integration and handwriting speed?

Although the present study did not find that the difference in VMI significantly predicted the difference in handwriting speed between the two groups, a significant though moderate correlation was found between visual motor integration and the Chinese handwriting speed in both the DCD and control group. In fact, the correlation was greater and more significant among children with DCD. This would suggest a bigger role of visual motor integration in the handwriting speed in children with DCD.
Visual motor integration involves both the visual processing of information and the planning and generation of motor response (Beery, 1997). Impairment in this process has been found to be associated with difficulty in handwriting legibility in various studies (Maeland, 1992; Rubin & Henderson, 1982; Sovik, 1981; Weil & Cunningham, 1994; Weng, 1998). Only one study was identified which investigated the relationship between visual motor integration and handwriting speed. Tseng and Chow (2000) found that VMI was a significant predictor of the handwriting speed of slow handwriters in Taiwan. However, the findings of the study may not be able to apply to children with DCD, as the study was conducted on children with slow and normal handwriting speed, instead of children with and without DCD.

Although no other previous studies was identified in examining the relationship of visual motor integration and handwriting speed, there were some studies investigating the mechanism underlying the poor motor control in children with DCD. Wilson et al (2001) conducted a study on 20 children with DCD aged between 8 and 12 years and 20 children without DCD of matched age and IQ. Children were asked to perform both real and imagined movement of pointing from a set of points to another set of points of varying widths but same distance. It was found that most of the children with DCD did not vary in their movement time for imagined movement with
added load to the pencil, as opposed to the control group with an increase in movement time. Children with DCD also showed poorer accuracy in their movement. This showed that for children with DCD, the processes required to represent internally both the force and timing components of movement sequences were impaired as they were unable to adjust the movement duration time for more precise movement. Therefore, they argued that children with DCD have impaired ability to represent internally the visuospatial coordinates of intended movement, which leads to poor control in skilled movement. They further argued that these children would therefore rely to a greater extent on the slow multi-modal sensory feedback, which includes visual and proprioceptive feedback, in monitoring and executing motor output. That would add time and error to each step of motor act. Thus, that implies that impairment of motor control and the subsequent reliance on visual feedback may therefore account for the slow writing speed and poor legibility of handwriting found in children with DCD in the present study.

Smits-Engelsman et al (2003) conducted a study on the 32 children with DCD and learning disabilities and their age-matched controls to investigate motor performance in a reciprocal aiming task, in which children drew straight-line segments between targets of varying sizes. It was found that children with DCD
moved with faster speed but poorer accuracy than their matched controls during cyclic movement of target aiming, which suggested that children with DCD have difficulty in the preplanning phase of movement for feed-forward mode of control. They further argued that online integration of visual information about hand position in relation to the visible target was more difficult for children with DCD, even though full knowledge of the spatial elements of the task was available. Therefore, children with DCD have to rely more on the sensory feedback control, which is slower and add more time. Thus, the result of the above study is consistent with the findings of Wilson et al’s study (2001).

Handwriting as a complicated motor task, requires the integration of ability of processing the visual image of the words to be copied, and the planning and the execution of movements to guide the writing aid to reproduce written words on paper (Cornhill and Case-Smith, 1996). The findings of previous studies on motor control of children with DCD would suggest that their slow handwriting speed might associate with their difficulty in feed-forward mode of motor control and the relying on the less efficient sensory feedback mode during the process of handwriting. In the present study, children with DCD were found to have a poorer performance in VMI. As visual motor integration involves both the visual processing and the process of
motor execution, weakness in visual motor integration might further impose a challenge in utilizing the feed-forward mode of control in these children. This would therefore greatly affect their handwriting speed.

The results of the present study, together with the previous studies on motor control difficulty in children with DCD demonstrated the significant relationship between visual motor integration and the handwriting speed of children with DCD. However, such relationship was found to be only moderate, thus indicating that other skills would be involved in writing proficiently.

5.5 Differences between English and Chinese Handwriting

Do children with DCD have more difficulty in writing Chinese proficiently than English or vice versa? According to the results of the present study, it was found that the difference in handwriting speed was more significant in English than in Chinese. (Between group effect of Chinese handwriting speed: F = 6.7; p < 0.05; for English: F = 8.50; p < 0.01). However, when examining the difference between groups, it was found that the difference in the English handwriting speed between the two groups increased from grade one to three, but the difference dropped drastically in grade four. This is in contrast to the difference found in the Chinese handwriting speed between
the lower and higher grades. This might be explained by the fact that as Chinese characters have varied complexity in their forms. The more complex the form of the character, the more demand on visuospatial analysis and coordinated movement (Chan, 1993; Huang, 1984; Tseng, 1998). In Hong Kong, children in lower grades learn more simple characters first before learning more complex characters. In contrast, most of the children in lower grades would have already mastered the writing of the 26 letters, which are the basic units of the English writing system. As mentioned earlier that the handwriting speed problem would become prominent as they reach higher grades, but the problem would be further complicated by the fact that children with DCD start to write more complex characters, which demands on more visual processing and motor coordination (Huang, 1984; Tseng, 1998). In addition, when examining individual differences, in cases where the individual with DCD wrote faster than the paired control subject, the difference in Chinese handwriting speed was small (from 0.2 to 0.4 characters/min); whereas the difference in English handwriting speed varied from 2 letters/min to 27.3 letters/min. This reflects again, that children with DCD mastered writing of English letters better than more complicated Chinese characters. Therefore, children with DCD would have more problems in Chinese than English handwriting speed, and the problem may become more evident as they reach higher grades.
Moreover, when examining the relationship between visual motor integration and handwriting speed, it was found that VMI correlated with Chinese handwriting speed only. Although VMI has been consistently found to be moderately correlated with English handwriting legibility (Daly et al., 2003; Maeland, 1992; Rubin & Henderson, 1982; Weil & Cunningham, 1994), such relationship was not found in English handwriting speed. In Tseng and Chow’s study (2000), VMI was also found to be a significant predictor of the Chinese handwriting speed. Thus, writing Chinese proficiently demands more than English, the skill of visual motor integration. With weakness in visual motor integration as shown in the present and previous studies (Dewey & Wilson, 2001; O’Brien et al., 1988); and impairment in feed-forward mode of motor control (Smits-Engelsman et al., 2003), children with DCD might have more problems in Chinese rather than English handwriting speed.

It was found that the English handwriting speed increased with grade except for grade four in the control group, in which the speed actually decreased. This might be explained by the fact that most of the children studying grade four in Hong Kong are expected to complete their English homework in cursive scripts. In the HATS, children are requested to write with manuscript. Children from both groups were administered with HATS during the second semester. Therefore, the children from
grade four would have been very accustomed to writing cursive scripts, but not manuscripts. That might lead to the result of a drop of speed in writing English in the control group.

5.6 Clinical Implications and Recommendations

5.6.1 Assessment of Children with DCD

Early identification of children with motor difficulties has been stressed for its importance in providing more effective intervention (Chow et al, 2001; Henderson & Sugden, 1992). In the present study, it has shown that children with DCD experience a definite difficulty in one of the complex motor skills, which is proficient handwriting. Although the problem may not be very obvious at a younger age, the problem may become prominent when the child is older, resulting in bigger gap of motor competence from his peers as demonstrated from longitudinal studies (Losse et al, 1991; Rasmusseen & Gillberg, 2000). Therefore, early identification is recommended.

In addition, the present study showed the presence of individual differences in handwriting speed and visual motor integration. Therefore, a comprehensive assessment in visual motor and handwriting skills is indicated due to the heterogenic nature of DCD.
5.6.2 Handwriting Intervention for Children with DCD

The present study showed that some children with DCD had a definite problem in writing efficiently compared to their peers. Evidences from previous studies revealed that most of these children would not grow out of the problems, which may have a negative impact on academic performance, social and emotional wellbeing (Losse et al, 1991). Therefore, providing effective intervention is very important to facilitate the development of handwriting skills in children with DCD. In light of the understanding of impaired ability of representing internally the visuospatial coordinates of intended movement, some authors suggested use of visual and motor imagery training to help these children to facilitate the development of motor skills, which demonstrated positive results (Driskell et al, 1994; Handy & Callow, 1999). Similar method may thus be used in enhancing the visual motor integration and handwriting skills. Although the present study demonstrated a significant relationship between visual motor integration and handwriting speed, the extent of the correlation was only moderate. More importantly, such relationship does not imply a causal one. Therefore, further studies would be needed to investigate the effectiveness of the remediation of visual motor integration on promoting the handwriting speed of children.
Besides providing direct intervention on the remediation of the performance components of handwriting skills, Occupational Therapists also play an important role in liaising with the school teachers as suggested by Cermak and Larkin (2002), to explain to them the handwriting difficulties suffered by children with DCD; and to arrange appropriate support for them. Children in Hong Kong usually need to complete enormous amount of school work and homework each day and most of the work is to be handwritten. In addition, slow handwriting speed would directly affect their performance in dictations, tests and examinations. They may become frustrated, and may even lose interest and motivation for learning. Therefore, appropriate allowance should be provided to children with handwriting speed difficulty which may include giving extra time to complete dictations, tests and examinations; and reducing the amount of homework which involves solely copying.

5.5.3 Limitations and Further Research

Relationship of Handwriting Speed and Academic Performance

The present study demonstrated that children with DCD had a significant problem in handwriting speed. However, do children with slow handwriting speed have a definite disadvantage on learning? Previous studies (Berninger et al, 1992; Graham & Weintraub, 1996) showed that slow handwriting speed would have a
negative impact on child’s motivation for handwriting, which would in turn affect’s child’s participation in school activities and poor academic performance may be resulted. However, with the advance in technology, nowadays in Hong Kong, children’s learning in classroom has been facilitated by different audio and visual media, which has gradually replaced the traditional learning method of recording teachers’ words or copying from blackboard. On the other hand, in Hong Kong, children’s homework still includes mainly handwritten work. Children with slow handwriting speed may spend much longer time in completing their homework, which may leave them very limited time for study. In addition, children with slow handwriting speed often could not complete dictation, tests and examination within the time constraint. Therefore, it would be worthwhile to investigate whether slow handwriting speed would associate with poor academic performance among children in Hong Kong.

**Relationship of Handwriting Speed and Legibility**

Although the present study focused only on one aspect of handwriting, which is speed, handwriting speed inevitably relates to legibility. Compared to their matched controls, trading off legibility for speed seemed to be especially evident in children with DCD. Previous studies have also demonstrated that children with DCD have
marked problems in their handwriting legibility (Chui, 2000; Henderson, 1992; Maeland, 1992). Do the problem of handwriting legibility and speed come together, or are they presented separately? If they do come together, how do the two aspects relate to each other? Therefore, it would be worthwhile to investigate the relationship between these two important aspects of handwriting.

Relationship of other Performance Components on Handwriting Speed

As the present study only revealed a moderate relationship between visual motor integration and Chinese handwriting speed, this implies that other performance components would also be involved. One of the performance components that is frequently being investigated is kinesthetic perception (Laszlo & Bairstow, 1983; Harris & Livesey, 1992; Tseng & Murray, 1994). However, most of these studies dealt with the legibility aspect only. It would be worthwhile to examine if kinesthetic perception significantly associates with handwriting speed and to compare it with visual motor integration in the importance in proficient handwriting.
6. Conclusion

Although children with Developmental Coordination Disorder (DCD) form a heterogeneous group, they experience different degrees of difficulties in various skills involving motor coordination. That often affects their ability to cope with demands of daily living. Handwriting speed problem is one of the common problems found in these children. Children with DCD often have difficulty to cope with academic demands as handwriting is an essential occupational skill for school-aged children. Therefore, a clearer understanding of the handwriting speed problem is very important in order to provide a more effective intervention for these children.

In the present study, children with DCD’s handwriting speed and visual motor integration performance were tested. It was found that, as a group, they had significantly slower handwriting speed in both Chinese and English. Their visual motor integration performance as measured by the VMI was also poorer than children without DCD. While a moderate correlation was found between the Chinese handwriting speed and visual motor integration, regression analysis showed the difference in visual motor integration between the two groups accounted for only 11.4% of variance. Although there is general assumption that visual motor integration
plays an important role in proficient Chinese handwriting as Chinese characters are more complex which demand more visuospatial analysis and coordinated upper limb movements, this relationship cannot be confirmed by our results. Further studies of this relationship would be needed.

Longitudinal studies consistently indicated that motor coordination difficulties experienced by children with DCD not only will persist, it often leads to psychological and social problems as a result of repeated failure in coping with daily demands. Therefore, more studies should be conducted to investigate their problems with a view to develop more effective intervention strategies.
References


Lam, L. F. S. (2001) [Relationship between Chinese and English handwriting speed,


with the Beery-Butenica Developmental Test of Visual Motor Integration. *Perceptual and Motor Skills, 84,* 1439-1443.

Psychological Services Section, Educational Department (2002). *Fun with reading and writing: A resource pack for primary school pupils.* The Printing Department: Hong Kong


disorder.: Inter- and intragroup differences. *Adapted Physical Activity Quarterly*, 13, 357-371.


Appendix 1: Original VMI Instructions

Verbal Instructions of Group Administration

Please do not open your booklets until I ask you to do so. The page with the hand pointing up should face you.

This is the way your booklet must stay on your desk until you are finished. This is the way you sit.

Now open your booklet by turning from the top, like this, to page 4. Page 2 has just blank squares on it, like this. Page 4 has forms in the top squares, like this.

You are to copy what you see at the top of each page. Make your drawing of each form in the space below it, like this.

Copy the forms in order. Start with item number 4. Numbers 1, 2, and 3 on the blank page are just for very young children.

Some of the forms are very easy, and some are very hard even for adults.

Do your best on the easy and the hard ones; do not skip any.

Remember, only one try on each form and you cannot erase.

Verbal Instructions of Individual Administration

Make one like that. Make yours right here.

Good. Go ahead and do the rest of them. Turn to the next page when you finish this one.

Do your best on both the easy and the hard ones; do not skip any.
Appendix 2: Forward Translation of VM1 Instructions

集體進行的口頭指示

在我未作出准許指示之前，不可打開冊子。把印有一隻手掌(指尖向上)的一面朝向自己。

你的冊子要這樣子放在桌子上，直到你完成爲止。你要這樣子坐著。

現在打開你的冊子，由上面打開，至第4頁。在第2頁，只有一些空白的方格，像這樣子。在第4頁，最上端的方格內有一些圖案，像這樣子。

請你模仿每頁上端的圖形，照著畫一次。請你在下面的方格，照著畫出每一個圖形，像這樣子。

請你按著次序畫出那些圖形，由第4號圖形開始。在空白頁上的第1、2和3號圖形，只適合一些年紀很小的孩子。

有些圖形很簡單，有些則連成人都會覺得困難。
盡力畫好每一個簡單或困難的圖形，不要放棄任何一個。

請你記得，每個圖形你只可以畫一次，你也不可以擦掉再畫。

個別進行的口頭指示

照著這個畫一次。把你的圖形畫在這裡。

很好。繼續畫其他的圖形。畫完這個便翻到下一頁。

盡力畫好每一個簡單或困難的圖形，不要放棄任何一個。
Appendix 3: Backward Translation of VMI Instructions

Verbal Instructions for *Group* Administration

Do not open the booklet before my permission. Let the page with the finger pointing up face you.

Your booklet should be placed on the desk like this until you’re finished. This is the way you should sit.

Now open your booklet from the top to page 4. On page 2, there are only blank boxes, like this. On page 4, there are some forms in the boxes on the top of the page, like this.

Please copy the figure on the top of each page. Copy it in the space below, like this.

Please copy the forms in order, starting from form number 4. Form number 1 to 3 on the blank pages are only for very young children.

Some of the forms are very easy, and some are very difficult even for adults. Try your best to copy each form, easy and difficult. Do not leave anyone out.

Please remember, you can only draw each form once and you cannot erase.

Oral Instructions for *Individual* Administration

Copy the form like this. Copy your form here.

Good. Continue drawing the rest of them. When you’re finished, turn to the next page.

Try your best to draw every form, easy and difficult. Do not leave anyone out.
Appendix 4: Revised Chinese Translation of VMI Instructions

集體進行的口頭指示

在我未作出指示之前，不可打開冊子。把印有一隻手掌(指尖向上)的一頁面向自己。

你的冊子要這樣子放在桌子上，直到你完成為止。你要這樣子坐著。

現在打開你的冊子，由上面打開，至第4頁。在第2頁，只有一些空白的方格，好像這樣。在第4頁，最上端的方格內有一些圖案，好像這樣。

請你模彷每頁上端的圖形，照著畫一次。請你在下面的方格，照著畫出每一個圖形，像這樣子。

請你按著次序畫出那些圖形，由第4號圖形開始。在空白頁上的第1、2和3號圖形，只適合一些年紀很小的孩子。

有些圖形很簡單，有些則連成人都會覺得困難。
盡力畫好每個簡單或困難的圖形，不要放棄任何一個。

請你記住，每個圖形你只可以畫一次，你也不可以擦掉再畫。

個人進行的口頭指示

照著這個畫一次。把你的圖形畫在這裡。

很好。繼續畫其他的圖形。畫完這個便翻到下一頁。

盡力畫好每個簡單或困難的圖形，不要放棄任何一個。
Appendix 5: Invitation letter to expert panel

Dear ________________,

Re: A study on the handwriting speed and visual motor skills of school-aged children with Developmental Coordination Disorder

I, Alice Kwoo am a MSc. student of the Hong Kong Polytechnic University. In my dissertation, I will investigate the handwriting speed and visual motor skills of school-aged children. Result of the study will help professionals to gain a better understanding of the handwriting problem of children with Developmental Coordination Disorder, which would facilitate the design of appropriate treatment for these children.

In this study, the Chinese version of the Developmental Test of Visual Motor Integration (VMI, 4th ed) will be used to measure children’s performance on visual motor integration. To establish its content validity, you are invited to sit on the panel to review and critique on the Chinese version of VMI (4th ed). You will need to fill out the attached background information sheet and the questionnaire. Please mail the signed consent form, together with the completed background information sheet and questionnaire in the attached stamped envelope before ________________.

Please be assured that all personal information provided in the background information sheet will not be disclosed to people who are not related to this study and your name will not appear on any publications resulted from this study.

I will appreciate if you can participate in my study. If you have any inquiry, please don’t hesitate to contact me at telephone 9XXX XXXX or my dissertation supervisor, Dr. Susanna Chow at telephone 2766XXXX. The success of this study depends on your support and I would like to thank you in anticipation of your help.

Yours Sincerely,

______________________________
Alice Kwoo
Occupational Therapist
MSc. Student
The Hong Kong Polytechnic University
Appendix 6: Questionnaire

Instructions

1. Please fill in the Background Information and answer the questions in the questionnaire below.

2. For each question, please put a (V) on Rating that best represent your opinion from strongly disagree to strongly agree.

3. Please give your comments concerning each question if indicated.

Background Information of Participants

Name:

Place of work:

Years of experience in pediatric field:

Experiences of administering VMI: Yes / No

Years of experience in administering VMI:

Frequency of the administration of VMI in a month:
Question 1: Do you agree that the words used in the translated version of VMI (4th ed) represented fluently as in the original version?

(Scoring key: 1 = Strongly Disagree; 2 = Disagree; 3 = Agree; 4 = Strongly Agree)

<table>
<thead>
<tr>
<th>Verbal Instructions of Group Administration</th>
<th>Rating</th>
<th>Comments/Recommended Modifications</th>
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<td>1 2 3 4</td>
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**Chinese version:**
在我未作出准許指示之前，不可打開冊子。把印有一觸手掌(指尖向上)的一面朝向自己。
你的冊子要這樣子放在桌子上，直到你完成為止。你要這樣子坐著。

**Original version:**
Please do not open your booklets until I ask you to do so. The page with the hand pointing up should face you.
This is the way your booklet must stay on your desk until you are finished. This is the way you sit.

**Chinese version:**
現在打開你的冊子，由上面打開，至第4頁。在第2頁，只有一些空白的方格，像這樣子。在第4頁，最上端的方格內有一些圖案，像這樣子。

**Original version:**
Now open your booklet by turning from the top, like this, to page 4. Page 2 has just blank squares on it, like this.
Page 4 has forms in the top squares, like this.
(Scoring key: 1 = Strongly Disagree; 2 = Disagree; 3 = Agree; 4 = Strongly Agree)

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<th>Subtest</th>
<th>Rating</th>
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<td>1 2 3 4</td>
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**Chinese version:**
請你模仿每頁上端的圖形，照著畫一次。請你在下面的方格，照著畫出每個圖形，像這樣子。
請你按著次序畫出那些圖形，由第4號圖形開始，在空白頁上的第1、2和3號，只適合一些年紀很小的孩子。

**Original version:**
You are to copy what you see at the top of each page. Make your drawing of each form in the space below it, like this.
Copy the forms in order. Start with item number 4. Numbers 1, 2, and 3 on the blank page are just for very young children.

**Chinese version:**
有些圖形很簡單，有些則連成人都會覺得困難。

**Original version:**
Some of the forms are very easy, and some are very hard even for adults.

Do your best on the easy and the hard ones; do not skip any.
Remember, only one try on each form and you cannot erase.
(Scoring key: 1 = Strongly Disagree; 2 = Disagree; 3 = Agree; 4 = Strongly Agree)

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<tr>
<td>照著這個畫一次。把你的圖形畫在這裡。</td>
<td></td>
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<tr>
<td>很好，繼續畫其他的圖形，畫完這個便翻到下一頁。</td>
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<td>盡力畫好每一個簡單或困難的圖形，不要放棄任何一個。</td>
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<td><strong>Original version:</strong></td>
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<td>Make one like that. Make yours right here.</td>
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<td>Good. Go ahead and do the rest of them. Turn to the next page when you finish this one.</td>
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<td>Do your best on both the easy and the hard ones; do not skip any.</td>
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Question 2: Do you agree that the words used in the translated version of VMI (4th ed) have the **same semantic meaning** compared with the original version?

(Scoring key: 1 = Strongly Disagree; 2 = Disagree; 3 = Agree; 4 = Strongly Agree)

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**Chinese version:**
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你的冊子要這樣子放在桌上，直到完成為止。你要這樣子坐著。

**Original version:**
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This is the way your booklet must stay on your desk until you are finished. This is the way you sit.

**Chinese version:**
現在打開你的冊子，由上面打開，至第4頁。在第2頁，只有一些空白的方格，像這樣子。在第4頁，最上端的方格內有一些圖案，像這樣子。

**Original version:**
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Page 4 has forms in the top squares, like this.
(Scoring key: 1 = Strongly Disagree; 2 = Disagree; 3 = Agree; 4 = Strongly Agree)

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**Chinese version:**
請你模仿每頁上端的圖形，照著畫一次。請你在下面的方格，照著畫出每一個圖形，像這樣子。
請你按著次序畫出那些圖形，由第4號圖形開始，在空白頁上的第1、2和3號，只適合一些年紀很小的孩子。

**Original version:**
You are to copy what you see at the top of each page. Make your drawing of each form in the space below it, like this.
Copy the forms in order. Start with item number 4. Numbers 1, 2, and 3 on the blank page are just for very young children.

**Chinese version:**
有些圖形很簡單，有些則連成人都會覺得困難。
盡量畫好每一個簡單或困難的圖形，不要放棄任何一個。
請你記得，每個圖形你只可以畫一次，你也不可以擦掉再畫。

**Original version:**
Some of the forms are very easy, and some are very hard even for adults
Do your best on the easy and the hard ones; do not skip any
Remember, only one try on each form and you cannot erase.
(Scoring key: 1 = Strongly Disagree; 2 = Disagree; 3 = Agree; 4 = Strongly Agree)

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**Chinese version:**

照著這個畫一次，把你的圖形畫在這裡。

很好，繼續畫其他的圖形，畫完這個便翻到下一頁。

盡力畫好每一個簡單或困難的圖形，不要放棄任何一個。

**Original version:**

Make one like that. Make yours right here.

Good. Go ahead and do the rest of them. Turn to the next page when you finish this one.

Do your best on both the easy and the hard ones; do not skip any.

p any.
Question 3: Do you agree that VMI (4th ed) is **culturally relevant** to the assessment of visual motor integration for Hong Kong children?

(Scoring key: 1 = Strongly Disagree; 2 = Disagree; 3 = Agree; 4 = Strongly Agree)

<table>
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Please justify your rating and give suggestions for modification if any:

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Question 4: Do you agree VMI (4th ed) adequately **represents** the assessment of visual motor integration?

(Scoring key: 1 = Strongly Disagree; 2 = Disagree; 3 = Agree; 4 = Strongly Agree)

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Please justify your rating and give suggestions for modification if any:
Question 5: Do you have any other comments or recommended modifications to the Chinese version of the VMI (4th ed)?

- End of Questionnaire -

* Thank You for Your Kind Assistance and Valuable Opinions *
Appendix 7: Consent Form for Expert Panel

Consent

I give * consent/not give consent to participate in the research study described. I understand the purpose and requirement of this study. I also know that I have the right to withdraw at any time without giving reasons. I understand that the personal information on myself will not be disclosed to people who are not related to this study and my name will not appear on any publications resulted from this study.

I understand I can contact Ms Alice Kwo at telephone 9XXX XXXX or Dr Susanna Chow at telephone 2766 XXXX for any questions about this study. If I have complaints related to this study, I can contact Mrs Michelle Leung, Secretary of the Departmental Research Committee, at 2766 XXXX. I know I will be given a signed copy of this consent form.

Signature of participant: ____________________
Name of participant: ____________________
Date: ____________________

For investigators’ use

Signature of Witness: ____________________
Name of Witness: ____________________
Date: ____________________

*delete as appropriate
Appendix 8: Invitation letter to parents of children for the inter-rater reliability study

敬啓者:

本人為香港理工大學復康治療學系的碩士生，現正進行一項研究，主題為「小學生抄寫速度與視覺動作統合表現的研究」。研究目的是透過評估小學生的抄寫速度與視覺動作統合表現去探討抄寫速度與視覺動作統合技能的關係。研究結果將有助教師的教學及專業人士訓練有特別需要的兒童。

貴子弟參與之職業治療部門被選為其中一間研究地點，希望貴家長同意由貴子弟的職業治療師提供貴子弟過往的視覺動作統合測驗結果作研究用途。所提供的資料將會保密，任何資料不會透露給與此研究無直接關係的人包括學校職員或治療人員，亦不會影響貴子女任何有關職業治療部門或學校之參與。研究結果只會用作此研究之使用，研究結果亦以組別名稱作公佈，我會嚴格遵守個人私隱條例。所有參與均是自願性質，故你及你的子女均可於任何時段不參與此研究或撤銷所提供之資料。

閣下如有任何查詢，可致電 9XXX XXXX 與本人聯絡，亦可致電 2776 XXXX 或經電郵地址 rsschow@與香港理工大學復康治療學系助理教授周美琴博士聯絡。

希望貴家長同意讓貴子弟參與是項研究，使是項研究能順利完成。

此致

貴家長

香港理工大學復康治療學系碩士生
職業治療師
顧靜儀
二零零四年_月___日
Appendix 9: Consent form to parents of children for the inter-rater reliability study

家長回條

本人 __________ (姓名)為子女 __________ (姓名)之家長/監護人*, 同意/不同意*本人之子女的職業治療師提供本人之子女的過往的視覺動作統合測驗結果作爲上述提及之“小學生抄寫速度與視覺動作統合表現的研究”研究的用途。本人並完全明白其研究之目的及內容。

本人亦知悉及明白本人擁有權利退出參與是項有關之研究並不須給予任何理由，以及該退出不會爲本人之子女在學習上及治療上帶來負面影響。本人明白到所有關於一切個人資料(包括本人及本人之子女)並不會透露予非相關於本研究之人士，同時本人之子女的樣貌及名字並不會顯示予研究報告之結果上。

如本人有任何疑問可聯絡該研究之負責人顧靜儀小姐：9XXX XXXX 或周美琴博士 (Dr. Susanna Chow): 2766 XXXX。另外如本人有任何投訴關於該研究，本人可致電予部門研究委員會秘書梁太 (Mrs Michelle Leung): 2766 XXXX。最後，本人可獲得已經簽署之同意書影印本乙份。

家長/監護人*簽署: __________
家長/監護人*姓名: __________
子女的姓名: __________
日期: ______________________

研究人員使用
見證人簽署: ______________________
見證人姓名: __________
日期: ______________________

* 請勿去不適用者
Appendix 10: Invitation letter to parents of children with DCD

敬啓者：

本人為香港理工大學復康治療學系的碩士生，現正進行一項研究，主題為「小學生抄寫速度與視覺動作統合表現的研究」。研究目的是透過評估小學生的抄寫速度與視覺動作統合表現去探討抄寫速度與視覺動作統合技能的關係。研究結果將有助教師的教學及專業人士訓練有特別需要的兒童。

貴子弟參與之職業治療部門被選為其中一間研究地點。希望貴家長同意讓貴子弟參與是項研究。在測試的過程中，每位小童需要完成由職業治療師提供之中文及英文抄寫測驗，需時約10分鐘，接著需要完成視覺動作統合測驗，需時約15分鐘，因此，在測試的過程中，可能會對小童的程序表構成小許不便。在測試前需要貴家長提供小童的個人資料，交回職業治療師。

所提供的個人資料將會保密，任何資料不會透露給與此研究無直接關係的人。貴子弟任何有關職業治療部門或學校之參與，研究結果只會用作此研究之使用。研究結果亦以組別名稱作公佈，我會嚴格遵守個人私隱條例。所有參與均是自願性質，故你及你的子女均可於任何時段不參與此研究或撤銷所提供之資料。

閣下如有任何查詢，可致電9XXX XXXX與本人聯絡，亦可致電2776 XXXX或經電郵地址rsschow@與香港理工大學復康治療學系助理教授周美琴博士聯絡。

希望貴家長同意讓貴子弟參與是項研究，使是項研究能順利完成。

此致
貴家長

香港理工大學復康治療學系碩士生
職業治療師
顧輝儀
二零零四年_月_____日
Appendix 11: Consent form to parents of children with DCD

家長回條

本人 ___________ (姓名)為子女 ___________ (姓名)之家長/監護人*, 同意/不同意*本人之子女參與上述提及之“小學生抄寫速度與視覺動作統合表現的研究”研究並完全明白其研究之目的及內容。

本人亦知悉及明白本人擁有權利退出參與是項有關之研究並不須給予任何理由，以及該退出不會為本人之子女在學習上及治療上帶來負面影響。本人明白及留意到所有經參與後帶來一切可能性風險。本人明白到所有關於一切個人資料(包括本人及本人之子女)並不會透露予非相關於本研究之人士。同時本人之子女的樣貌及名字並不會顯示予研究報告之結果上。

如本人有任何疑問可向負責人顧靜儀小姐: 9XXX XXXX 或周美琴博士 (Dr. Susanna Chow): 2766 XXXX。另外如本人有任何投訴關於該研究，本人可致電研究委員會秘書梁太 (Mrs Michelle Leung): 2766 XXXX。最後，本人可獲得已經簽署之同意書影印本乙份。

家長/監護人*簽署: ___________

家長/監護人*姓名: ___________

子女的姓名: ___________

日期: ___________

研究人員使用

見證人簽署: ___________

見證人姓名: ___________

日期: ___________

* 請刪去不適用者
Appendix 12: Supplementary information form to parents of children with DCD

小童個人資料

性別: __________________

就讀之年級: _____________

就讀學校之所在地區: ______________

出生日期: ______________

今年是否留級: 是/否*

主力手: 左/右/沒分左右*

語言: 能/不能* 說流利廣東語

過去兩年在香港就讀幼稚園或小學: 是/否*

曾被註冊醫生診斷為以下其中一項疾病: 是/否*

- 視覺障礙（能配戴眼鏡以糾正的視覺障礙如近視不包括在內）
- 聽覺障礙
- 肢體障礙
- 智能障礙
- 行為問題（如過度活躍症）

父母/監護人的教育程度:

☐ 小學或以下
☐ 中學
☐ 大學或以上

* 請刪去不適用者
Appendix 13: Invitation letter to school principal

敬啓者：

本人為香港理工大學復康治療學系的碩士生，現正進行一項研究，主題為「小學生抄寫速度與視覺動作統合表現的研究」。研究目的是透過評估小學生的抄寫速度與視覺動作統合表現去探討抄寫速度與視覺動作統合技能的關係。研究結果將有助教師的教學及專業人士訓練有特別需要的兒童。

是項研究的對象是小一至小四的學生，根據分層抽樣方式，貴校被選為其中一間研究地點。若貴校同意參加是項研究，小一至小四各級將會各選出一班，該班將會選出數名學生進行測試。

在測試的過程中，每位學生先需要完成動作協調的測驗，需時約30分鐘。在同日，被選出的學生將按其所屬年級以小組形式進行中文及英文抄寫測驗，需時約10分鐘，接著需要完成視覺動作統合測驗，需時約15分鐘。過程所提供的的一切資料將會保密，只用作集體分析，個人資料絕對保密。

希望貴校同意讓學生參與是項測試，使是項研究能順利完成。若台端有任何查詢，可致電9XXX XXXX與本人聯絡，亦可致電2776 XXXX或經電郵地址rsschow@與香港理工大學復康治療學系助理教授周美琴博士聯絡。

此致

____________________小學校長

香港理工大學復康治療學系碩士生
職業治療師
顧詩儀
二零零四年__月____日
Appendix 14: Invitation letter to parents of children without DCD

敬啓者:

本人為香港理工大學復康治療學系的碩士生及一名全職職業治療師，現正進行一項研究，主題為「小學生抄寫速度與視覺動作統合表現的關係」，研究目的是透過評估小學生的抄寫速度與視覺動作統合表現去探討抄寫速度與視覺動作統合技能的關係；研究結果將有助教師的教學及專業人士訓練有特別需要的兒童。

貴子[編]的學校被選為其中一間研究地點，而貴子弟被抽籤成爲參加研究的學生。在測試的過程中，每位學生需要完成動作協調的測驗，需時約30分鐘，測驗內容包括評估學生的大小肌肉協調及平衡技巧，參與此測驗之風險包括在評估平衡技巧及跳躍技巧時失去平衡而跌倒。但是，所有平衡技巧及跳躍技巧的評估項目均在平地上進行。本人曾受專業訓練，並具有豐富評估兒童的經驗，本人必會密切監察測驗的整個過程並確保兒童在絕對安全的情況下進行評估，避免有任何意外發生的機會。接著貴子弟將進行中文及英文抄寫測驗，需時約10分鐘，接著需要完成視覺動作統合測驗，需時約5分鐘。因此，在整個測試的過程中，可能會對小童的程序表構成小許不適。在測試前需要貴家長提供學生成績資料，測試後，若貴家長欲查詢貴子女在各項測試上的結果，可與本人聯絡。

所提供的個人資料將會保密，任何資料不會透露給與此研究無直接關係的人包括學校職員，亦不會影響貴子女任何有關學校之參與。研究結果只會用作研究之使用。研究結果亦以組別名稱作公佈，我會嚴格遵行個人私隱條例。所有參與均是自願性質，故你及你的子女均可於任何時段不參與此研究或撤銷所提供之資料。

閣下如有任何查詢，可致電9XXX 9XXX與本人聯絡，亦可致電2766 XXXX或經電郵地址
rshshow@

與香港理工大學復康治療學系助理教授周美琴博士聯絡。

希望貴家長同意貴子女參與是項研究，使是項研究能順利完成。

此致

貴家長

香港理工大學復康治療學系碩士生
九龍醫院職業治療師
顧靜儀
二零零四年__月____日
Appendix 15: Consent form to parents of children without DCD

家長回條

本人 __________ (姓名) 爲子女 __________ (姓名) 之家長/監護人*, 同意/不同意*本人之子女參與上述提及之“小學生抄寫速度與視覺動作統合表現的研究”研究並完全明白其研究之目的及內容。

本人亦知悉及明白本人擁有權利退出參與是項有關之研究並不須給予任何理由，以及該退出不會為本人之子女在學習上帶來負面影響。本人明白及留意到所有經參與後帶來一切可能性風險。本人明白到所有關於一切個人資料(包括本人及本人之子女)並不會透露予非相關於本研究之人士，同時本人之子女的樣貌及名字並不會顯示予研究報告之結果上。

如本人有任何疑問可聯絡該研究之負責人顧靜儀小姐: 9XXX XXXX 或周美琴博士 (Dr. Susanna Chow): 2766 XXXX。另外如本人有任何投訴關於該研究，本人可致電野部門研究委員會秘書梁太 (Mrs Michelle Leung): 2766 XXXX。最後，本人可獲得已經簽署之同意書影印本乙份。

家長/監護人*簽署: __________
家長/監護人*姓名: __________
子女的姓名: __________
日期: __________

* 請刪去不適用者
Appendix 16: Supplementary information form to parents of children without DCD

小童個人資料

姓名: ______________________

性別: __________

就讀之年級: ________

出生日期: ________

今年是否留級: □是    □否

主力手: □左    □右    □沒分左右

語言: □能說流利廣東語  □不能說流利廣東語

過去兩年在香港就讀幼稚園或小學: □是    □否

過去曾或現正接受學校或教統局安排之功課啓導或輔導班: □是    □否

體能及智能發展評估: □從未評估  □評估發展正常  □評估發展有障礙

曾被註冊醫生診斷為以下其中一項障礙: □是    □否

  □視覺障礙 (能配戴眼鏡以糾正的視覺障礙如近視不包括在內)
  □聾啞障礙
  □肢體障礙
  □智能障礙
  □讀寫困難
  □發展性協調障礙
  □行爲問題 (如過度活躍症)
  □或其它發展障礙, 請列明: ____________________________

父母/監護人的教育程度:

□ 小學或以下    □ 中學    □ 大學或以上
**Appendix 17: Classification of basic strokes of Chinese characters**

<table>
<thead>
<tr>
<th>No.</th>
<th>Strokes</th>
<th>Name</th>
<th>Form</th>
<th>No.</th>
<th>Strokes</th>
<th>Name</th>
<th>Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>横</td>
<td>横</td>
<td>一</td>
<td>15</td>
<td>跳横钩</td>
<td>跳</td>
<td>し</td>
</tr>
<tr>
<td>2</td>
<td>横豎</td>
<td>横</td>
<td>一</td>
<td>16</td>
<td>跳钩</td>
<td>跳</td>
<td>し</td>
</tr>
<tr>
<td>3</td>
<td>横豎横</td>
<td>二</td>
<td>一</td>
<td>17</td>
<td>跳挑</td>
<td>跳</td>
<td>り</td>
</tr>
<tr>
<td>4</td>
<td>横豎豎</td>
<td>三</td>
<td>一</td>
<td>18</td>
<td>撇</td>
<td>撇</td>
<td>ノ</td>
</tr>
<tr>
<td>5</td>
<td>横豎鉤</td>
<td>二</td>
<td>一</td>
<td>19</td>
<td>撇點</td>
<td>撇</td>
<td>ノ</td>
</tr>
<tr>
<td>6</td>
<td>横撇</td>
<td>三</td>
<td>一</td>
<td>20</td>
<td>撇挑</td>
<td>撇</td>
<td>ノ</td>
</tr>
<tr>
<td>7</td>
<td>横撇横鉤</td>
<td>四</td>
<td>一</td>
<td>21</td>
<td>捨</td>
<td>捨</td>
<td>ノ</td>
</tr>
<tr>
<td>8</td>
<td>横撇鉤</td>
<td>二</td>
<td>一</td>
<td>22</td>
<td>點</td>
<td>點</td>
<td>ノ</td>
</tr>
<tr>
<td>9</td>
<td>横捺</td>
<td>三</td>
<td>一</td>
<td>23</td>
<td>捨</td>
<td>捨</td>
<td>ノ</td>
</tr>
<tr>
<td>10</td>
<td>横左弧鉤</td>
<td>四</td>
<td>一</td>
<td>24</td>
<td>捨撇</td>
<td>捨</td>
<td>ノ</td>
</tr>
<tr>
<td>11</td>
<td>跳</td>
<td>横</td>
<td>一</td>
<td>25</td>
<td>弧</td>
<td>弧</td>
<td>ノ</td>
</tr>
<tr>
<td>12</td>
<td>跳横</td>
<td>横</td>
<td>一</td>
<td>26</td>
<td>右弧撇</td>
<td>右</td>
<td>ノ</td>
</tr>
<tr>
<td>13</td>
<td>跳横豎</td>
<td>二</td>
<td>一</td>
<td>27</td>
<td>右弧鉤</td>
<td>右</td>
<td>ノ</td>
</tr>
<tr>
<td>14</td>
<td>跳横撇鉤</td>
<td>三</td>
<td>一</td>
<td>28</td>
<td>左弧鉤</td>
<td>左</td>
<td>ノ</td>
</tr>
</tbody>
</table>

Adapted from: Curriculum Development Council, 1996, p.17
**Appendix 18: Classification of structures of Chinese characters**

<table>
<thead>
<tr>
<th>No.</th>
<th>Structure</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Single construction (單一部位)</td>
<td>口, 山, 女</td>
</tr>
<tr>
<td>2</td>
<td>Up-and-down construction with equal proportions (上下相等)</td>
<td>忠, 變, 朵</td>
</tr>
<tr>
<td>3</td>
<td>Up-and-down construction with 2:1 proportions (上大下小)</td>
<td>黑, 盆, 然</td>
</tr>
<tr>
<td>4</td>
<td>Up-and-down construction with 1:2 proportions (上小下大)</td>
<td>家, 孕, 罵</td>
</tr>
<tr>
<td>5</td>
<td>Up-and-down construction with 1:1:1 proportions (上中下相等)</td>
<td>桌, 算, 草</td>
</tr>
<tr>
<td>6</td>
<td>Left-and-right construction with equal proportions (左右相等)</td>
<td>好, 船, 朋</td>
</tr>
<tr>
<td>7</td>
<td>Left-and-right construction with 2:1 proportions (左大右小)</td>
<td>劃, 都, 鄰</td>
</tr>
<tr>
<td>8</td>
<td>Left-and-right construction with 1:2 proportions (左小右大)</td>
<td>隊, 他, 諷</td>
</tr>
<tr>
<td>9</td>
<td>Left-and-right construction with 1:1:1 proportions (左中右相等)</td>
<td>樹, 做, 謝</td>
</tr>
<tr>
<td>10</td>
<td>Inside-and-outside construction with the outer component covering the upper part of the lower component (上包下)</td>
<td>門, 同, 岡</td>
</tr>
<tr>
<td>11</td>
<td>Inside-and-outside construction with the outer component covering the whole inside component (全包圍)</td>
<td>回, 國, 因</td>
</tr>
<tr>
<td>12</td>
<td>The left side component covering the upper part of the right side component (左上包)</td>
<td>左, 友, 疲</td>
</tr>
<tr>
<td>13</td>
<td>The left side component covering the lower part of the right side component (左下包)</td>
<td>迷, 建, 趣</td>
</tr>
</tbody>
</table>

*Adapted from: Psychological Services Section of Education Department, 2002*