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Visual perceptual abilities of Chinese-speaking and English-speaking children [1]

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Summary.—This paper reports an investigation of Chinese-speaking and English-speaking children's general visual perceptual abilities. The Developmental Test of Visual Perception was administered to 41 native Chinese-speaking children of mean age 5 yr. 4 mo. in Hong Kong and 35 English-speaking children of mean age 5 yr. 2 mo. in Melbourne. Of interest were the two interrelated components of visual perceptual abilities, namely, motor-reduced visual perceptual and visual-motor integration perceptual abilities, which require either verbal or motoric responses in completing visual tasks. Chinese-speaking children significantly outperformed the English-speaking children on general visual perceptual abilities. When comparing the results of each of the two different components, the Chinese-speaking students' performance on visual-motor integration was far better than that of their counterparts (ES=2.70), while the two groups of students performed similarly on motor-reduced visual perceptual abilities. Cultural factors such as written language format may be contributing to the enhanced performance of Chinese-speaking children's visual-motor integration abilities, but there may be validity questions in the Chinese version.

Researchers have reported differences between Chinese and non-Chinese students' visual perceptual abilities (Carlson, 1962; Lesser, Fifer, & Clark, 1965; Chan, 1976; Pong-Leung, 1983; Stevenson, Stigler, Lee, Lucker, Kitamura, & Hsu, 1985; Stevenson, Ying-Lee, & Hsu, 1990; Hoosian, 1991; Jensen & Whang, 1993). In distinguishing between students' visual perceptual abilities, it is important to attend to both the interrelated components of general visual perceptual abilities, namely, motor-reduced visual perceptual abilities and visual-motor integration perceptual abilities (Hammill, Pearsons, & Voress, 1993). This study was an attempt to build a comprehensive model of measuring visual perceptual abilities among students in order to address the shortcomings of research that identifies Chinese students as performing better in visual perception, without fully accounting for the interplay of motor and motor-free factors involved in visual perception tasks.

According to Gardner (1996), the definition of "visual perception in a broad sense is the ability of the brain to understand and interpret (make sense of) what the eyes see; and based on understanding and interpretation, it is the ability to express the meaning verbally or motorically" (p. 8). Verbal understanding is expressed by motor-reduced visual perceptual abilities. This requires little or no motor ability (Hammill, *et al.*, 1993). In contrast, perceptual abilities for visual-motor integration require the coordination of vision with movements of the body or parts of the body (Frostig & Horne, 1964). In the assessment of general visual perceptual abilities, Hammill, *et al*. argued that both verbal and motoric forms of expression of a learner's understanding are important for teachers to diagnose in order to assist students' learning; therefore, verbal and motoric expression should be separated to allow measurement of genuine visual abilities, motor-free visual abilities, and visual-motor coordination abilities. The evaluation should "include assessment tasks that are exclusively visual perceptual (requiring little or no motor abilities) and tasks that involve visual-motor integration or visually guided motor behaviour" (p. 5). Similarly, Leonard, Foxcroft, and Kroukamp (1988) cautioned examiners to be careful when using visual perceptual tests to evaluate visual-motor integration perceptual status and suggested the value of measuring visual perception and visual-motor perception independently.

Considerable evidence has accumulated over time that Chinese children have stronger visual perceptual abilities (Carlson, 1962; Lesser, Fifer, & Clark, 1965; Chan, 1976; Pong-Leung, 1983; Stevenson, Stigler, Lee, Lucker, Kitamura, & Hsu, 1985; Stevenson, Ying-Lee, & Hsu, 1990; Hoosian, 1991; Jensen & Whang, 1993). However, these results and conclusions are mostly drawn from studies of *either* motor-reduced visual perceptual abilities *or* visual-motor integration perceptual abilities due to the features of the instruments being employed. For

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example, Hoosian (1991) and Pong-Leung (1983) used the Wechsler Intelligence Scale for Children and the Bender Visual Gestalt Test, respectively, to assess the visual perceptual abilities of children in Hong Kong. Both of these instruments measure visual-motor skills only. In the studies of Carlson (1962), Chan (1976), Stevenson, *et al.* (1985), Stevenson, *et al.* (1990), and Jensen and Whang (1993), the instruments employed measured motor-reduced visual skills only. Therefore, the question of whether Chinese children outperform their English speaking counterparts on *general* visual perceptual abilities, when both of the skills are considered in a single instrument, deserves an in-depth investigation.

In addition, although the cited studies encompass several decades of inquiry, all of the studies cited above were conducted in previous decades, before what has been termed 'global communications' technology. Given the major cultural and environmental changes that have occurred in the extracurricular environment in the past 20 years, it is important to consider whether similar results would be obtained in the 21st century when the influence of these or other factors are taken into account as differences in the populations under study. In order to develop more sophisticated knowledge in this area, this study used the Developmental Test of Visual Perception (DVTP–2nd edition; Hammill, *et al.*, 1993) which includes tasks that measure both skills to address the following hypotheses: (1) Chinese-speaking children will perform better than English-speaking children on general visual perceptual abilities when motor-reduced visual perceptual abilities and visual-motor integration perceptual abilities are considered; and (2) children in the two language groups will perform differently on tasks of motor-reduced visual perceptual abilities and visual-motor integration perceptual abilities.

METHOD

Participants

A total of 41 native Chinese children (22 boys, 19 girls) of mean age 5 yr. 4 mo. (*SD* = 2 mo.) who were born and resided in Hong Kong, and 35 native English-speaking children (19 boys, 16 girls) of mean age 5 yr. 2 mo. (*SD* = 3 mo.) who were born in Australia and resided in Melbourne participated in this study. All of the participants were regular attendants of their kindergartens. The Australian participants were from two kindergartens located in the city centre of Melbourne, which catered to a majority of children from families with middle to high socio-economic status as many of their parents worked at a university nearby. The Chinese participants were from seven kindergartens located in different districts in Hong Kong and with varied socio-economic status. Unlike some Western countries such as Australia where data on socio-economic status (SES) of kindergarten students are collected and accessible to researchers, the government of Hong Kong does not release this information for unfunded research. The participating Hong Kong kindergartens did not allow the authors to collect this information because of the Privacy Ordinance. So, the authors of the study were not given access to that information. We acknowledge that the potential disparity of SES of the two samples could be a confounding factor in the interpretation of the results.

Two methods were used to reduce complexity that might be caused by different cultural factors. Firstly, those children who were identified as having dyslexia were excluded. Secondly, those Chinese and Australian children who had migrated to other countries and recently returned to their own country were also excluded from this study. To minimize the influence of genetic and parental effects, both parents of the Chinese participants had to be of Chinese ethnicity. For Australian children, the ethnicity of Australian participants as well as their parents was British, American, Canadian, or Australian, with their first language being English.

Measures

The Developmental Test of Visual Perception–2 (DTVP–2) (Hammill, *et al.*, 1993) was administered to participants to measure their visual perceptual abilities. This test contains a battery of eight subtests. The subtests fall under two groups, motor-reduced and visual-motor integration. Tests of visual-motor integration include: Eye-hand coordination, which requires children to draw a line within a straight broad band; Copying, in which children are shown simple figures and asked to draw them on a piece of paper; Spatial relations, which requires children to make copy of shapes by connecting points arranged with regular spacing; and Visual-motor speed, in which children trace very quickly a sign inside different geometric shapes. Tests of motor-reduced coordination include: Position in space, which requires children to match one figure from a series of similar but different figures; Figure-ground, in which children are asked to find as many of the figures as they can on a page where the figures are hidden in a complex and confusing background; Visual closure, which requires children to match a figure from a series of figures that have been incompletely drawn; and Form constancy, in which children are shown a stimulus figure and asked to find it in a series of figures. Participants' performance was assessed according to the scoring key provided in the test manual of DTVP–2 (Hammill, *et al.*, 1993). The score for each subtest was assigned to either the motor-reduced visual perception or the visual-motor integration composite. The general visual perception composite comprised scores from all the subtests.

Procedure

The DTVP–2 was administered to the Chinese-speaking participants by the first author, a native Chinese speaker in Hong Kong. The verbal instructions were translated from English (which was provided in the manual) into Cantonese (a major Chinese dialect in Hong Kong) by a native Chinese bilingual fluent in both Chinese and English. A pilot study testing the accuracy and understandability of the Chinese instructions was conducted with 10 kindergarten children of age five. No significant changes were necessary after this pilot. The test was administered to the English-speaking participants by a native Australian research assistant who worked in the field of childcare at a university in Melbourne, and who had been trained by the first author to administer the test. As in Hong Kong, the DTVP–2 was administered individually to the participants in their kindergartens. The time required for the entire test was about 45 minutes. To maintain the attentiveness of participants, the test was administered in two to three sessions, and each participant was asked to finish three to four subtests in each session, allowing the children to go back to their normal classrooms in between sessions.

RESULTS

Results Between the Two Language Groups

Table 1 shows the mean quotients of General Visual Perception (GVPQ), Motor-reduced Visual Perception (MRVPQ), and Visual-motor Integration Perception (VMIQ) and the standard deviations of each composite for each language group, the *t* test results and the effect sizes for equality of means between the two groups. Table 2 provides mean standard scores and standard deviations of each subtest for each language group, the *t* test results and the effect sizes for equality of means between the two groups.

TABLE 1

Means and Standard Deviations For Actual Age, GVPQ, MRVPQ, and VMIQ of Native English Speaking Participants (*n* = 35) and Native Chinese Speaking Participants (*n* = 41)

Variable	Language Group	*M*	*SD*	*t* test		Cohen's *d*
				t	*p*	
Actual age, yr.: mo.	English	5:2	0:2	−0.52	.61	N/A
	Chinese	5:4	0:3			
General Visual Perception Quotient (GVPQ)	English	105.97	14.22	−6.85	<.001†	1.55
	Chinese	124.05	8.45			
Motor-Reduced Visual Perception Quotient (MRVPQ)	English	106.71	16.41	−1.40	.17	0.32
	Chinese	111.15	10.99			
Visual-Motor Integration Perception Quotient (VMIQ)	English	104.71	12.78	−11.82	<.001†	2.70
	Chinese	134.71	9.28			

Note.—For all quotients, the minimum is 37 and maximum is 156 ($37 \leq \bar{x} \leq 156$). *$p < .05$. †$p<.01$.

TABLE 2

Means and Standard Deviations For Each Subtest of Native English Speaking Participants (*n* = 35) and Native Chinese Speaking Participants (*n* = 41)

Item	Language Group	*M*	*SD*	Comparison		
				t	*p*	*Cohen's d*
Eye coordination	English	10.46	1.52	−7.76	<.001†	1.79
	Chinese	13.61	1.95			
Position in space	English	10.20	3.23	−4.10	<.001†	0.94
	Chinese	13.02	2.78			
Copying	English	11.14	2.50	−10.08	<.001†	2.30
	Chinese	16.51	2.15			
Figure-ground	English	12.49	3.67	2.13	.04*	-0.49
	Chinese	10.95	2.58			
Spatial relation	English	11.11	2.78	−10.46	<.001†	2.40
	Chinese	17.39	2.45			
Visual closure	English	8.51	3.33	−2.40	.02*	0.56
	Chinese	10.44	3.61			
Visual-motor speed	English	10.09	3.30	−5.13	<.001†	1.16
	Chinese	13.37	2.23			
Form consistency	English	12.83	1.87	1.32	.19	-0.30
	Chinese	12.27	1.82			

Note.—Scores from 1 to 20. *$p < .05$. †$p < .01$.

The results in Table 1 show that the Chinese-speaking children achieved higher scores than the English-speaking children on both Motor-Reduced Visual Perception and Visual-Motor Integration; and the two contribute to a higher score in General Visual Perception. However, the *t* test indicates that the main effects of language group were significant only for General Visual Perception and Visual-Motor Integration ($p < .01$) with effect sizes 1.55 and 2.70 respectively, while that for Motor-Reduced Visual Perception ($p > .05$) was not significant. The *t* test together with the large magnitudes of the effect sizes (i.e., >0.8; cf. Cohen, 1969) confirm that the Chinese-speaking children's performance in general visual perceptual abilities was better than that of the English-speaking children. However, the Chinese-speaking group scored similarly to the English-speaking group on the motor-reduced visual perception skills. The results in Table 2 also show that the Chinese-speaking children scored significantly higher than the English-speaking children in the subtests of Eye-hand Coordination (ES=1.79), Position in Space (ES=0.94), Copying (ES=2.30), Spatial Relation (ES=2.40), Visual Closure (ES=0.56), and Visual-motor Speed (ES=1.16), while the English children significantly outperformed the Chinese children on the figure-ground subtest (ES= -.049). These findings imply that the Chinese speaking children's comparatively outstanding performance in general visual perception is contributed to mainly by their visual-motor integration. Table 3 shows the results of the difference of Motor-reduced Visual Perception and Visual-motor Integration for the two language groups (the discussion of the results refer to the section of implication).

TABLE 3
Difference of MRVPQ and VMIQ For the Two Language Groups

	Language Croup	*M* Difference	*SD*	SE Mean	*t*	*p*	*Cohen's d*
MRVPQ–VMIQ	English	2	10.98	1.86	1.08	.29	-2.19
	Chinese	–23.56	12.31	1.92	–12.26	<.001†	

$^*p < .05$. $^†p < .01$.

Correlations Between Motor-reduced Visual Perception and Visual-motor Integration

Table 4 shows that the correlation between Motor-reduced Visual Perception and Visual-motor Integration for the English-speaking group was high ($r = .74$, p=0.00, 2-tailed). However, the correlation for the Chinese-speaking group is only .27 (p=0.085, 2-tailed). Figures 1 and 2 display the scatter plots for the English-speaking and the Chinese-speaking groups respectively to identify the potential associations between Motor-reduced Visual Perception and Visual-motor Integration. Figure 1 indicates a positive association among the English-speaking group while Figure 2 indicates a non-associated relationship among the Chinese group. Both the correlation coefficients and scatter plots suggest that these tests of Motor-reduced Visual Perception and Visual-motor Integration are not functioning the same way in the English-speaking and Chinese-speaking groups.

TABLE 4
Correlations Between MRVPQ and VMIQ For the Two Language Groups

Item	Pearson Correlation with VMIQ	
	English-speaking Group	Chinese-speaking Group
MRVPQ	.74*	.27
95% Confidence Interval of the Difference (Lower to Upper)	0.54 to 0.86	-0.04 to 0.53

FIGURE 1
Scatter Plot of Motor-reduced Visual Perception against Visual Motor Integration for English-speaking Group

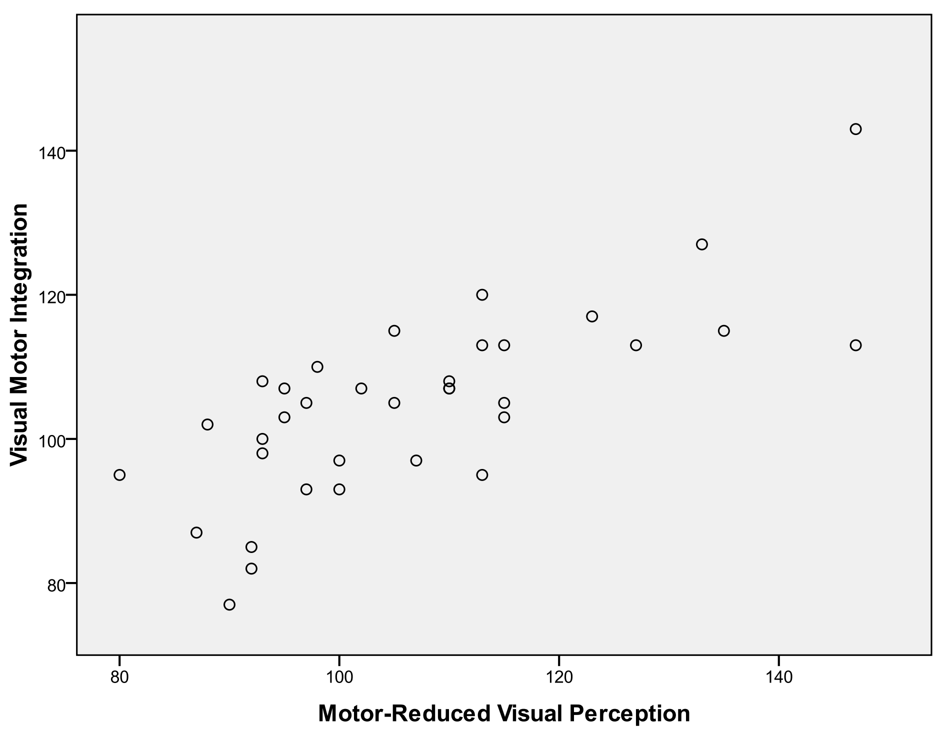
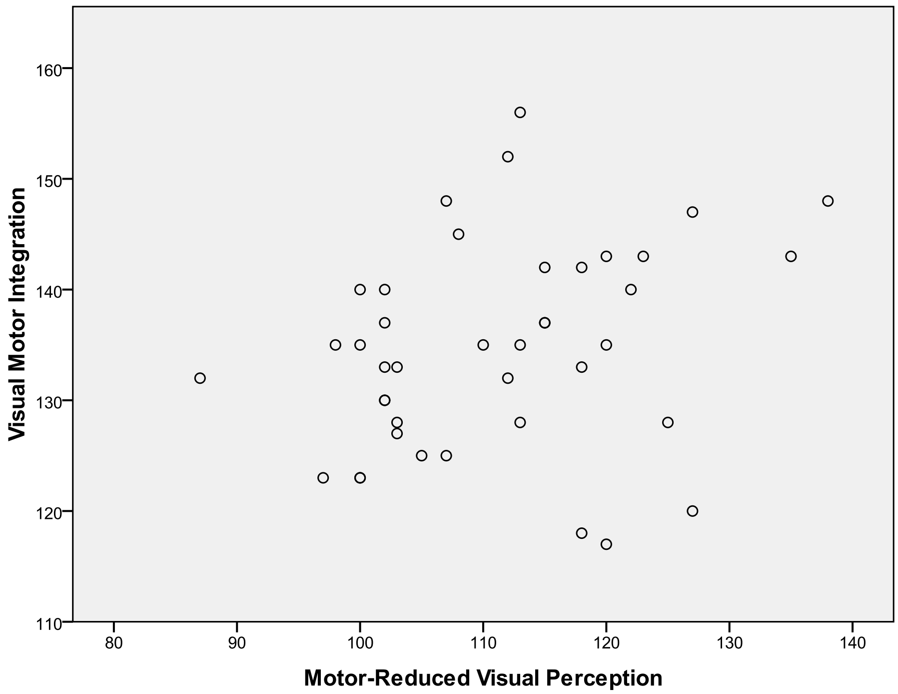


FIGURE 2
Scatter Plot of Motor-Reduced Visual Perception against Visual Motor Integration for the Chinese-speaking Group



DISCUSSION

In an attempt to explain these findings, there is one key cultural factor—language—that may be considered as a potential source. This suggestion draws on the work of Huang & Hanley in 1994. In Huang & Hanley's study, the relationships among phonological awareness, visual skills and reading ability were investigated in one hundred and thirteen-seven 8-year-old primary school children, with one group of children living in Hong Kong and Taiwan who were learning to read Chinese and one group of children living in the UK who were learning to read English. Results of this study showed that the performance on the phonological awareness test (rhyme and phoneme detection) was significantly related to the reading ability of British children even after the effects of IQ and vocabulary had been partialled out. In contrast, results of the test on visual skills (visual paired associates learning) was significantly related to the reading ability of the children in Hong Kong and Taiwan. Huang and Hanley concluded that visual skills might be more important to the learning of Chinese. Gitterman and Sies (1992) made a similar statement that if Chinese script could possibly influence language organization in the brain, there may be reason to suspect its influence in spatial conceptualization. Flaherty (1998) explained that Chinese words are made up of a finite set of radicals and forms, and these units are spatially and visually related to one another. Related studies such as Marks, Shankweiler, Liberman, and Fowler (1997), Mann, Liberman, and Shankweiler (1980), Flaherty (2000), and Sugishita and Omura (2001) also indicated a strong relationship between reading Chinese words, visual encoding, and visual memory. Thus, the results of the group of studies provide a reasonable basis for the visual properties of Chinese written language developing learners' visual abilities.

Written Chinese is a logographic system which puts emphasis on the spatial layout of strokes, and the orthography of Chinese is based on the spatial organization of the components of the characters (Hoosain, 1991; Kao, 2000; Wang, 2009). Chinese words are represented by a large number of basic writing units, known as characters in an imaginary square (Wong 2002). Sasaki (1987) points out that reading Chinese is a relatively complex task of visual recognition and memory and it is not possible to know the pronunciation of Chinese characters unless one has actually mastered its orthography. For this reason, scholars such as Hoosain (1991), Kao (2000), and Kao, Leong, and Gao (2002) emphasized the close relationship between learning to write Chinese and the visual-spatial properties of Chinese words. Likewise, the studies of Salkind, Kojima, and Zelniker (1978), Bagley, Iwawaki, and Young (1983), Flaherty and Connolly (1996), and Flaherty (2000, 2003) drew a similar conclusion that prolonged training in a highly visual writing system such as Chinese can enhance learners' spatial and visual skills. Flaherty (2003) stated that the influence of writing Chinese on learners' visuospatial ability affects the entire nervous system and the behaviours supported by it.

In contrast to Chinese words, the configurations of alphabetic words in languages such as English are more or less tied to their pronunciation and composed of left-to-right letters following a unidirectional scanning path (Kao, Leong, & Gao, 2002) with the structure of English words varying greatly in length (Wang, 2009). Therefore, as Wang (2009) pointed out, the shape of English words does not seem to be a distinctive visual feature which can be easily operationally conceptualized. Children learning to read and write English have to learn that "big" (in Chinese, 大) is a "small word", while "little" (in Chinese, 小) is actually much longer than "big."

“Big” and “Little” in Chinese and English written languages

In Chinese	大	小
In English	Big	Little

Because of these enormous differences between Chinese and English written language, it has been proposed that there may be relatively greater overlap between the cognitive processes in visual processing that are engaged during Chinese word identification and picture identification than is the case for word identification in English (Chee, Weekes, Lee, Soon, Schreiber, & Hoon, 2000). It can be argued that training in Chinese handwriting may shape brain development and facilitate eye-hand coordination, which enhances the visual-motor integration abilities of the learners.

Implications

The relationships among general visual perceptual abilities, motor-free visual perceptual abilities and visual-motor integration perceptual abilities have been an issue in the area of development of cognitive functions across since the 1980s. In the assessment of general visual perceptual abilities, the work of scholars such as Bortner and Birch (1960, 1962), Rosenblith (1965), Maccoby (1965), Colarusso and Hammill (1972), Leonard, Foxcroft, and Kroukamp (1988), Parush, Yochman, Cohen, and Gershon (1998), Schoemaker, van der Wees, Flapper, Verheij-Jansen, Scholten-Jaegers, and Geuze (2001), Bonifacci (2004), and Tsai and Wu (2008) supported the autonomous systems of visual perception and motor development, and maintains that there is no clear interrelation between the two abilities. The supporters explain that young children can always make perceptual discriminations well before they can match the perceived distinctions in their own copying behaviour (Maccoby & Bee, 1965). Likewise, the authors of the Developmental Test of Visual Perception (which was the instrument employed in this study), postulated the prior development of visual-perceptual form to that of visual-motor form. For this reason, they suggest a theoretical assumption: the score on Motor-reduced Visual Perception should always be higher than that of Visual-motor Integration for every single child. However, in this study, as shown in Table 3, the Chinese-speaking children’s performance in visual-motor integration abilities is far higher than their motor-reduced visual perceptual abilities and the difference is statistically significant, while the English-speaking children performed similarly on both skills with scores on motor-reduced visual perceptual abilities slightly higher than for visual-motor integration abilities.

Factors considered influential on the children were carefully controlled. To account for the differences, one of the possible sources is culture. Hong Kong is a place under the heavy influence of the Confucian heritage culture (Ho, 1991; Biggs, 1996), while Melbourne is a city with more “Western” culture. The DTVP–2 was developed in the U.S. where the culture is much more similar to that in Australia than in Hong Kong. Hence, the results of the study confirm the existing knowledge of the prior development of motor-reduced visual perceptual abilities to that of visual-motor integration abilities in Western culture but bring into question whether this is applicable to the Chinese culture (Lai & Leung, in press). Lai & Leung agree with existing knowledge that, among the Chinese cultural group, motor-reduced visual perception and visual-motor integration are two separate systems but question the prior development of the former to that of the latter. If this is the case, Lai & Leung’s argument may imply an alternative form of relationship between motor-reduced visual perception and visual-motor integration among the Chinese cultural group and this unknown relationship may, in some way, explain the relatively low correlation between these two factors (refer to Table 4) in this study. Otherwise, some sort of unforeseen and unpredictable validity problem arises as the correlation between the two factors is so vastly different. Further investigation in this area is worth conducting for eliciting new knowledge.

Regarding the issue of normative statistics for the Chinese students, a ceiling effect on the subtests of Copying and Spatial Relation was observed (refer to Table 2). This, therefore, suggests that the DTVP–2 may not be an effective tool to assess individual Chinese students’ visual perceptual or visual-motor difficulties or to identify candidates for remedial referral. For diagnostic use of DTVP–2 among Chinese students, this study suggests the need to establish norms for Chinese students. However, as noted earlier, there is a possibility that the results may be due to some sort of unforeseen and unpredictable validity problem.

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