Archives of Clinical Neuropsychology 23 (2008) 455–466

Archives
of
CLINICAL
NEUROPSYCHOLOGY

A psychometric study of the Test of Everyday Attention for Children in the Chinese setting

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Accepted 28 March 2008

Abstract

OBJECTIVE: To explore the psychometric properties of the Test of Everyday Attention for Children (TEA-Ch) in the context of a Chinese setting.
METHODS: Confirmatory factor analysis was conducted to examine the construct validity of the Chinese version of the TEA-Ch among a group of 232 children without attention deficit hyperactivity disorder (ADHD). Test–retest reliability was tested on a random sub-sample of 20 children at a 4-week interval. Clinical discrimination was also examined by comparing children with and without ADHD (22 in each group) on the performances of the TEA-Ch.
RESULTS: The current Chinese sample demonstrated a three-factor solution for attentional performance among children without ADHD, namely selective attention, executive control/switch, and sustained attention ($\chi^2(24) = 34.56$; RMSEA = .044; $p = .075$). Moreover, the whole test demonstrated acceptable test–retest reliability at a 4-week interval among a small sub-sample. Children with ADHD performed significantly more poorly than healthy controls in most of the subtests of the TEA-Ch.
CONCLUSIONS: The results of the present study demonstrate that the test items remain useful in China, a culture very different from that in which the test originated. Finally, the TEA-Ch also presents several advantages when compared to other conventional objective measures of attention.

Keywords: Attention; Confirmatory factor analysis; Cognitive development; Chinese

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1. Introduction

Attention deficit hyperactivity disorder (ADHD) is one of the pervasive cognitive/behavioral developmental disorders and is characterized by levels of inattention, hyperactivity, and impulsivity that are age-inappropriate (American Psychiatric Association, 1994). Although much research has been carried out to understand the nature of this disorder, we still do not clearly understand the etiology and the primary underlying psychological deficits that lead to symptom

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doi:10.1016/j.acn.2008.03.007

presentation. One of the models explaining the related functional impairments in these children is the postulation of the frontal lobes involved in the disorder (Barkley, 1997; Boucagnani & Jones, 1989; Chelune, Fergusson, Koon, & Dickey, 1986). Recent findings suggest that it is the neural network impairment of frontal circuits rather than an impairment within the frontal lobes that leads to the clinical and neurocognitive deficits observed in ADHD (Berquin et al., 1998; Lou, Henriksen, & Bruhn, 1984; Lou, Henriksen, Bruhn, Borner, & Nielsen, 1989). Given the major roles of frontal networks on different types of attentional and executive control, the neuropsychological testing of ADHD has shed light on the assessment of multiple frontal network abilities, including sustained attention, selective attention, and response inhibition (Barkley, 1997; Sergeant, Geurts, & Oosterlaan, 2002).

However, most of the previous studies have focused primarily on laboratory-based tests that seem to be detached from real life, and a laboratory setting may make children feel uneasy (Anderson, Holcomb, & Doyle, 1973; Aron, Robbins, & Poldarck, 2004; Bellgrove, Hawi, Kirley, Gill, & Robertson, 2005a; Bellgrove et al., 2005b; Corkum & Siegel, 1993; Huang-Pollock, Nigg, & Carr, 2005; Mason, Humphreys, & Kent, 2005; Shallice, Coser, Del Savio, Meuter, & Rumiati, 2002; Van der Meere & Sergeant, 1987). Despite the impressive sensitivity and clinical utility of these tests, these laboratory-based tests have their own limitations. For example, the conventional Continuous Performance Test may be regarded as too boring to engage in by children with attentional deficits.

In contrast with the tests and paradigms formerly used, the Test of Everyday Attention for Children (TEA-Ch) (Manly, Robertson, Anderson, & Nimmo-Smith, 1999) is a new ecological measure of attention that is more suitable for the child population (Manly et al., 1999). The TEA-Ch was developed in line with Posner and Petersen's (1990) theory of attention networks, and is therefore driven by current theoretical views on attention. The authors of the TEA-Ch took motor speed into account in the design of the test, and they controlled for motor speed in some of the subtests. Moreover, the TEA-Ch is a game-like test. As a result, children are likely to feel more comfortable taking it and be more willing to co-operate with researchers. More recently, Chan and his team (e.g., Chan, Yip, & Su, 2007) have provided the preliminary psychometric properties of the Chinese version of the TEA-Ch among a group of healthy school-age children. They also showed that the subscales used for this version demonstrated impressive clinical utility in discriminating children with ADHD from healthy controls. These findings therefore suggest that the TEA-Ch is a potential tool for clinical practice in Chinese populations.

In light of the fact that all of the available findings on the TEA-Ch were limited to Western samples (such as samples from the UK, Australia, and the US), there is no documented data concerning the suitability and validity of the TEA-Ch in the Chinese population. Given the diversity of the subtests that are embedded in the TEA-Ch, it is worthwhile to examine the psychometric properties of a Chinese version of this test. The purpose of the current study was to establish the psychometric properties of the TEA-Ch in children without ADHD in the Chinese context. It also examined the clinical utility of the translated TEA-Ch in discriminating children with ADHD from healthy controls.

2. Methods

2.1. Participants

Two independent samples of healthy developing children were recruited from Hong Kong and the city of Guangzhou in China, respectively. The Hong Kong sample included 158 children (84 boys and 74 girls) between the ages of 5 and 15, with a mean age of 10.69 (S.D. = 2.54). The mainland sample included 74 children (35 boys and 39 girls) between the ages of 5 and 10, with a mean age of 7.42 (S.D. = 1.57). The children were divided in five age-groups, namely 5–7 years old, 7–9 years old, 9–11 years old, 11–13 years old, and 13–16 years old. Potential participants who reported that they had suffered a previous head injury or neurological illness, delayed development, or sensory loss were excluded from the present study. All of the participants had normal or corrected-to-normal vision. Table 1 summarizes the demographics of the present sample and their IQ scores. There were no significant statistical differences in IQ performance ($F = 2.184$, $p = .072$) or demographic distribution ($\chi^2 = 5.718$, $p = .221$) between the two groups. Therefore, the two samples were merged to a larger sample for subsequent data analysis.

Moreover, 22 children (18 boys and 4 girls) with ADHD (mean age of 8.39; S.D. = 1.01; mean IQ of 106.08, S.D. = 19.46) were recruited from the regional hospital in Guangzhou. The children's parents and teachers completed the ADHD checklist, which consists of the 18 ADHD behaviors that are listed in DSM-IV, the CRS-R (Conners, 1989; Chinese version, Wang, Wang, & Ma, 1999), and the CBCL (Achenbach, 1978; Chinese version, Wang et al., 1999), which also covers the DSM-IV symptoms for ADHD. Inclusion in the study required a diagnosis of ADHD

Table 1
Distribution of boys and girls by age group and their IQ scores in the sample of the TEA-Ch

Age group	Total	Boys	Girls	IQ (S.D.)
(1) 5–7[a]	38	17	21	110.37 (14.47)
(2) 7–9	45	19	26	116.64 (13.93)
(3) 9–11	56	27	29	114.71 (12.04)
(4) 11–13	39	25	14	112.05 (10.80)
(5) 13–16	54	31	23	110.76 (10.55)
Total	232	119	113	113.01 (12.47)

[a] Upper cutoff of each band (e.g. only children under 7 years would appear in band 1).

that was based on clinical semi-structured parent and child interviews with an expert consultant pediatrician. All of the ADHD children were recruited from consecutive referrals to three child behavioral clinics that serve large urban populations in Guangdong Province, China. Handedness was assessed by means of the Annett Hand Preference Questionnaire (Annett, 1970). Twenty-two healthy children (Fifteen boys and seven girls) were also recruited from a primary school in Guangdong Province as the healthy controls. Their mean age was 8.23 (S.D. = 1.25), and their estimated FIQ was 110.10 (S.D. = 16.55). Potential participants were excluded if they had a history of neurological, psychiatric, or pervasive developmental problems or any other serious medical condition or an estimated IQ below 75. The two samples did not differ significantly in terms of age and IQ estimates.

2.2. Measures

2.2.1. The TEA-Ch

The TEA-Ch was designed to be a game-like test intended for use between the ages of 6 and 16. The TEA-Ch was translated into Mandarin and Cantonese for the current study. The details of the test items are described elsewhere (Manly et al., 1999, 2001). In brief, these items are summarized as follows.

(1) *Score!* Children were required to silently count the tones and announce the total number of tones at the end of each trial. The number of tones ranged from 9 to 15, with a total of 10 trials in this subtest. The score given was the number of trials in which the child gave the correct response.
(2) *Code transmission*. In this subtest, children listened to a 10-min audio tape of digits and immediately announced the digit presented just before ‘55’ when they heard the number ‘55.’ The score given was the number of digits correctly announced by the participant.
(3) *Walk do not walk.* Children were given an A4 sheet showing footprints on a path made up of 14 squares. While listening to a tape, they marked the footprints for the go tone until the stop tone appeared. The task required children to listen to the entire sound before marking their sheets. There were four practice trials and 20 formal testing trials. The score given in this subtest was the number of correct responses given by the child.
(4) *Score DT.* Children were asked to complete two tasks: one was similar to the task in Score!, and the other was to listen to a meaningful audio news broadcast and figure out the animal mentioned in it. Children were asked to report the number of tones and the animal mentioned in the news broadcast. The score given depended on correct responses on the number of tones and on the animal. Each participant was asked to complete two practice trials and 10 formal testing trials.
(5) *Sky search DT.* Children were asked to complete a parallel version of the sky search subtest (see below). At the same time, they were asked to silently count the number of tones in a similar way to the Score! subtest and to announce the number of tones. After the practice trial, the formal testing trial and timing started while a countdown played on the tape. The time taken to complete the trial, the number of correct responses on the number of tones, the number of tones completed, and the number of correctly circled pairs of craft were recorded.
(6) *Sky search.* Children were given a colorful A3 sheet with numerous pairs of craft randomly distributed across it. The task was to try to circle as many pairs of identical craft as possible on the sheet as quickly as possible. To control for the effect of the confused factor, motor speed, on visual selection, the children then completed a motor control version of the test. The sky search Attention Score was produced by subtracting the motor control time-per-target

from the more attentionally demanding sky search time-per-target. This method of calculation ensured that the sky search attention score was free from the impact of motor speed.

(7) *Map mission.* This measure was a timed-out test. Children were asked to circle as many targets as possible in 1 min on an A3 size map. The targets were symbols of pairs of knives and forks. The score was the number of targets correctly circled.

(8) *Creature counting.* In each trial of this subtest, a variable number of ‘creatures’ were depicted in their dens. The children were asked to count the creatures from top to bottom and to use the up and down arrows as cues to switch the direction in which they were counting. The children’s ability to count up and down from 1 to 15 was assessed first, followed by two practice trials and seven formal testing trials. The number of correct responses and the time taken to complete the trials were recorded. The sum of the time taken to respond and the total number of correct response switches were calculated.

(9) *Opposite worlds.* The children were shown a sheet presenting a mixed, quasi-random array of the digits 1 and 2. In the ‘same world’ trial, they were required to announce the digits actually presented as quickly as possible. In the ‘opposite world’ trial, they were required to announce the opposite digit (‘one’ for 2 and ‘two’ for 1) to the digit presented as quickly as possible. In the measurement phase, the children pointed to and announced each digit in turn, moving on to the next one only if the correct response was given, thus incurring a time penalty when an error was made. The time taken to complete the task was recorded as the score for this subtest.

Intellectual functioning was assessed using the Wechsler Intelligence Scale for Children-Revised for China, C-WISC (Gong & Cai, 1993) for children over the age of six and the Nonverbal Intelligence Test (Gong et al., 1997) for children under the age of six. Five subtests were selected from the C-WISC to pro-rate the IQ estimate, namely the arithmetic, vocabulary, digit span, block design, and object assembly subtests. Five subtests were also selected from the Nonverbal Intelligence Test for the same purpose, namely the color match, number–color, sorting, connecting, and numbers subtests.

2.3. Procedure

All of the tests were administered by three trained research assistants using a standardized procedure in a quiet room at school. The total duration of testing was about 2 h, with a brief opportunity to rest between tasks as the examiner set up the next test. The study was approved by the ethics committees of the Institute of Psychology. Written consent was obtained from the parents or guardians of the children. A convenience sub-sample of 20 participants (9 boys and 11 girls) was randomly selected to be re-tested 4 weeks later.

2.4. Data analysis

The CFA was used to test the factor structure of the TEA-Ch measures in the typically developing children. First, the participants’ raw scores for the TEA-Ch subtests were transformed into standardized scores (*Z*-scores). LISREL8.72 was then used to test a general-factor model. We tested a three-factor model proposed by Manly et al. (2001), in which the factors are sustained attention, selective attention, and executive (attentional) control. The goodness of fit of the model was further guided by four additional fit indices suggested by Chou and Bentler (1995) and Byrne (1998), namely the Normed Fit Index (NFI), the Non-Normed Fit Index (NNFI), the Incremental Fit Index (IFI), and the Comparative Fit Index (CFI). A value of .90 or above indicates that the model adequately fits the data. In addition, we tested the most parsimonious general-factor model in which a single latent variable can account for the variance of all observed variables. The attention performances of children with ADHD were then examined, along with those for the matched healthy controls.

For the test of test–retest reliability, a random sub-sample of 20 participants (9 boys and 11 girls) was selected to be re-tested 4 weeks later. The mean age and IQ of this sub-sample were 7.68 (S.D. = .41) and 107 (S.D. = 17.4), respectively. There was no significant difference between this sub-sample and the original sample in terms of age and education. The test–retest correlation coefficients were calculated for the test–retest reliabilities of each subtest and factor score.

The effects of age and sex on the performances in each of the TEA-Ch variables (raw scores) were analyzed using ANOVA. Finally, clinical discrimination of the TEA-Ch was examined by comparing the performances between children with ADHD and healthy controls with the derived factor scores.

3. Results

3.1. Latent factor structure of the TEA-Ch

The results of the CFA are presented in Table 2. The factor loadings for each subtest on the corresponding latent factors in the three-factor model were all above .40, which suggested that all of the latent factors appeared to be have been adequately measured by their respective observed variable. In this model, each observed variable from the TEA-Ch battery was ascribed to three different latent attentional factors, based on their theoretical origins. Score!, code transmission, walk do not walk, Score DT, and sky search DT were ascribed to "sustained attention." Sky search and map mission were associated with the "selective attention" factor, and creature counting and opposite worlds were associated with a broad "executive" or "attentional control" factor. The results suggested that the three-factor model fits the data adequately, as indicated by the non-significant χ^2 values and smaller RMSEA values, $\chi^2(24) = 34.56$ ($p = .075$) and RMSEA = .044. The non-significant χ^2 values and smaller RMSEA values suggested that this three-factor model adequately fits the data. Moreover, all four of the diagnostic indices for the model were above .90 (NFI .97, NNFI .99, IFI .99, CFI .99), indicating that the three factors alone form a good fit with the patterns of attentional performance observed in Chinese participants. The means and correlation matrix are presented in Table 3. The three-factor models of TEA-Ch performance is presented graphically in Fig. 1

Table 4 shows the mean scores for the TEA-Ch subtests and their correlations. The correlation coefficients were calculated by matching all of the participants' scores in baseline assessments and retest assessments. Some subtests did not demonstrate a significant test–retest correlation, but the majority of the other five subtests showed significance at the .01 level at 1-month interval. Children were required to find two symbols in the different versions of the map mission subtests, and all of them did better in the retest session. The walk do not walk subtest gave a significant level near the .05 level, and the correlation coefficient of .433 can be considered a significant finding for the small sample size ($n = 20$). The Score! and sky search DT subtests are discussed later.

Table 5 shows the influence of age on performance in each of the TEA-Ch variables (raw scores) using ANOVA. Unsurprisingly, age exerted a significant effect on each measure, the p-values in each case being below <.001. Correla-

Table 2
Factor loadings and goodness of fit indices of competing CFA models in Chinese participants

	General-factor model	Three-factor model
Sky search	.68	.71[a]
Map mission	.73	.78[a]
Creature counting	.60	.61[b]
Opposite worlds	.88	.93[b]
Score!	.47	.51[c]
Code transmission	.66	.73[c]
Walk do not walk	.51	.54[c]
Score DT	.72	.75[c]
Sky search DT	.36	.43[c]
χ^2	68.43	34.56
d.f.	27	24
p	.000	.075
NFI	.96	.97
NNFI	.96	.99
IFI	.97	.99
CFI	.97	.99
RMSEA	.082	.044

[a] Selective attention.
[b] Attentional control.
[c] Sustained attention.

Table 3
Means, standard deviations, and the covariance matrix of the individual subtest items of TEA-Ch in Chinese participants

	M	S.D.	1	2	3	4	5	6	7	8	9
1. Sky search	.13	.70	–	.56**	.41**	.60**	.29**	.41**	.29**	.50**	.10
2. Map mission	.07	.95		–	.39**	.67**	.31**	.40**	.34**	.53**	.22**
3. Creature counting	.10	.65			–	.56**	.21**	.39**	.33**	.41**	.20**
4. Opposite worlds	.10	.85				–	.35**	.58**	.44**	.61**	.28**
5. Score!	.10	.83					–	.40**	.32**	.34**	.26**
6. Code transmission	.14	.81						–	.40**	.51**	.41**
7. Walk do not walk	.11	.82							–	.38**	.19**
8. Score DT	.08	.93								–	.34**
9. Sky search DT	.10	.58									–

Note: The scores are *Z*-score. *Correlation is significant at the .05 level (2-tailed). **Correlation is significant at the .01 level (2-tailed).

tion analysis and partial correlation analysis controlling for IQ were used to further examine the relationship between age and performance in each of the TEA-Ch measures. As can be seen in Table 6, the correlations between age and performance in each of the TEA-Ch measures controlling and without controlling for IQ were both significant at the .01 level, which suggests that there is a progressive advancement in attention performance with advancing age.

The effects of sex were examined for each measure across the whole sample using ANOVA. There was no significant difference in performance between the 119 boys and 113 girls in any task other than creature counting (time-per-switch), in which the boys performed moderately better than the girls (boys' mean time-per-switch = 4.90, S.D. = 3.34; girls' mean time-per-switch = 5.82, S.D. = 3.69; $F = 3.933$, $p < .05$).

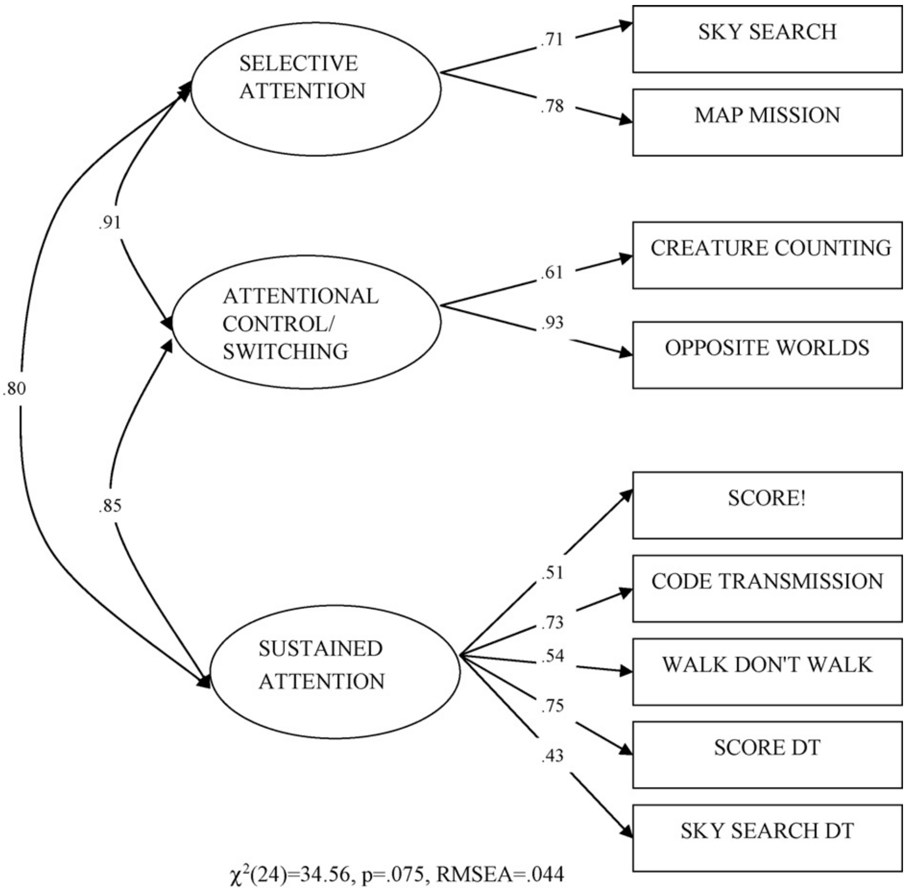

Fig. 1. The three-factor model of TEA-Ch performance in Chinese participants.

Table 4
Correlation of baseline assessment and retest assessment of each subtest of the TEA-Ch

Subtest	Baseline assessment ($n = 20$)				Retest assessment ($n = 20$)				Spearman correlation coefficient ($n = 20$)
	Min	Max	Mean	S.D.	Min	Max	Mean	S.D.	
Sky search	3.0	9.0	4.7	1.4	2.0	7.0	4.4	1.3	.588**
Score!	2.0	10.0	8.4	2.1	4.0	10.0	7.8	1.8	.045
Creature counting	3.2	8.7	5.3	1.4	2.8	9.4	4.3	1.5	.724**
Sky search DT	−4.3	8.4	1.3	3.1	−2.4	12.0	1.1	3.2	.132
Map mission	6.0	30.0	19.4	6.2	18.0	50.0	32.9	8.5	.386
Score DT	6.0	16.0	10.7	2.5	6.0	20.0	12.7	3.7	.268
Walk do not walk	6.0	19.0	11.0	3.7	6.0	17.0	12.3	3.8	.433
Same world	16.0	35.0	24.6	5.2	16.0	38.9	24.0	6.3	.789**
Opposite world	23.0	54.0	33.9	8.0	21.2	44.9	29.5	7.0	.770**
Code transmission	24.0	40.0	34.1	4.2	22.0	39.0	35.3	3.9	.702**

**$p < .01$.

The children with ADHD performed significantly more poorly than did the healthy controls in visual reproduction ($t = -2.36$, $p = .023$, 2-back, $t = -3.13$, $p = .004$). Moreover, the ADHD children performed significantly below the non-ADHD children in five out of the nine subtests in the TEA-Ch (Table 7). When we collapsed the nine subtests into the three factor domains of attention, the ADHD children showed a poorer performance in the sustained attention factor (Table 8).

4. Discussion

The major findings of the current study show that the current Chinese sample demonstrated a three-factor solution for attentional performance among children without ADHD, namely selective attention, executive control/switch, and sustained attention. Moreover, the whole test demonstrated acceptable test–retest reliability at a 4-week interval among a small sub-sample. Moreover, children ADHD performed significantly below than healthy controls in most of the subtests of the TEA-Ch. When we collapsed the nine subtests into three factor domains of attention, the ADHD children showed a poorer performance in the sustained attention factor.

The result of the CFA on the latent structure of the Chinese sample was consistent with the theoretical framework for attention networks in general (Posner & Petersen, 1990) and with the rationale for the development of the TEA-Ch in particular (Manly et al., 2001). Manly et al. (2001) demonstrated a three-factor structure for the TEA-Ch among a group of 293 healthy Caucasian children between the ages of 6 and 16. These were selective attention (sky search, map mission), attentional control/switching (creature counting, opposite worlds), and sustained attention (Score!, code transmission, walk do not walk, Score DT, and sky search DT). Moreover, a similar three-factor structure for an adult version of this test, the Test of Everyday Attention (Robertson, Ward, Ridgeway, & Nimmo-Smith, 1994; Robertson, Ward, Ridgeway, & Nimmo-Smith, 1996), has been demonstrated among healthy Chinese adults (Chan, Hoosain, & Lee, 2002; Chan, Lai, & Robertson, 2006; Chan, Robertson, & Crawford, 2003) and patients with traumatic brain injuries (Chan & Lai, 2006). These latent constructs seem to be stable both across cultures and across the human lifespan. Taken together, the preliminary findings suggest that the Chinese version of the TEA-Ch can be used to investigate the attentional performance of children in the Chinese context.

As expected, age difference in attentional performance was observed in the present study. Age correlated significantly to all of the subtests of the TEA-Ch, even after controlling for IQ. These findings were consistent with previous research (Mezzacappa, 2004). In the pilot study conducted by Manly and his colleagues using TEA-Ch measures, a developmental plateau was observed in the range from 6 to 16 years of age (Manly et al., 2001). However, the present study mainly focused on the attentional performance of children aged three to eight, thus focusing on children much younger than the children in Manly's study. Although some floor effects were observed, even 3-year old children were able to finish at least one item in the TEA-Ch. This suggests that attention abilities may emerge at a very young age. Furthermore, when using factor scores to investigate the relationship between three components of attention and age, only two components showed significance in the partial correlation analysis. However, when using one-way ANOVA, the effect of age on each attentional component was presented.

Table 5
Raw scores on each subtest by age group and the results of ANOVA

	Age band					F-Value	p-Value
	1 ($N=38$) Mean (S.D.)	2 ($N=45$) Mean (S.D.)	3 ($N=56$) Mean (S.D.)	4 ($N=39$) Mean (S.D.)	5 ($N=54$) Mean (S.D.)		
Sky search (time-per-target)	8.33 (3.91)	4.87 (1.71)	4.24 (1.74)	2.80 (0.92)	2.50 (0.87)	54.27	.0005
Map mission (accuracy)	14.66 (6.43)	21.27 (8.56)	28.50 (10.29)	45.28 (9.72)	49.19 (10.38)	114.48	.0005
Creature counting (time-per-switch)	8.75 (3.55)	6.93 (3.64)	5.15 (3.58)	3.72 (2.01)	3.02 (0.76)	27.82	.0005
Opposite worlds (time)	46.79 (9.25)	35.77 (6.79)	28.45 (5.57)	22.27 (3.87)	21.21 (3.99)	128.57	.0005
Score! (accuracy)	7.34 (1.91)	8.33 (1.69)	8.64 (1.68)	9.54 (0.76)	9.56 (0.82)	17.18	.0005
Code transmission (accuracy)	27.05 (6.94)	33.80 (4.54)	35.73 (3.52)	36.92 (3.59)	38.17 (1.76)	44.56	.0005
Walk do not walk (accuracy)	11.76 (5.08)	14.93 (4.65)	15.71 (4.36)	19.46 (0.88)	19.69 (0.58)	35.72	.0005
Score DT (accuracy)	6.97 (2.58)	11.67 (2.57)	14.61 (2.72)	16.72 (2.75)	17.80 (2.00)	125.87	.0005
Sky search DT decrement)	16.15 (28.92)	3.00 (5.96)	1.25 (3.23)	0.47 (1.18)	0.28 (1.42)	12.44	.0005

Table 6
Correlation and partial correlation controlling for IQ between age and performance of each TEA-Ch measures

Subtest	Pearson's correlation coefficient	Correlation with IQ Partialled out
Sky search (time-per-target)	−.65**	−.67**
Map mission (accuracy)	.82**	.83**
Creature counting (time-per-switch)	−.58**	−.59**
Opposite worlds (time)	−.81**	−.82**
Score! (accuracy)	.45**	.46**
Code transmission (accuracy)	.60**	.61**
Walk do not walk (accuracy)	.60**	.64**
Score DT (accuracy)	.80**	.82**
Sky search DT (decrement)	−.31**	−.33**

Note: **Correlation is significant at the 0.01 level (2-tailed).

Table 7
Attentional performance between ADHD children and healthy controls (bold: $p < 0.05$)

	ADHD ($n = 22$)		Controls ($n = 22$)		t	p
	M	S.D.	M	S.D.		
Memory						
Logical memory	9.28	9.28	9.16	2.56	0.326	0.727
Visual reproduction	9.96	2.64	11.68	2.50	**−2.36**	**0.023**
2-back (correct response)	4.80	2.24	7.80	4.29	**−3.13**	**0.004**
2-back (reaction time)	635.64	283.28	684.28	231.49	−0.24	0.810
TEA-Ch						
1. Sky search						
Attended time (s)	7.17	5.41	4.50	1.59	**2.30**	**0.030**
Mean reaction time (s)	8.04	5.56	5.20	1.58	**2.30**	**0.036**
2. Score!	7.95	2.13	8.27	2.57	−0.448	0.657
3.Creature counting						
Correct response	5.31	1.46	5.77	1.41	−1.05	0.300
Mean reaction time (s)	114.64	47.35	101.55	43.71	0.95	0.346
Time score	5.85	2.71	4.77	2.13	1.47	0.149
4. Sky search DT	3.67	11.59	7.99	32.75	−0.58	0.563
5. Map mission	24.64	9.55	23.05	8.80	0.58	0.569
6. Score DT	8.77	3.52	11.13	3.01	**−2.39**	**0.021**
7. Walk do not walk	12.18	3.98	11.86	3.56	0.28	0.781
8. Same world	27.14	8.71	22.40	5.94	**2.10**	**0.041**
8. Opposite world	37.55	12.24	30.41	8.82	**2.22**	**0.032**
9. Code transmission	28.72	7.32	34.72	4.25	**−3.31**	**0.002**
Sustained attention response to task						
Correct response	171.16	25.21	188.88	8.31	**−.34**	**0.002**
Commission errors	18.2	3.86	18.44	4.36	−0.80	0.427

Table 8
Comparison of TEA-Ch factor scores between ADHD children and healthy controls

TEA-Ch (z-score)	ADHD ($n = 22$)		Controls ($n = 22$)		t	p
	M	S.D.	M	S.D.		
Selective attention	0.26	1.33	−0.21	0.57	1.52	0.136
Executive control/switch	0.15	1.01	−0.08	0.89	0.23	0.819
Sustained attention	−0.27	1.01	0.36	0.88	−2.22	0.032

Manly et al. (2001) found some degree of relationship between IQ and the TEA-Ch. A similar result was demonstrated in the present study. The block design subtest of the C-WISC has been viewed as a good measure of attentional performance related to the frontal lobes (Ward, 2004). The digit span subtest has been found to be related to attentional performance in vigilance tests, such as the CPT (Rosenthal, Riccio, Gsanger, & Jarratt, 2006; Tomporowski & Simpson, 1990). These two subtests showed significant correlation to the subtests of the TEA-Ch. Moreover, verbal intelligence was also found to relate to attention (Pascualvaca et al., 1997). In particular, the Vocabulary subtest, which represents verbal intelligence, showed significant correlation to the map mission subtest. Furthermore, the object assembly subtest demonstrated significant correlation to the creature counting subtest, which may be due to the similar nature of the tasks. creature counting required the participant to switch between two counting rules in the task, and the object assembly subtest required the participant to change the assembly method used according to the situation. Both tasks required cognitive agility. Although significant correlation was found between IQ and the TEA-Ch, only five TEA-Ch subtest scores showed significant relationships with IQ scores. These results suggest that the TEA-Ch is designed to assess abilities that are not well captured by measures of general ability.

The present findings were generally consistent with previous studies on attentional deficit in ADHD (e.g., Anderson et al., 1973; Corkum & Siegel, 1993) and with the performance profiles of the TEA-Ch in particular (e.g., Heaton et al., 2001; Manly et al., 2001). The TEA-Ch is a relatively new test that specifically captures different components of attentional performance in healthy developing children and clinical cases. However, relatively few published studies have been conducted to evaluate the utility of the TEA-Ch within the ADHD population. Manly et al. (2001) found that ADHD children showed impaired performance in only six of the nine subtests in the TEA-Ch as compared to healthy controls. Specifically, children with ADHD performed significantly worse in four subtests assessing sustained attention and one subtest assessing attentional control/switching. No significant group differences were found in selective attention. Heaton et al. (2001) also demonstrated that ADHD children performed significantly worse than the clinical control group in three subtests assessing sustained attention, and that the two groups showed comparable performance in the two subtests for divided attention. In the current study, we found that the ADHD children performed significantly worse in five of the TEA-Ch subtests, of which four assessed sustained attention and one assessed attentional control/switch. The results were consistent with previous findings that have emphasized both sustained attention deficit and difficulty in the suppression of prepotent responses (e.g., Barkley, 1997). When we collapsed the subtests into the three latent factors derived from the CFA model, the only significant difference demonstrated between the ADHD children and healthy controls was in the sustained attention factor. Taken together, these findings are also in accordance with the view that the frontal systems are crucial to the neurological basis for the ADHD disorder (Barkley, 1997).

In conclusion, the current study provides invaluable data to support the validity of a test originally developed in the West when applied in a very different culture, namely China. There is also an adult version, the Test of Everyday Attention (Robertson et al., 1994, 1996), and its adapted Chinese version (Chan & Lai, 2006; Chan et al., 2006). Given the diversity of the subtests that are embedded in the TEA-Ch, this test and its adult version may have a wider range of application, from healthy populations to various clinical populations along the developmental lifespan continuum. A particular strength of this study lies in its provision of the developmental profile of attentional performance based on the Chinese version of the TEA-Ch. The present findings may therefore serve as the preliminary norms for healthy developing Chinese children. This study may lay the basis for future cross-cultural studies on attentional performance in healthy developing children and specific clinical cases. Further research is needed before the Chinese version of the TEA-Ch can be fully embraced as a reliable and valid measure for these purposes.

Acknowledgements

The authors would like to thank the Harcourt Test Company for their kind permission to translate the TEA-Ch into Mandarin and Cantonese for research purposes. They would also like to thank Zhijing Xie, Miaoyan Guo, and Christie Lau for their help in collecting the healthy and clinical data for this study. This study was supported partially by a research initiation fund from the Institute of Psychology, Chinese Academy of Sciences (O7CX031003; KSCX2-YW-R-131), to Raymond Chan, and the private funding of the Hong Kong Spectrum Co. Ltd.

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