# ABSTRACT

**Background:** The Griffiths Mental Development Scales (GMDS) are used in many countries to assess the development of children from birth to 8 years. There is a need for accurate and culturally appropriate developmental assessment tools for Chinese children. Here, we adapted the GMDS for use in Chinese children and compare the developmental trajectories between Chinese and British children.

**Methods:** Children with typical development were recruited from seven urban cities in China between 2009 and 2013. The Griffiths Mental Development Scales- Chinese (GDS-C) were adapted and used to assess the development of urban Chinese children. Developmental curves were computed for six subscales using LMS methods and compare against the British curves from the Griffiths Mental Development Scales- Extended Revised (GMDS-ER).

**Results:** The GDS-C were used to assess the developmental status of 815 Chinese children. Plots of the 1st, 5th, 10th, 25th, 50th, 75th, 90th, 95th and 99th percentiles and full percentile tables were obtained, which showed similar trends to data from the British GMDS-ER.

**Conclusions:** The Chinese developmental curves obtained from the GDS-C showed similarities and differences to the developmental curves from the British GMDS-ER. The development of urban Chinese children should be assessed with the culturally appropriate GDS-C.

# INTRODUCTION

The Griffiths Mental Development Scales (GMDS) assess the development of a child from 0 to 8 years across six separate subscales: Locomotor (A), Personal-social (B), Language (C), Eye-hand co-ordination (D), Performance (E) and Practical Reasoning (F) (Luiz et al., 2006). The GMDS have been used extensively by paediatricians and psychologists in many Caucasian countries including the United Kingdom, Italy, Germany, Switzerland and Australia. The GMDS for 0-2 years old was re-standardized in 1996. For 2-8 years old, re-standardization was done in 2006 and was renamed as Griffiths Mental Development Scales- Extended Revised (GMDS-ER). A survey by the British Psychological Society showed that GMDS was the most widely used developmental scale in the United Kingdom.(Griffiths, 1996)

The GMDS-ER was developed based on observations of the performance of children from Western societies. Many countries in East Asia including China, Singapore and Malaysia are using GMDS as a developmental assessment tool.(Cheuk & Wong, 2005; J. Ho, Amar, & Ismail, 2001) However, there are obvious differences between the culture in Asian compared to Western societies. For example, most children in China will be taught to use chopsticks(S. Wong, Chan, Wong, & Wong, 2002) rather than a knife and fork. Statistics published in the GMDS manual show there were significant differences in mean scores in the locomotor development subscale, with non-Caucasian children scoring nearly six points higher.(Boyle et al., 2011) However, their sample included 613 children in the Caucasian group and only 42 in the non-Caucasian group, and it was not clear what proportion of these children were Chinese.

Childhood development can be affected by different parenting styles(Farah et al., 2008; Landry, Smith, & Swank, 2003), adequacy of environmental stimulation, and socio-economic status.(Ip et al., 2013; Santos et al., 2008) These factors can be influenced by ethnicity and the country where the child is raised. Furthermore, a previous study using the Bayley scales of infant development showed there were significant differences between mental and motor developmental scores among Asian and Caucasian children.(Y.-T. Wu et al., 2008) A review of published studies also indicated differences in the rate and sequence of motor development among children originating from Europe or Asia.(Mayson, Harris, & Bachman, 2007) A previous study on the gross motor skill of rolling over in 72 Hong Kong infants found that they rolled from supine to prone before they rolled from prone to supine(Nelson, Yu, Wong, Wong, & Yim, 2004), which was in contrast to the sequence identified in a Canadian normative study.(Piper, 1994)

This collaborative study recruited children from Hong Kong and six other cities in China (Beijing, Tianjin, Shanghai, Xian, Zhengzhou, and Kunming). Our study aimed to adapt the Chinese version of the GMDS as a tool for assessing the developmental status of Chinese children aged 0 to 8 years and the developmental trajectories of Chinese and British children were compared.

# METHOD

A collaborators’ meeting was held in Kunming Medical University in November 2009 to discuss the translation of the British version of the GMDS from English to simplified and traditional Chinese. Modifications to the GMDS were made according to the Chinese culture. The Chinese version of the GMDS was then back translated to check the accuracy of the translation. This modified GMDS for Chinese children was named the Griffiths Mental Development Scales for China (GDS-C). The GDS-C could be conducted in either Mandarin or Cantonese.

Using the GDS-C, we assessed the development of Chinese children in the study sample. Assessors at the seven centres in the participating cities were all registered Griffiths users and were experienced in conducting psychological tests. Each assessor viewed a DVD of a child being tested and then submitted a report of their assessment to ensure the overall scoring agreement was within two items per scale. For quality purposes, each centre submitted video recordings of their assessors testing a child.

The inclusion and exclusion criteria were similar to the GMDS-ER where British children were recruited for the standardisation. Inclusion criteria were infants and children with apparently normal developmental milestones (i.e., no developmental concerns from parents/carers and normal regular developmental surveillance from baby and child health centres), and children born at full term (≥ 37 weeks) with uncomplicated gestational and neonatal history.

Exclusion criteria were ex-prematurity; children with a history of seizures including febrile convulsion; a known developmental delay; children with a history of central nervous system infection, suspected or diagnosed with a disease related to the central nervous system including muscle diseases, visual or hearing disorders; and children suspected or diagnosed with metabolic diseases, syndromal disorders, or chromosomal disorders.

For the six Chinese cities and Hong Kong, stratified random sampling were used to recruit subjects from the postnatal wards, baby and child health centres affiliated to teaching hospitals and from local preschools and primary schools. We aimed to recruit 60 boys and 60 girls in each of the age year from one to eight years.

Ethical approval was obtained from the Institutional Review Board of each of the local teaching hospitals and child health centres.

Basic demographic data were also collected. Data collected by the seven centres in China and Hong Kong were sent for statistical analysis by Prof. Faragher and his team at the Liverpool School of Tropical Medicine, United Kingdom. Same statistical methods were used for analysis of the developmental data for the British children age 3- 8 years old and Chinese children age 0-8 years old.

Using the LMS method(Cole & Green, 1992), the raw scores of the six subscales were converted to the corresponding percentiles. The LMS method has proven to be a powerful tool for deriving and presenting reference charts(Orden & Apezteguia, 2016). Developmental curves with respect to all the six subscales together with the “general quotient” (GQ) were plotted. The GQ were derived by calculating the average of the raw scores of the six subscales. The developmental curves were then fitted using smoothing splines. The percentile graphs demonstrated normative trends in developmental scores for each subscale. The spread of data across the full age range from Birth to 8 years yielded reliable curves. The 1st, 5th, 10th, 25th, 50th, 75th, 90th, 95th and 99th percentiles were displayed in each plot. All graphical outputs were performed with SAS statistical software (SAS for Windows, version 9.2). Cronbach’s alpha was used to determine the internal consistency of the subscales and GQ, respectively. The Chinese developmental curves were compared against the British curves published in the GMDS-ER.

# RESULTS

A total of 815 children (424 boys and 391 girls) aged 7 days to 8 years were recruited into the study. 31 children were recruited from Beijing, 100 from Tianjin, 169 from Kunming, 160 from Shanghai, 124 from Xian, 111 from Zhengzhou and 120 from Hong Kong. The Cronbach’s alpha for Subscales A to E were 0.70, 0.72, 0.73, 0.71, and 0.69 indicating the internal consistencies of these scales were acceptable. However, the Cronbach’s alpha of Subscale F was 0.49, which may suggest the set of items in this scale may not be adequate to provide a single unidimensional latent construct in Chinese subjects. Interestingly, GQ had a high Cronbach’s alpha of 0.98 indicating the correlations between subscales were strong.

We found similarities and differences in the six subscales when comparing the Chinese cohort with the British cohort beyond 2 years (Figure 1).

In the Locomotor Subscale (A), the Chinese cohort had lower initial scores compared to the British cohort at 2 years. Beyond 3 years, the percentile curve in the Chinese cohort was higher than that of the British cohort. The British cohort showed a steady growth rate in Subscale A. On the other hand, the Chinese cohort exhibited a non-linear growth in Subscale A. The two sets of curves converged after 6 years, except in the 1st percentile.

In the Personal-social Subscale (B), the initial upper percentiles scores in the two cohorts were almost identical at 2 years. Similar to Subscale A, the British cohort exhibited a relatively steady growth rate in Subscale B. Comparatively, the Chinese cohort showed rapid growth from 2 to 4 years, with relative plateauing from 5 to 6 years before accelerating again. The two sets of curves converged beyond 6 years.

In the Language Subscale (C), the mid-range of the curve showed significant widening between the two cohorts. The British cohort showed a stable growth rate in Subscale C from 2 to 5 years before plateauing. The Chinese cohort had a relatively lower initial score in Subscale C, especially for the high percentiles (e.g., 99th percentile) at 2 years. A relatively faster growth rate occurred between 2 to 4 years surpassing that of the British scores within this phase. Nevertheless, the curves started to level off earlier in the Chinese cohort at around 4 years compared to the British cohort at around 5 years.

In the Eye-hand co-ordination Subscale (D), the initial scores in the Chinese cohort were less than or equal to that of the British cohort at 2 years. The two sets of curves plateaued beyond 6 years when the level of higher functioning in the children reached the ceiling of the scale. Before plateauing, the Chinese cohort had a relatively stable growth rate compared to the British cohort. The two cohorts showed similar scores in the five percentiles at around 6 years. The scores deviated beyond 6 years.

In the Performance Subscale (E), the initial scores of the British cohort were substantially higher than that of the Chinese cohort. However, from 36 months onwards, the Chinese cohort had an accelerated growth rate while the British cohort growing at a lower rate. The Chinese cohort showed convergence after 4.5 years where as the British cohort showed widening of scores from 6 years onwards with no convergence resulting in flatter curves in the British cohort. From 4.5 years onwards, the Chinese cohorts have higher scores across all the percentiles.

In the Practical Reasoning Subscale (F), the Chinese cohort showed higher initial percentile scores. The Chinese cohort showed widening of lower percentiles in Subscale F compared to the British cohort. In addition, the upper percentiles in the Chinese cohort reached the ceiling of the scales at a lower age compared to the British cohort. However, from 69-72 months onwards, the lower percentiles (1st, 5th, 10th and 25th percentiles) of the British cohort showed higher percentile scores than the Chinese cohort.

The General quotient (GQ) was calculated as the average of the previous six subscales. The GQ scores in the Chinese cohort were generally higher than in the British cohort as seen by all of the Chinese percentile curves being above the corresponding British curves, except for the 1st percentile. Deviations in the two sets of curves were most apparent in the mid-range of the scale.

# DISCUSSION

The current study demonstrated that the developmental curves of Chinese children (GDS-C) has notable differences with the British curves published in the GMDS-ER.

Previous studies have shown that cross-cultural differences exist in the language and social development of children from different backgrounds.(Iverson, Capirci, Volterra, & Goldin-Meadow, 2008; Lin & Chiu, 2014) Here, we demonstrated that cross-cultural differences may be seen across all domains of childhood development (gross motor, fine motor, language, social, performance, and practical reasoning abilities), reflecting cognitive development. The reasons behind the different developmental profiles between Chinese and Caucasian children are likely to be multi-factorial. Cultural factors, parenting style, and the educational system all have major influences on a child’s development.

The gross motor (Subscale A) and fine motor skills (Subscales D) of Chinese and Caucasian children followed similar developmental trajectories. However, Chinese children had lower initial scores at 2 years of age compared to their Caucasian counterparts. Until recently, China had a ‘one-child’ policy which limited the majority of families to having only one child. In Chinese culture, it is a child’s responsibility to support his/her parents in their old age.(Hua et al., 2014) As the only child in the family, parents tend to be very protective and take great measures to protect their child from physical injuries. Chinese parents are also reluctant to give their children small objects to play with, such as playdough, small bricks, or crayons, because they are concerned that they may swallow them by accident. A previous study showed the prevalence of Developmental Co-ordination Disorder in Chinese one-child families was higher than that in multi-child families.(Hua et al., 2014) Furthermore, because all the children recruited in this study were from urban areas in China or Hong Kong, they might have fewer opportunities to play outdoors due to the lack of open spaces and parks where they can run and play freely.

Similar to findings from a previous study that assessed the daily functional skills of Chinese children(V. Wong, Wong, Chan, & Wong, 2002), our study found that Chinese children had higher scores in social and self-care skills (Subscale B) compared to Caucasian children from 3 to 5 years. This period of rapid growth in these skills in Chinese children coincides with when they are in preschool. Therefore, the higher scores would reflect the early attendance of preschool, where the children are taught these valuable skills.

Chinese children had lower initial scores in language subscales (Subscale C) until 3.5 years of age compared to their Caucasian counterparts. The majority of children in our Chinese cohort spoke Mandarin, which is a ‘tonal’ language where every sound in the phonetic transcription system has four distinct pronunciations. Furthermore, Chinese is a language rich in homophones, idioms and aphorisms, making it a complicated language for preschoolers to learn. Previous fMRI studies have demonstrated that Chinese speech processing involves more brain regions than English speech processing. Both languages share brain processing regions, namely the ventral precentral gyrus, pars opercularis, and pars triangularis, but an additional area, the left middle frontal gyrus, was found to be unique in Chinese speech production.(J. Wu et al., 2015) As more brain areas are required for Chinese speech production, this might explain the lower initial scores in Chinese children.

The performance (Subscale E) and practical reasoning skills (Subscale F) had very different developmental trajectories among the Chinese and Caucasian children. Our findings are consistent with previous report from OECD where children in Far East were found to achieve better Mathematics skills than British children(OECD, 2014). Our study showed that Chinese children excel in non-verbal play skills such as matching shapes and solving puzzles. Chinese children are able to answer questions based on general knowledge, such as the concepts of opposites, height, weight, time, days of week, and counting numbers. These are concepts that can be taught by parents as well as by preschool teachers. It is well known that parenting styles and beliefs affect the learning and academic achievement of children (Chao, 1994; Haight, Wang, Fung, Williams, & Mintz, 1999). Confucian principles put huge emphasis on education, obedience and conscientiousness(D. Y. Ho, 1994). Many Chinese parents believe that children's learning is a major responsibility of parents; they believe that parental control and training are essential so that their children do not fall short of standards(Heaven & Ciarrochi, 2008). Among families in China, maternal education level tends to be associated with more authoritative parenting rather than less(Lui & Rollock, 2013), and it is known that authoritative parenting style is linked to better academic success(Baumrind, 1971, 1991; Weiss & Schwarz, 1996). In addition, traditional Chinese preschool teachers tend to have an ‘instructional role’ when interacting with young children. Therefore, despite lower initial scores in Chinese children, a rapid increase in performance scores was observed at 3 years of age onwards when they enter preschools. Furthermore, bright Chinese children reach ceiling earlier than the British cohort in practical reasoning (subscale F). As a result, although scores from Subscale F can be used to detect childhood developmental delay, its use is limited in children with normal development after 4 years of age. It should be used with caution because the 99th percentile curve plateaued soon after 4.5 years of age.

It is interesting to note that for the trajectories of subscale E, despite higher initial scores for the British cohort, from 4.5 years onwards, the Chinese cohorts have higher scores across all the percentiles in comparison to the British cohort. We believe that this might be due to frequent training of non-verbal/ visual spatial skills such as pattern recognition, building puzzles in preschools for Chinese children. As a result, children with weak non-verbal skills would have significant improvement after entering preschools. In contrast, in subscale F, although bright Chinese children reached ceiling earlier than British children, children in the lower percentile scores continued to have much lower scores as shown by the lack of convergence of scores towards 8 years old in the Chinese cohort. This might indicate that practical reasoning skills such as logic or complex thinking would be harder to ‘train’ at school or at home. Furthermore, Subscale F would be affected by the language ability of the child. Children with weak language skills would struggle with the items with higher level of difficulty towards the end of Subscale F.

The current study should be interpreted with the following caveats. First, GMDS-ER was revised and standardized close to 10 years ago. Therefore, some of the differences between the British and Chinese cohorts might be due to changes over time. Nevertheless, GMDS-ER remained to be a ‘gold standard’ for developmental assessment for children age 0 to 8 years old in many countries. At the time of the study, Griffiths III, which is the latest version of the Griffiths was not available yet. Furthermore, Griffiths III only provided developmental assessment for children age 0 to 6 years of age. Second, we did not have the GMDS raw data for children under 2 years of age conducted in Britain and South Africa, thus we were unable to compare variables such as socioeconomic status, maternal education level, or the children’s birth order, which we recorded in our Chinese cohort. Third, the majority of children were recruited from urban areas in China. We chose urban areas as they have similar education systems and culture. Furthermore, over half of China’s population now resides in urban areas.(World Bank, 2016) Nevertheless, future studies should also recruit children from rural areas in China.

## CONCLUSION

Culturally appropriate developmental assessment tools are essential for accurate diagnosis of developmental problems in young children. The prompt identification of developmental delay allows early intervention in the period of rapid brain growth during preschool years. In view of the differences between the British and Chinese developmental curves, the newly adapted GDS-C would provide more accurate developmental profiles for urban Chinese children. Our study can serve as a pilot study for validation of the Griffiths-III for use in Chinese children in the future.

# KEY MESSAGES

* We modified and adapted the Griffiths Mental Development Scales for use in Chinese children
* Obvious differences between the Chinese and the British developmental curves were noted
* GDS-C provides reliable developmental curves for urban Chinese children up to 8 years

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Figure 1. Developmental trajectory of Chinese children compared with published British norm

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