Extension and Application Analysis of Children's Empathy Quotient-Systemizing Quotient Model Based on Data Mining Techniques

Lixia Chen[1,2], Xiaoyu Bai[1,2], Xinghong Deng[3], and Xinying Li[1,2(✉)]

[1] Key Laboratory of Mental Health, Institute of Psychology, Chinese Academy of Sciences, Beijing 100101, China
lixy@psych.ac.cn

[2] Department of Psychology, University of Chinese Academy of Sciences, Beijing 100101, China

[3] Xing'an County Maternal and Child Health Hospital, Guilin 541399, Guangxi Province, China

Abstract. Objective: To use the data mining technique to construct a multidimensional information assessment model of Children's Empathy Quotient (EQ-C) and Children's Systemizing Quotient (SQ-C) with certain reliability and validity and establish a regional norm in Guangxi, China, based on this model. Then, with the data analysis, to investigate the developmental patterns and related applications of empathy and systemizing cognitive styles of children aged 3−12. **Methods**: With a multilevel stratified sampling method, we randomly selected 937 children with ASDs (ASD) and children with healthy controls aged 3−12 years from 5 kindergartens, 3 elementary schools, and 1 ASD group in the Guangxi region according to urban and rural areas, children's age, and gender, and have their parents fill in the questionnaire. We have carried out item analysis, exploratory factor analysis, and validation factor analysis based on the desensitized data to construct a multidimensional information assessment model and verify the credibility and reliability of the model through further reliability and validity analysis. Through cluster analysis, statistically significant age groups were classified, and a constant model of age groups in the Guangxi region was established. Then make data analysis based on a multidimensional information assessment model and distribution of norms. **Results:** We obtain a three-dimensional EQ-C information assessment model and a four-dimensional SQ-C information assessment model through data mining. The two models show internal consistency reliability of (0.80, 0.89); the retest reliability coefficients of (0.66, 0.73) and $p < 0.001$, respectively, and all validity indicators meet the measurement requirements. And built the mean norm and percentile norm of the Guangxi region based on age groups. **Conclusion:** The three-dimensional EQ-C information assessment model, four-dimensional SQ-C information assessment model, and the norms can effectively reflect the development of empathy cognitive style and systemizing cognitive style of children aged 3−12 years old. According to the data analysis, the developmental patterns of empathy and systemizing cognitive styles of children aged 3−12 years can provide a reference for promoting children's empathy and systemizing education.

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1 Introduction

The Children's Empathy Quotient (EQ-C) scale and the Children's Systemizing Quotient (SQ-C) scale were designed by Auyeung and his research team at the University of Cambridge, UK, based on the empathizing-systemizing (E-S) theory [1]. Empathy allows us to recognize others' emotions and thoughts and give appropriate emotional responses, and helps us better understand and predict others' behaviors and make effective social interactions [2]. And Systemizing allows us to recognize and derive the laws of the whole system by analyzing and exploring certain features, and it is also a driving force in building systems [2, 3]. Empathy Quotient (EQ) and Systemizing Quotient (SQ) were initially proposed based on the psychological gender difference model [4]. Investigating typical gender differences in people's interests or abilities can provide insight into an individual's gender-independent cognitive style, which can play a role in our lives. For example, it is shown that EQ and SQ scores are better predictors of an individual's future orientation towards a more suitable career or academic choice than gender [3]. And the level of children's EQ scores also affects how children develop pro-social behavior and social skills [5]. The EQ-C and the SQ-C scales, which can assess empathy and systemic cognitive styles in children with healthy controls, can also be used in children with autistic spectrum disorders (ASD) (hereafter referred to as autism) for empathy and systemizing disposition assessment. ASD mainly features social functioning deficits, repetitive behaviors, and narrow interests [6]. ASD has become one of the major public health problems affecting people's health [7], but its etiology is still unclear. Simon Baron-Cohen, professor of experimental psychology at the University of Cambridge, UK, has proposed the two-factor E-S theory, which can explain the social and non-social core features of ASD in terms of empathy and systemizing [1]. The EQ-C scale and the SQ-C scale have also been applied in intervention studies in autism and research on children's attention deficit and hyperactivity disorders, etc. [8, 9]. Many countries have translated and used the EQ-C and SQ-C scales, and China now has a preliminary revised Chinese version of the EQ-C-SQ-C based on a sample of children with healthy controls aged 4 to 11 years. As with the original version, both EQ-C and SQ-C are studied on a single dimension [10]. In China, no norms of the EQ-C scale and SQ-C scale have been found to investigate the distribution of children's general empathy and systemizing levels.

This study aims to investigate the applicability of the multidimensional information assessment model of EQ-C and SQ-C in 3–12-year-old children with autism and children with healthy controls in China. Based on previous studies, this study extends the age range of the subjects to 3−12 years old according to the current enrollment status of school-age children in China; the subjects cover both children with autism and children with healthy controls; and given the regional characteristics of the Chinese cultural environment, the subjects are sampled from rural (including some left-behind children) and non-rural areas respectively. Through data mining, we construct a multidimensional

information assessment model of EQ-C and SQ-C and establish the mean norm and percentile norm in the Guangxi region. Based on these assessment models and norms, to investigate the developmental patterns and applications of empathy cognitive styles and systemizing cognitive styles in children aged 3 to 12 with autism and children with healthy controls in China.

2 Subjects and Methods

2.1 Subjects

At first, based on urban-rural regional divisions, we conducted stratified random sampling from 5 kindergartens and three elementary schools. These samples come from 1 rural kindergarten, one rural elementary school, four non-rural kindergartens, and two non-rural elementary schools in the Guangxi region. Then the samples are randomly sampled by age and gender stratification. And finally, a random sample from autism groups is stratified by age and gender. The subjects should fulfill the following conditions at the same time: 1) the subject children should be aged from 3 to 12 years old; 2) the parents should give their informed consent and follow the principle of voluntary participation in the survey. The electronic questionnaire is completed by the children's principal guardians. We collect 984 original questionnaires, excluding 47 invalid questionnaires with obvious regular responses and short response times. We obtain 937 valid questionnaires, which include 508 boys (54.2%) and 429 girls (45.8%). Among them, there are forty children with autism (23 boys and 17 girls); 301 children aged 3−4 years (32.12%), 344 children aged 5−6 years (37.71%), 82 children aged 7−8 years (8.75%), 98 children aged 9−10 years (10.46%), and 112 children aged 11−12 years (11.95%).

After three months, 30 of the original survey respondents are randomly selected for retesting, and a total of 30 valid questionnaires are returned. The retest samples include 16 (53.3%) boys and 14 (46.7%) girls. Among them, two children have autism, and 7 (23.3%) are 3–4 years old, 11 (36.7%) are 5–6 years old, 5 (16.7%) are 7–8 years old, 2 (6.7%) are 9–10 years old, and 5 (16.7%) are 11–12 years old.

2.2 Research Process

We have given a presentation to the teachers of each kindergarten and elementary school participating in the study, professional trainers in autism, and a few parents and asked them to complete the electronic questionnaire on a trial basis to test the generalizability of the questionnaire. Parents are asked to voluntarily fill out the electronic questionnaire with their informed consent. Three hundred returned valid questionnaires serve as sample 1 for item analysis and exploratory factor analysis; 637 returned valid questionnaires serve as sample 2 for validation factor analysis and reliability analysis. We retested 30 original respondents after three months and collected 30 questionnaires for retest reliability analysis. Finally, the scale and subscale scores are analyzed for differences in age and gender, and then the mean norm and percentile norm of the Guangxi region are established based.

2.3 Instrument

The EQ-C and SQ-C Questionnaire developed by Auyeung et al. [3] is the basis of the test instrument. After being authorized by Auyeung's team, we have translated and back-translated the questionnaire in simplified Chinese and revised it by incorporating Chinese cultural characteristics and feedback from the parents' pilot study. The original questionnaire consists of the EQ-C scale (27 items) and the SQ-C scale (28 items), containing a total of 55 items. The questionnaire consists of 32 positive questions. Each question has four response options and is scored from 0 to 2. According to the response options of "strongly agree," "basically agree," "basically disagree," and "totally disagree," the scores are (2, 1, 0, and 0) respectively. Among them, 23 items (2, 3, 4, 7, 9, 11, 13, 15, 16, 17, 20, 22, 23, 27, 32, 33, 36, 40, 47, 51, 53, 54, 55) are reverse scored. In this study, the EQ-C scale and the SQ-C scale that make up the questionnaire will be analyzed statistically separately.

2.4 Statistical Methods

In this study, we use IBM SPSS26.0 and IBM AMOS24.0 to conduct statistical analyses on the EQ-C scale and SQ-C scale, respectively. The following statistical methods have been used in this study: item analysis, exploratory factor analysis, validation factor analysis, content validity analysis, criterion validity analysis, internal consistency reliability analysis, retest reliability analysis, product difference correlation analysis, independent sample t-test, and multivariate analysis of variance. In particular, we use AMOS 24.0 software for the validation factor analysis and SPSS 26.0 software for the rest of the analyses, and $p < 0.05$ means that the analyses have statistical significance.

3 Results

3.1 Project Analysis

The following are the results from the analysis based on sample 1 ($N = 300$). The scores of 27 items from the EQ-C scale and the scores of 28 items from the SQ-C scale were analyzed separately according to the following methods: the sum of scores of each scale was divided into high-score and low-score groups using the extreme grouping method. The high-score group consists of data in the top 27% out of the total, and the low-score group consists of data in the bottom 27%. Through the independent sample t-test, the differences between the high-score and low-score groups of each item were then compared. The results showed that the t-statistics of items 17 and 42 from the EQ-C scale and items 15, 27, and 47 from the SQ-C scale were less than 3.00, indicating that the discriminating power of these five items was relatively poor. Other items differed significantly in both high-score and low-score groups ($t > 3.00$ and $P < 0.001$) [11]. In addition, individual items were selected by calculating the correlation between each item and the total score. Using Pearson's correlation method, the results show that the correlation coefficients between the following items of the EQ-C scale (2, 6, 17, 33, 42, 43) and the total score were less than 0.4, and the correlation coefficients between the following items of the SQ-C scale (11, 15, 27, 47, 51) and the total score were less than

0.4, indicating that the homogeneity of these 11 items and respective scales was not high. Other items were significantly correlated with the overall score with correlation coefficients of 0.4 or higher ($P < 0.001$) [11].

3.2 Validity Analysis

3.2.1 Exploratory Factor Analysis

To test the structural relationship between the EQ-C scale and SQ-C scale in the context of Chinese, this study analyzed the exploratory factors of the EQ-C scale and SQ-C scale, respectively. Exploratory factor analysis was based on sample 1 ($N = 300$). During the exploratory factor analysis, items were retained according to the following criteria: 1.) the commonality of the item is greater than or equal to 0.3; 2.) the load coefficient of the item after rotation is greater than or equal to 0.4; 3.) the difference between the absolute values of the two factors across the loads is greater than or equal to 0.05 [12]; 4.) Each factor belongs to more than two items. Priority was given to items that clearly do not meet the criteria when deleting items during analysis. Exploratory factor analysis was performed on the 27 entries of the EQ-C scale, and it was concluded that the KMO value (0.88) and Bartlett's sphericity test ($P < 0.001$) met the prerequisite requirements for principal component analysis. Using the varimax-rotation method, three factors with eigenvalues greater than 1 were extracted with loads of each item between 0.52 and 0.79, the common degree between 0.46 and 0.68, and the cumulative variance interpretation rate of 54.03%. By deleting items that do not meet the criteria described above, the EQ-C scale ultimately yielded a three-dimensional model consisting of 17 items. Based on the content characteristics of each item and existing research, the three dimensions were named as follows: Cognitive Empathy (CE), Emotional Empathy (EE), and Social Skills (SS) [13]. Each dimension included the following items from the original scale: Cognitive Empathy (7, 9, 13, 23, 53), Emotional Empathy (18, 26, 30, 31, 37, 45, 48, 52), Social Skills (20, 40, 36, 55).

Exploratory factor analysis of the SQ-C scale was performed, and the KMO value (0.91) and Bartlett's sphericality test ($P < 0.001$) were good. Using the varimax-rotation method, four factors with eigenvalues greater than 1 were extracted, with loads of each item between 0.40 and 0.82, the common degree between 0.43 and 0.72, and the cumulative variance interpretation rate of 54.99%. According to the above exploratory factor analysis criteria, the terms that do not meet the criteria were deleted. After multiple analyses and comprehensive assessments, the four-dimensional model of the SQ-C scale (including a total of 17 items) was considered stable. According to the core characteristics of the systematization [4] and the common characteristics of the items under each dimension, the four dimensions were named as follows: Construction Preference (CP), including the original items (5, 12, 21, 24), Detail Attention Preference (DAP) including the original items (19, 25, 44, 46), Rule Preference (RP) including the original items (8,34,35,41,49,50), and Technical Sensitivity (TS) including the original items (29, 38, 39).

The three subscales of the 17-item EQ-C scales were named Cognitive Empathy, Emotional Empathy, and Social Skills according to their dimensions and are marked as CE, EE, and SS, respectively. The four subscales of the 17-item SQ-C scales were named

Table 1. Confirmatory Factor Analysis (Sample 2, N = 637)

Index	χ^2/df	RMR	RMSEA	GFI	AGFI	IFI	CFI	TLI
EQ-C(17-item)	3.36	0.03	0.06	0.93	0.91	0.93	0.93	0.92
SQ-C(17-item)	2.66	0.02	0.05	0.95	0.93	0.94	0.94	0.93

Construction Preference, Detail Attention Preference, Rule Preference, and Technical Sensitivity according to their dimensions and are marked as CP, DAP, RP, and TS, respectively.

3.2.2 Confirmatory Factor Analysis

Based on the above exploratory factor analysis results, confirmatory factor analysis was carried out using sample 2 (N = 637), and the goodness of fit of the two models was tested using the maximum likelihood estimate method. The analysis results showed that the standardized factor loading of each item from the 17-item EQ-C scales was between (0.52–0.76) ($P < 0.001$), and the standardized factor loading coefficient of each item from the 17-item SQ-C scales was between (0.48–0.76) ($P < 0.001$). The model fit indexes for both scales (see Table 1) met the measurement criteria (GFI, AGFI, IFI, CFI, and TLI were greater than 0.90) [14].

3.2.3 Content Validity

The sample size in this study was large. The distributions of 17-item EQ-C scale scores, 17-item SQ-C scale scores, and each subscale score were close to normal. In addition, the absolute value of the skewness coefficient is between 0.112 and 0.441, the absolute value of the kurtosis coefficient was between 0.191 and 0.971, and the absolute value was less than 1. Therefore, scores of both scales and subscales can be approximately regarded as normal distribution.

According to psychometric theory, the correlation between a scale's total score and its subscales can also assess the content validity of this scale. The results in Table 2 show that the correlation coefficient between the score of the EE subscale and the total score of the scale was 0.59 ($P < 0.01$) for the 17-item EQ-C scale, and the correlation coefficients between the scores of the other two subscales and the total score of the main scale were greater than 0.74 ($P < 0.01$). The correlation coefficients between the score of each subscale and the total score of the main scale for the 17-item SQ-C scale were greater than 0.80 ($P < 0.01$). According to the psychometric theory, a correlation coefficient greater than 0.6 between the subscale score and the total score of the scale [15] indicates good content validity, and the above results showed both the 17-item EQ-C and the 17-item SQ-C scales have good content validity.

Table 2. Correlation between Scales and Subscales (N = 937)

	EQ-C(17-item)	SQ-C(17-item)
EE	.59**	
CE	.74**	
SS	.75**	
CP		.83**
DAP		.80**
RP		.88**
TS		.80**

** $P < 0.01$; EE Emotional Empathy, CE Cognitive Empathy, SS Social Skills, CP- Construction Preference, DAP Detail Attention Preference, RP Rule Preferences, TS Technique Sensitivity

3.2.4 Criterion Validity

To test whether the 17-item EQ-C scale and 17-item SQ-C scale could distinguish between children with ASD and healthy controls, 40 healthy children who were controlled in age and gender were matched with children with autism. The difference in the total score of the 17-item EQ-C scale and the scores of each item between children with autism and healthy children was examined. The difference between the total score of the 17-item EQ-C scale and the scores of each item was statistically significant. In addition, the difference between the total score of 17-item SQ-C scale and the scores of each item between the two samples were also statistically significant.

An independent sample t-test revealed that the scores from the 17-item EQ-C scale in children with autism and healthy children were significantly different ($t = -3.95$, $P < 0.001$). The EQ score for children with autism (13.33 ± 5.50) was lower than that for healthy children (18.58 ± 6.36). There was also a statistically significant difference between children with autism and the healthy control in scores from the 17-item SQ-C scale ($t = 2.80$, $P < 0.006$). In addition, the SQ scores for children with autism (20.38 ± 9.18) were higher than the SQ scores of healthy controls (15.40 ± 6.46).

3.3 Reliability Analysis

The internal consistency reliability coefficients (Cronbach's a coefficient) and test-retest reliability coefficients of 17-item EQ-C scale, 17-item SQ-C scale and each sub-scale meet the requirements of measurement [11] (see Table 3 for results). The Cronbach's a coefficient of the 17-item EQ-C scale is 0.80, and the Cronbach's a coefficient of the 17-item SQ-C scale is equal to 0.89. The coefficient of test-retest reliability was greater than or equal to 0.60 ($P < 0.001$) except for the Social Skills (SS) subscale, which was below 0.60. These results demonstrate good internal consistency and stability of the two scales.

Table 3. Reliability Analysis (Sample 2, N = 637)

Index		Internal Reliability (Cronbach's a)	Test-retest Reliability (Pearson r)
		N = 637	N = 30
	EQ-C(17-item)	0.80	0.66***
	EE	0.84	0.71***
	CE	0.83	0.70***
	SS	0.77	0.58***
	SQ-C(17-item)	0.89	0.73***
	CP	0.70	0.60***
	DAP	0.70	0.75***
	TS	0.63	0.60***
	RP	0.76	0.83***

*** $P < 0.001$; CE Cognitive Empathy, EE Emotional Empathy, SS Social Skills, CP- Construction Preference, DAP Detail Attention Preference, TS Technique Sensitivity, RP Rule Preferences

3.4 Norm in Areas of Guangxi Provinces

3.4.1 Age and Gender Differences in Scale and Subscale Scores

Multivariate ANOVA analysis was performed using the total score of 17-item EQ-C scale, the total score of the 17-item SQ-C scale, and the scores of each subscale as dependent variables and age groups as independent variables. The results showed that the age group differences in the above scores were statistically significant (F between 2.48 and 12.26, $P < 0.05$). Further analysis was conducted based on multiple LSD comparisons, and the adjacent age groups with no statistically significant mean differences ($P > 0.05$) between groups were combined and divided into three new age groups: 3–4 years old, 5–8 years old, and 9–12 years old.

Taking the newly divided age group and gender as independent variables, and the total scores of the 17-item EQ-C scale, the 17-item IQ-C scale, and the scores of each subscale as the dependent variables, the results shown in Table 4 are as follows. 1.) Only the 17-item EQ-C scale score and CE, SS, and TS sub-scale scores were significantly different by gender ($P < 0.05$). 2.) The age group differences for all of the above dependent variables were significant ($P < 0.05$), while the interaction between gender and age groups was not significant. The results of pairwise comparisons of gender differences (shown in Table 5) showed that boys scored significantly lower in the 17-item EQ-C scale and the CE and SS subscales than girls ($P < 0.05$), while boys scored significantly higher than girls in the TS subscale ($P < 0.05$). Other scales and subscale scores were not significantly different in gender ($P > 0.05$). From the results of LSD multiple comparisons in age groups and the distribution of the estimated marginal mean of scale scores, it can be seen that during the period of 3–8 years, the average score of the 17-item EQ-C scale showed an increasing trend with age, and then reached the peak during the 5–8 years, followed by a slow downward trend, even reducing to below the average at 9–12 years

Table 4. Multivariate ANOVA on Score of Scales and Subscales between Age groups and Gender (N = 937)

Variable	Gender				Age Group				Gender × Age Group			
	SS	df	F	Sig.	SS	df	F	Sig.	SS	df	F	Sig.
EQ-C (17-item)	517.88	1	13.55	0.000	1305.24	2	17.07	0.000	124.19	2	1.62	0.198
EE	47.27	1	3.34	0.068	124.40	2	4.39	0.013	31.74	2	1.12	0.327
CE	80.87	1	8.54	0.004	373.89	2	19.75	0.000	5.40	2	0.29	0.752
SS	47.45	1	8.37	0.004	111.03	2	9.79	0.000	43.24	2	3.81	0.022
SQ-C (17-item)	0.24	1	0.00	0.947	921.57	2	8.25	0.000	20.69	2	0.19	0.831
CP	13.39	1	2.93	0.087	164.47	2	17.98	0.000	2.00	2	0.22	0.804
DAP	0.42	1	0.10	0.755	29.81	2	3.42	0.033	0.58	2	0.07	0.936
RP	0.09	1	0.01	0.919	88.63	2	4.92	0.008	6.28	2	0.35	0.706
TS	20.24	1	6.98	0.008	24.78	2	4.27	0.014	1.72	2	0.30	0.743

EE-Emotional Empathy, CE-Cognitive Empathy, SS-Social Skills, CP- Construction Preference, DAP-Detail Attention Preference, RP-Rule Preferences, and TS-Technique Sensitivity

old. The average score of the 17-item SQ-C scale continued to rise with age, reaching the overall average between the ages of 5 and 8 and continuing to rise afterward.

Considering that most of the scores of the above scales and sub-scales have no significant difference between different genders, and the interaction between gender and age group is not significant, but only the age group has significant differences, this study gave the mean norm and percentile norm of the age groups.

3.4.2 Mean Norm in Age Groups

Grouped by the three age groups, 3–4 years old, 5–8 years old, and 9–12 years old, the mean and standard deviation of the 17-item EQ-C scale, 17-item SQ-C scale and each subscale were calculated (see Table 6).

3.4.3 Percentile Norm

Based on the three age groups, seven percentile norms of the 17-item EQ-C scale and 17-item SQ-C scale were established (see Table 7).

4 Discussion

4.1 Multidimensional Information Assessment Model and Norm

The present study was based on the revised, simplified Chinese version of the EQ-C scale and SQ-C scale, and sampling was conducted in Guangxi. Sampling was conducted by multilevel stratified random sampling according to urban and rural area division, autistic

Table 5. Pairwise Comparison of Gender Differences in the Scores of Scales and Subscales (N = 937)

Variable			MD	SE	Sig.	95% CI	
						Lower Bound	Upper Bound
EQ-C (17-item)	Male	Female	−1.567*	0.426	0.000	−2.402	−0.731
EE	Male	Female	−0.473	0.259	0.068	−0.982	0.035
CE	Male	Female	−.619*	0.212	0.004	−1.035	−0.203
SS	Male	Female	−.474*	0.164	0.004	−0.796	−0.153
SQ-C (17-item)	Male	Female	0.034	0.514	0.947	−0.976	1.043
CP	Male	Female	−0.252	0.147	0.087	−0.541	0.037
DAP	Male	Female	−0.045	0.144	0.755	−0.327	0.237
RP	Male	Female	0.021	0.207	0.919	−0.385	0.427
TS	Male	Female	.310*	0.117	0.008	0.080	0.540

* $p < 0.05$; MD-Mean difference; SE-standard error; EE-Emotional Empathy, CE-Cognitive Empathy, SS-Social Skills, CP- Construction Preference, DAP-Detail Attention Preference, RP-Rule Preferences, and TS-Technique Sensitivity

Table 6. Mean Scores of Scales and Subscales (Mean ± SD)

Dimension	3–4 years	5–8 years	9–12 years	Total
	(n = 301)	(n = 426)	(n = 210)	(n = 937)
EQ-C (17-item)	16.56 ± 6.00	18.85 ± 6.55	16.40 ± 5.93	17.57 ± 6.34
EE	8.10 ± 3.79	8.88 ± 3.70	8.78 ± 3.90	8.61 ± 3.79
CE	5.58 ± 3.28	6.39 ± 2.99	4.72 ± 3.00	5.75 ± 3.15
SS	2.89 ± 2.38	3.58 ± 2.40	2.90 ± 2.43	3.21 ± 2.42
SQ-C (17-item)	15.34 ± 7.62	16.71 ± 7.24	18.13 ± 7.66	16.59 ± 7.52
CP	3.21 ± 2.33	3.80 ± 2.02	4.34 ± 2.09	3.73 ± 2.18
DAP	4.46 ± 2.11	4.87 ± 2.11	4.75 ± 2.00	4.71 ± 2.09
RP	5.00 ± 2.98	5.22 ± 2.93	5.87 ± 3.16	5.30 ± 3.01
TS	2.66 ± 1.68	2.82 ± 1.70	3.16 ± 1.76	2.85 ± 1.71

EE-Emotional Empathy, CE-Cognitive Empathy, SS-Social Skills, CP- Construction Preference, DAP-Detail Attention Preference, RP-Rule Preferences, and TS-Technique Sensitivity

and children with healthy controls division, and age and gender division, respectively. A representative sample of 937 children was obtained. The 17-item three-dimensional EQ-C information assessment models (including "Emotional Empathy," "Cognitive Empathy," and "Social Skills") and 17-item four-dimensional SQ-C information assessment

Table 7. Percentile Norm of Scales (N = 937)

Dimension	Percentile	3–4 years	5–8 years	9–12 years
EQ-C (17-item)	5	8.00	8.00	8.00
	10	9.00	10.00	9.00
	25	12.00	13.00	12.00
	50	16.00	19.00	15.50
	75	20.00	24.00	20.25
	90	26.00	28.00	25.00
	95	27.90	29.00	28.00
SQ-C (17-item)	5	4.10	6.00	7.00
	10	6.00	8.00	9.00
	25	9.00	12.00	13.00
	50	15.00	16.00	17.00
	75	20.00	21.00	22.25
	90	25.80	27.00	30.90
	95	32.00	30.65	33.45

models (including "Construction Preference," "Detail Attention Preference," "Rule Preference," and "Technique Sensitivity") were obtained through data mining. The statistical analysis revealed that the 17-item three-dimensional EQ-C information assessment models and the 17-item four-dimensional SQ-C information assessment models had good structural validity, content validity, criterion validity, internal consistency reliability, and retest reliability. In one of the tests of criterion validity, differences in the characteristics of children with autism and children with healthy controls on EQ and SQ have been analyzed: children with autism had significantly lower EQ scores than children with healthy controls, while children with autism had significantly higher SQ scores than children with healthy controls. This finding is consistent with Baron-Cohen's study [1]. However, this study did not classify ASD, and the comparison of specific classifications requires further study. Based on the results of the above analysis, the 17-item three-dimensional EQ-C information assessment models and the 17-item four-dimensional SQ-C information assessment models can be applied to children with autism aged 3–12 years and to the general population for empathy and systematic cognitive style assessment.

According to the cluster analysis results, the age groups were divided into three groups with statistical significance: 3–4 years old, 5–8 years old, and 9–12 years old. The mean norm and percentile norm of Guangxi were established based on these three age groups. Using the mean norm as a criterion for comparison, the higher SQ score means the child is more motivated to systematize [2]. A higher EQ score means that the child is better developed in the traits related to empathy [16]. The percentile norm, on the other hand, assesses the rank of the child's EQ score or SQ score in the group, and a

higher score of the child's EQ score or SQ represents a higher position in the percentile norm.

4.2 Developmental Patterns and Application Analysis of CHILdren's Empathy and Systematic Cognitive Styles

The three-dimensional EQ-C information assessment model was used to analyze the gender differences in children's EQ scores. There were significant gender differences in the EQ scores of children aged 3–12 years: girls had higher EQ scores than boys, which is consistent with the results of most studies [3, 13]. This is reflected in the higher scores of "Cognitive Empathy" and "Social Skills" for girls than for boys. However, the difference in "Emotional Empathy" scores between boys and girls was not significant, which is inconsistent with the Dutch version of the EQ study [13], which may indicate that emotional empathy is more susceptible to cultural differences, but the details need to be further verified. Gender differences in children's SQ scores were analyzed from the four-dimensional SQ-C information assessment model: there was no significant difference in SQ scores between boys and girls, which is inconsistent with the conclusion of Auyeung that SQ scores were significantly higher in boys than in girls [3]. This conclusion needs to be further verified. Further specific analysis revealed that there were no significant differences between boys and girls in Guangxi in terms of " Detail Attention Preference," "Rule Preference," and "Construction Preference," which might be influenced by the local education style or cultural environment, but the specific reasons need to be further investigated. In contrast, the "Technique Sensitivity" of boys in this study was significantly better than that of girls. This may indicate that boys have a greater potential for creative thinking in technology and may be able to stimulate greater creativity if they are targeted according to their preferences.

Data analysis of the mean norm of the age group of the four-dimensional SQ-C information assessment model shows that the overall SQ development trend of children aged 3–12 years continued to evolve with age. Specifically, the development trends of "Construction Preference," "Rule Preference," and "Technique Sensitivity" were similar to the overall SQ development trend. Only in terms of the trend of "Detail Attention Preference," 9–12 years old showed slightly lower scores than those of 5–8 years old. The above SQ trends may indicate that the development of children's systematic cognitive style is closely related to the gradual maturity of children's minds. Children aged 9–12 years show a decline in "Detail Attention Preference," which may be attributed to the one-sided mindset of children at this age. Their inability to analyze problems in a critical and comprehensive way is a result of their radical thinking. This also indicates that in education, children at this age need more comprehensive and detailed guidance.

The analysis of the data of the mean norm of the age group of the three-dimensional EQ-C information assessment model shows that the overall development trend of EQ of children aged 3–12 years starts to rise from 3–4 years old, reaches a developmental peak from 5–8 years old, and then starts to gradually decline. The EQ of children aged 9–12 years old is even lower than the overall average level. Specifically, according to the analysis of the development trend of three dimensions, the development trends of "Emotional Empathy," "Cognitive Empathy," and "Social Skills" of children are similar to the overall development trend of EQ. The scores of "Emotional Empathy" of children

aged 9–12 are slightly higher than the overall average. The critical period for the development of "Emotional Empathy," "Cognitive Empathy," and "Social Skills" of children is from 3 to 8 years old. According to the above differences in each age group, the specific reasons are analyzed: children's EQ at the age of 3–4 years old is in a rising stage, probably because children at this age are in a period of rapid development of representational thinking. They are good at imitation, and their speech skills are beginning to develop rapidly. They are curious about the behavior of adults and like to imitate adults to care for others. However, because children at this age have a great deal of egocentricity in their minds, they are not yet able to understand the emotions of others from others' points of view. Their social skills are insufficient and limited to imitation, so EQ is still at a low level. However, the overall development trend keeps moving forward. 5–8 years old enjoy a great development of EQ, probably because children at this age gradually overcome egocentricity in their minds. Their perspective selecting ability also begins to develop, making it easier for them to understand and empathize with others. The EQ of children aged 9–12 years has been decreasing or even lower than the overall average, which is probably related to the fact that children at this stage begin to enter the rebellious stage. Children experience a greater development of their sense of independence and desire for self-esteem at this stage. At the same time, with the development of abstract logical thinking at this stage, they are able to require themselves and judge others according to their moral standards and no longer blindly follow authority. In their emotions, mentality, opinions, and behaviors, they started separating from their parents. Examples are indifference to people and "the tendency of disagreeing with parents" [17, 18]. These seemingly rebellious behaviors make parents feel that their children are "regressing" in terms of EQ. If this hypothesis is true, and given that children between the ages of 9–12 have developed a certain level of self-awareness and self-judgment, EQ tests for children between the ages of 9 and 12 can be completed by themselves. The results may be more consistent with the true characteristics of children in this age group. The current 17-item EQ-C scales would be more appropriate for children aged 3–8 years. This hypothesis needs to be confirmed by research.

The above study only gave an approximate developmental range of 3–8 years for the critical period of child EQ development due to the age-based division of the norm. The specific breakdown of the critical period of child EQ development needs to be further studied. According to the key developmental range of children's EQ derived from this study, if education and development of children's cognitive empathy, emotional empathy, and social skills can be strengthened throughout kindergarten education and early elementary school grades, it will be beneficial to promote the development of children's pro-social behavior and social skills [5].

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