

Rasch Analysis of the Q-CHAT in Colombian Toddlers with Autism Spectrum Disorder

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Abstract The objective of this study was the validation of the Colombian version of The Quantitative Checklist for Autism in Toddlers (Q-CHAT) by means of the Rasch Rating Scale Model. The Q-CHAT was applied to parents of 100 typically developing toddlers and 40 toddlers and preschoolers with Autism Spectrum Disorder (ASD). The Q-CHAT scores showed some limitations. The questionnaire did not meet the condition of unidimensionality. Two dimensions were detected. The first dimension, with 13 items and 4 response categories (13i-4c), showed good psychometric properties: the items fit the Rasch Rating Scale model, the reliability of persons and items was appropriate, and scores adequately discriminate between children with and without ASD. The second dimension is a measure of traits that are usually associated with ASD, but that have shown validity problems. Thus, it is proposed that dimension 1 of the Q-CHAT (13i-4c) be used as the screening tool for ASD in Colombia.

Keywords Autism spectrum disorder · Q-CHAT · Rasch rating scale model · Screening

Autism Spectrum Disorder (ASD) is a complex neurodevelopmental condition characterized by impairments in social communication and social interaction, with restricted and repetitive patterns of behavior (American Psychiatric

Association 2013). Detection in the first two years of life allows early intervention, maximizing the benefits for the ASD children and their families (Barbaro and Dissanayake 2009; Dewrang and Sandberg 2010; Fernell et al. 2013; Peacock and Lin 2012).

In Colombia, institutions driven by the World Autism Organization are pointing to the need for early detection of ASD in primary health care and educational contexts (Jiménez 2009). This is a very difficult task due to the insufficient training of health professionals in identifying early signs of autism and to the absence of validated instruments for this purpose. ASD screening instruments play an important role in the diagnosis, allowing professionals to identify whether a deeper assessment of the child's development is needed.

In the last twenty years, great effort has been made to carry out ASD screening in early childhood. However, ASD screening has been criticized due to its categorical (instead of quantitative or dimensional) approach to ASD, that is not consistent with the fact that ASD is expressed as a continuum (Allison et al. 2012). To solve this problem, *The Quantitative Checklist for Autism in Toddlers* (Q-CHAT; Allison et al. 2008) was developed in the United Kingdom, and its psychometric properties analyzed by means of Classical Test Theory (CTT), showing adequate reliability (*Cronbach alpha* = 0.83). The Q-CHAT has been used in diverse studies in the United Kingdom and Singapore (Allison et al. 2012; Auyeung et al. 2012; Magiati et al. 2015; Wong et al. 2014), but very limited evidence exists regarding its quality (Magiati et al. 2015). The original Q-CHAT version has been adapted in Spanish speaking countries such as Chile and Argentina.

The aim of this study was to analyze the psychometric properties of the Q-CHAT in a Colombian sample by means of the Rasch measurement approach. The *Rating Scale Model* (RSM; Andrich 1978), an extension of the *Rasch Model* (RM;

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Rasch 1960) for polytomous items, was used; Rasch models have several advantages over CTT (Bond and Fox 2015; Inchausti et al. 2014; Lönnfjord and Hagquist 2017).

Methods

Participants

The sample was composed of 40 ASD children (18–40 month-old, 39 males and 1 female, previously diagnosed by a multidisciplinary team, according to CIE-10 or DSM-IV-TR criteria) and 100 comparison participants. It can be seen from Table 1 that there were no differences between ASD and the comparison group in social strata or maternal education, but there was a significant difference in mean age (that was statistically controlled in further analyses). ASD children were free of other neurological disorders prior to acceptance into the study; and those in the comparison group had a history of typical neurological development, and no one in their families was reported to have neither neurological nor psychiatric condition. Parents had all volunteered to take part in this research by filling out a paper version of the Q-CHAT.

Measures

Quantitative Checklist for Autism in Toddlers (Q-CHAT)

The Q-CHAT is a parent-report questionnaire that contains 25 items focusing on behaviors that reflect autistic traits in early childhood, such as repetitive activities or reduced sharing of interest. A thorough description of the Q-CHAT can be found in Allison et al. 2008. Each item presents five options based on the frequency with which the child exhibits the behavior. Application time is about 5–10 min. A high frequency of an autistic trait scores 4, and a low frequency trait scores 0. Half the items are reverse scored. Unanswered or ambiguous answers score 0. Higher total Q-CHAT scores are indicative of more autistic traits.

Procedure

The research project followed ethical norms. Informed consent was obtained from parents/caregivers. Allison and colleagues [Autism Research Centre at University of Cambridge (UK)] authorized the adaptation to Spanish of the original English version. Pediatricians and medical students applied the test to parents/caregivers of children from the comparison group and experienced neuropsychologist applied the test to parents of ASD children.

Data Analysis

RM analyses were performed with Winsteps 3.81.0 (Linacre 2011). The model proposed by Rasch (1960) is based on two major assumptions: the attribute can be represented on a single dimension where people and items are conjointly located; and person level and item location are the only (probabilistic) predictors of a right answer. For scales with Likert format, the RSM (Andrich 1978), an extension of the RM for polytomous data, models this relationship as follows:

$$\ln (P_{nik} / P_{ni(k-1)}) = B_n - D_i - F_k$$

P_{nik} is the probability that person’s n answer is category k ;

$P_{ni(k-1)}$ is the probability that the observation or response is $k-1$;

B_n is the skill, attitude, trait of person n ;

D_i is the location of item i ;

F_k is the transition point (step) between k and $k-1$.

The functionality of the response categories was analyzed following criteria proposed by Linacre (2011): (a) sufficient frequency and regular distribution of the chosen categories; (b) the average measures according to category should monotonically go up in the rating scale; (c) no category should misfit, and (d) the transition points should increase monotonically.

Table 1 Q-CHAT sample demographics characteristics

	ASD group ($N = 40$)	Comparison group ($N = 100$)	Statistics (differences between groups)
Age (months)	32.05 (6.72)	27.86 (6.14)	$t(138) = -3.55, p > .01$
Maternal schooling			$\chi^2 = 2.46, p = .48$
Bachelor	5 (12.5%)	15 (15%)	
Technical	6 (15%)	9 (9%)	
Technologist	11 (27.5%)	20 (20%)	
Ungraduate	18 (45%)	56 (56%)	
Social strata			$\chi^2 = 0.10, p = .75$
Very low/Low	20 (50%)	47 (47%)	
Medium/High	20 (50%)	53 (53%)	

Model fit and dimensionality were assessed. Model fit was tested by means of *Outfit*, based on the chi-square statistic, and *Infit*, based on the chi-square statistic but with each observation weighted by its statistical information and thus less sensitive to outliers. Infit/Outfit values over 2 indicate severe misfit Linacre (2011). Although strict unidimensionality is never achieved in practice (Zickar and Broadfoot 2009), principal component analysis of residuals allows to evaluate unidimensionality; the least stringent criterion is Reckase's (1979): the percent of variance explained should be over 20% and there should not be a second dominant factor (Linacre 2011).

ANCOVAs were used to test whether the Rasch-modelled scores discriminated between ASD and healthy subjects (with the effect of age statistically removed).

Results

The analysis of the Q-CHAT response categories showed that they were functional according to Linacre (2011). Item *Infit* and *Outfit* values were in adequate ranges. Unidimensionality was tested using principal component analysis of the residuals. The Q-CHAT Rasch dimension, which is analogous to a first factor in a common factor analysis, explained 37.3% of the variance: not optimal according to Linacre (2011), but acceptable following Reckase (1979). The variance explained by the first component extracted had a magnitude of 5.3 corresponding to 13.2% of the variability that cannot be attributed to the model; this is indicative of a second dimension (Linacre 2011). The polarity of residuals in the first contrast indicated the existence of two dimensions: a first one, with items 1, 2, 4, 5, 6, 8, 9, 10, 14, 15, 17, 19 and 21, i.e., items with social/communication content. And a second dimension consisting of items 3, 7, 11, 12, 13, 16, 18, 20, 22, 23, 24, and 25, representing behavioral content.

Analysis of the Q-CHAT Dimensions

The main results of the item analysis by dimensions can be seen from Tables 2 and 3.

Dimension 1 of the Q-CHAT A first scale composed of items 1, 2, 4, 5, 6, 8, 9, 10, 14, 15, 17, 19 and 21 was analyzed. The lack of monotonic ordering of the steps indicated category malfunctioning. To attain a metrically acceptable category system, a 4-category system was constructed by collapsing the original categories 3 and 4 into category 3. The new categories functioned appropriately and thus subsequent score analyses were carried out on these 4-category 13 items, i.e., Q-CHAT Dimension 1 (13i-4c).

Q-CHAT Dimension 1 (13i-4c) item and person parameters were estimated. Fit was good. No item and only 4 persons (2.9%) showed severe misfit. Overall reliability of the item

Table 2 Q-CHAT dimension 1 item analysis

Item	Item location	Model S.E	Infit	Outfit
1	0.45	0.12	0.72	0.64
2	0.44	0.12	0.83	0.71
4	-0.67	0.10	0.73	0.65
5	0.26	0.11	1.69	1.99
6	0.16	0.11	1.09	0.92
8	-1.25	0.10	0.88	0.89
9	0.00	0.11	0.69	0.69
10	0.04	0.11	0.85	0.97
14	0.21	0.11	1.28	1.27
15	-0.12	0.10	0.99	0.99
17	0.28	0.11	1.55	1.39
19	0.29	0.11	0.95	0.98
21	-0.10	0.10	1.01	1.00
Mean	0.00	0.11	1.02	1.01
SD	0.46	0.01	0.30	0.36

estimates was good (*Item Separation Reliability* = .94). The reliability of person estimates was adequate (*Person Separation Reliability* = .77), indicating that parameter estimation was precise enough. This statistic is similar to Cronbach's α in CTT.

A discriminant validation test of this dimension was carried out. Clinical group ASD level (average $Bn = 0.21$, $SD = 0.53$) was above that of the comparison group (average $Bn = -1.31$, $SD = 0.69$) indicating a higher level in the spectrum of autism. ANCOVA indicated that there was a significant effect of ASD condition on Rasch Q-CHAT Dimension 1 (13i-4c) score after controlling for age, $F(1, 137) = 141.603$, $p < .001$, partial eta squared = 0.51.

Table 3 Q-CHAT dimension 2 item analysis

Item	Item location	Model S.E	Infit	Outfit
3	-0.43	0.07	1.08	1.09
7	0.56	0.08	0.71	0.81
11	0.13	0.07	1.28	1.27
12	-0.96	0.09	1.14	1.01
13	0.35	0.07	0.86	0.97
16	-0.75	0.08	0.92	0.91
18	-1.02	0.09	1.51	1.46
20	0.67	0.08	1.08	1.01
22	0.07	0.07	0.89	0.86
23	0.14	0.07	0.84	0.83
24	0.17	0.07	0.93	0.97
25	1.08	0.10	1.20	1.19
Mean	0.00	0.08	1.04	1.03
SD	0.64	0.01	0.21	0.18

Dimension 2 of the Q-CHAT The category system was adequate. As to model fit, 16 persons (11.4%) and no item showed severe misfit. Item location, standard error, *Infit* and *Outfit* values were estimated (Table 3). Overall reliability of the item estimates was excellent (*Item Separation Reliability* = .98), but *Person Separation Reliability* was low (.58). Moreover, it was found that this dimension *inadequately* discriminated between the clinical and the comparison group. Clinical group level ($Bn = -0.32$, $SD = 0.39$) was *below* that of the comparison group ($Bn = -0.08$, $SD = 0.47$). The effect of ASD condition on Rasch Q-CHAT Dimension 2 score was significant after controlling for age, $F(1, 137) = 10.79$, $p < .001$, partial eta-squared = 0.07.

Discussion

The psychometric study of the Q-CHAT in Colombia has found out that data from this test are not unidimensional. Two dimensions were found out. The first one, Dimension 1 (13i-4c), composed of 13 4-category items, showed adequate psychometric properties. This short scale, including items that recognize cognitive signs related with social interaction and communication, allows to discriminate between healthy and ASD toddlers. Thus, it is proposed that dimension 1 of the Q-CHAT (12i-4c) be used as the screening tool for ASC in Colombia. Allison et al. (2012) carried out a study to identify the Q-CHAT 10 most predictive items; they were items 1, 2, 5, 6, 9, 10, 15, 17, 19 and 25. Dimension 1 (13i-4c) includes 9 of these 10 items (1, 2, 5, 6, 9, 10, 15, 17, 19). Item 1 (*Does your child look at you when you call his/her name?*), showing the highest location on the ASD continuum, was also the item with most predictive power in Allison et al. (2012).

Some validation studies of the previous version of this questionnaire, the M-CHAT, have found out that the items that best discriminate between healthy and ASD subjects are those assessing joint attention (Canal-Bedia et al. 2011; Cuesta-Gómez et al. 2016; Inada et al. 2011; Manzone 2013; Robins et al. 2001; Wong et al. 2004). Our study evidenced that all the items measuring joint attention discriminated between the clinical and comparison groups. These items were located on the high end of the ASD continuum, i.e., they are signs of medium and high levels of ASD. This is consistent with the fact that joint or shared attention, an important aspect of social interaction, is affected in ASD subjects (Clifford and Dissanayake 2008; Clifford et al. 2007; Goldberg et al. 2008; Manzone 2013; Ventola et al. 2007). Some other aspects of interaction and social communication, such as showing interest for other children, answering when called by name, making eye contact, and using simple gestures are also informative of ASD.

The second dimension evidenced a validity problem: there were statistical differences between groups, but they were in

the opposite direction; this dimension *inadequately* discriminated between the clinical and the comparison group. Dimension 2 items are related to restricted patterns of interest/activities, repetitive behavior, echolalia and sensory processing. In previous studies, it has been found that these signs onset is usually after the child is 3 years old (Baranek et al. 2003; Swinkels et al. 2006). Thus repetitive behaviors and restricted interest could be useful to discriminate between ASD and healthy children when they are older. These findings could be associated with the fact that cultural interpretation of child behaviors might be different in Colombia; future studies should explore this possibility.

Compliance with Ethical Standards

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent Informed consent was obtained from all individual participants included in the study.

Conflict of Interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

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