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Laura C. Chezan
Old Dominion University, lchezan@odu.edu

Jin Liu
University of South Carolina

Ruiqin Gao
University of South Carolina

Erik Drasgow
University of South Carolina

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RESEARCH ARTICLE

Investigating the quality of life for children with autism spectrum disorder scale using Rasch methodology

Laura C. Chezan[1] | **Jin Liu**[2] | **Ruiqin Gao**[2] | **Erik Drasgow**[2]

[1]Department of Communication Disorders and Special Education, Old Dominion University, Norfolk, Virginia, USA

[2]Department of Educational and Developmental Science, University of South Carolina, Columbia, South Carolina, USA

Correspondence
Jin Liu, Department of Educational and Developmental Science, University of South Carolina, Columbia, South Carolina, USA.
Email: liu99@mailbox.sc.edu

Funding information
Darden College of Education and Professional Studies, Old Dominion University, Virginia

Abstract

Our purpose in this study was to provide additional psychometric evidence of the Quality of Life for Children with Autism Spectrum Disorder (QOLASD-C) scale. We used Rasch modeling to investigate the QOLASD-C functioning, the characteristics of the items comprising the scale, and the item functioning across subgroups of children with ASD based on gender and race/ethnicity. Results showed that QOLASD-C was unidimensional, met the local independence assumption, and measured quality of life (QOL). The items showed excellent fit to the model and good discriminating ability between low and high QOL. Most items showed a moderate difficulty level. No differential item functioning was observed based on children's gender and race/ethnicity. Implications for research and practice are discussed.

Lay Summary

A scale with good psychometric properties is the foundation for developing effective and high-quality interventions to promote quality of life (QOL) in children with autism. We investigated the quality of the items comprising the Quality of Life for Children with Autism Spectrum Disorder (QOLASD-C) scale and its overall functioning across subgroups of children with autism spectrum disorder (ASD). We found that the scale is comprised of quality items that can differentiate between children with low and high QOL without bias based on children's age and race/ethnicity. Because the scale's item measure more precise average levels of QOL, we recommend that practitioners use the QOLASD-C as an initial screening measure or in conjunction with other reliable and valid measures assessing treatment effectiveness on individual target outcomes.

KEYWORDS
autism spectrum disorder, differential item functioning, quality of life, Rasch modeling

INTRODUCTION

Quality of life (QOL) refers to a universal construct comprised of objective and subjective indicators that measure one's well-being across life domains (Claes et al., 2010; Tavernor et al., 2013). Over the last three decades, QOL has received considerable attention in the autism spectrum disorder (ASD) research and in the autism community. Specifically, researchers have demonstrated that individuals with ASD have a lower QOL than neurotypical individuals (e.g., Ayres et al., 2018; Kamp-Becker et al., 2011; van Heijst & Geurts, 2015) across life domains, including physical and emotional well-being (Croen et al., 2015; Schieve et al., 2012), and social inclusion and interpersonal relationships (Bauminger & Schulman, 2003; Kuhlthau et al., 2010; Laugeson & Ellingsen, 2014; Locke et al., 2010).

To better understand the lower QOL in individuals with ASD, researchers have recently investigated the impact of personal and environmental variables, such as age, gender, ASD severity, and race/ethnicity on the QOL in children, adolescents, and adults with ASD (e.g., Chiang & Wineman, 2014; Howlin & Matiagi, 2017; Kim & Bottema-Beutel, 2019; Oakley et al., 2021). Nonetheless, the findings have been mixed. The mixed findings reported in previous studies investigating the association between personal and environmental variables and QOL have raised questions related to the validity and reliability of the QOL measures for individuals with ASD. One of the limitations of the QOL measures used in previous studies is that these measures were developed for healthy and ill neurotypical individuals rather than for individuals with ASD who experience unique social-communication and behavioral characteristics which may have resulted in inaccurate findings (Chezan, Liu, Cholewicki, et al., 2022; McConachie et al., 2018, 2019; Williams & Gotham, 2021). In addition, a paucity of research exists on developing and validating QOL measures for children with ASD (Chezan, Liu, Cholewicki, et al., 2022; Cholewicki et al., 2019; Gomez et al., 2020).

To address the limitations listed previously, Cholewicki et al. (2019) developed the Quality of Life for Children with Autism Spectrum Disorder (QOLASD-C) scale. The QOLASD-C scale is designed for children aged 5 to 10 years old. It measures QOL across three domains (i.e., interpersonal relationships, self-determination, and emotional well-being). These domains were included because they (a) can be assessed based on social partners' perceptions of well-being (Keith & Schalock, 1994), (b) represent the domains most frequently evaluated in children with similar characteristics (Myers, 2003), and (c) are relevant to the development of children with ASD (Cannella et al., 2005; Shogren et al., 2012).

The scale was validated with a sample of 309 parents of children with ASD and the results suggested that the higher-order factor model was optimal with high internal consistency (Chezan, Liu, Cholewicki, et al., 2022). Furthermore, the QOLASD-C scale showed decent convergent and divergent validity. The factor structure of the QOLASD-C scale was cross-validated with a large sample ($N = 1317$) of parents of children with ASD (Chezan, Liu, Drasgow, et al., 2022). The results identified a bifactor model as the optimal model and suggested high internal consistencies. Furthermore, the scale showed decent convergent and divergent validity and a cut-off score of 37 was suggested to differentiate children with low and high QOL.

Although the QOLASD-C scale has good psychometric properties, several aspects require further investigation. First, the overall scale's functioning has been investigated through model fit using factor analysis; however, additional psychometric evidence could be gathered by examining other aspects related to the scale's functioning, such as local independence and distribution patterns. Second, results of published studies revealed inconsistent findings on the factor structure of QOLASD-C. Specifically, higher-order and bi-factor models were identified in different studies, although there were similarities between the two types of factor structure as illustrated by an overall factor and three domains. In addition, high first-order factor loadings and factor correlations (above 0.80) indicated similarities across the three domains.

Therefore, a more parsimonious general factor model may be considered to examine the quality of the QOLASD-C scale within the item response theory (IRT) framework. This method has been used in prior literature when validating scales conceptualizing multiple domains (La Porta et al., 2011). When using IRT, the estimation of how an individual may be rated is based on their placement on the construct (DiStefano et al., 2019). Estimation of a child's placement on the measured construct is separated from the responses on the scale's items. Differential item functioning (DIF) should be examined to determine whether the scale's items function similarly across different demographic groups.

Rasch modeling is a type of IRT model that can be used to validate survey scales (de Ayala, 2009) and to investigate the abovementioned aspects. Rasch modeling consists of one-parameter logistics models (Rasch, 1960) that compute the probability that a person provides a specific response to an item on a scale when the person's ability level (i.e., the amount of the construct that the person possesses) and the item's difficulty (i.e., the relation between an item on the scale and the construct) are known in advance (Baker, 2001). We selected the Rasch rating scale model (Andrich, 1978) because the four-category Likert-scale items share the same response options (DiStefano & Jiang, 2020).

To accommodate the characteristic of Likert data in the model estimation process, the parameter of the threshold is included in addition to the person's ability and item difficulty. Conceptually, the threshold can be thought of as the cut-off point where a child moves from one category to the next adjacent category on the Likert scale continuum (DiStefano & Morgan, 2011). The number of thresholds is equal to the number of response categories on the scale -1. For the QOLASD-C scale, the number of thresholds is three. In other words, three cut-off points split the continuum into four ordered categories.

In Rasch modeling, we can obtain the probability of a specific child who would be rated in a specific ordered category (τ) given his/her level of person's ability (θ) and item difficulty (δ) using the formula below (Wind, 2022):

$$P_{ni(x=k)} = \frac{\exp \sum_{k=0}^{x} (\theta_n - \delta_i - \tau_k)}{\sum_{j=0}^{m} \sum_{k=0}^{j} (\theta_n - \delta_i - \tau_k)},$$

where $j = 0, 1, \ldots k, \ldots m$, and k represents a specific category modeled in the formula.

The probability can be transformed into a logit score by taking the natural odds log value.

$$\ln\left(\frac{P_{ni(x=k)}}{P_{ni(x=k-1)}}\right) = \theta_n - \delta_i - \tau_k.$$

The log-odds of being in one response category k compared with the next adjacent response category $k-1$ (e.g., 2 to 1 or 3 to 2) is determined by θ, the person ability, δ, the item difficulty, and τ, the item threshold of the response category (Wind, 2022). The threshold structure is the same across all items, but each item may have different difficulties. The Rasch formulas connect all key concepts in the modeling process to allow the calculation of scores (or measures) for each person and each scale's item on an equal-interval scale called a logit scale (i.e., logits), a process named calibration (DiStefano et al., 2019). The logit varies if the probability is computed across all children for an item (item logit) or across items to compute the score for an individual (i.e., person logit; DiStefano & Jiang, 2020).

Several defining characteristics of Rasch modeling are (a) sample free-measurement models (DiStefano et al., 2019; Schumaker, 2004), (b) measurement of constructs using polytomously scored items data (e.g., Likert-type scale) (Gomez et al., 2012), and (c) the use of threshold values (i.e., cut-off points from one response category of the Likert-type scale into the adjacent category) in the estimation process.

Thus, considering the paucity of valid and reliable QOL measures for children with ASD and the need to continuously provide more psychometric evidence of existing measures, our main purpose in this study was to investigate the QOLASD-C scale functioning, the characteristics of the items comprising the scale, and the item functioning across subgroups of children with ASD based on gender and race/ethnicity. Our research questions:

1. What information does Rasch modeling provide on the QOLASD-C scale functioning (i.e., reliability, dimensionality, local independence, and distribution patterns)?
2. What are the item characteristics (i.e., item-total correlations and item fit)?
3. How do the QOLASD-C scale items function across different subgroups of children with ASD based on gender and race/ethnicity?

METHOD

Participants

A total of 1847 parents of children with ASD completed the QOLASD-C scale to rate their children's QOL. The inclusion criteria for participation in the study were to (a) have a child with ASD between the ages of 5 and 10 years and (b) have lived with their child with ASD during the past 12 months. The sample of parents was approximately equal in terms of gender and consisted of 49.9% females and 47.2% males. A small percentage (2.9%) of parents did not report their gender or reported their gender as non-binary/third gender. The average age of the children was 7.4 years ($SD = 1.37$). The sample of children consisted of slightly more girls (58.4%) than boys (39.5%). For 2.6% of the children, parents reported their gender as non-binary/third gender. The children in the sample were African American (39.0%), White (34.5%), African Indian or Alaska Native (13.1%), Hispanic (6.7%), Native Hawaiian/Pacific Islander (3.4%), Asian (2.3%), and mixed (0.5%). In terms of ASD severity, parents reported various levels of support or ASD severity for their children, including limited support (43.5%), substantial support (42.3%), and very substantial support (11.3%).

Instrument

The QOLASD-C is a brief parent-proxy scale (Chezan, Liu, Cholewicki, et al., 2022) measuring the QOL in young children with ASD aged 5 to 10 years old. The scale consists of 16 items. Parents rate their children's QOL using a 4-point Likert-type scale comprised of four response categories (i.e., 1 = *strongly disagree*, 2 = *moderately disagree*, 3 = *moderately agree*, and 4 = *strongly agree*). A description of the scale and its psychometric properties have been discussed in the introduction.

Rasch analyses

We conducted Rasch analyses using Winsteps Rasch measurement software Version 3.75.0 (Linacre, 2006; 2012). To ensure accurate item estimations, model assumptions were examined (Sick, 2010). First, the construct should be unidimensional (i.e., a scale measures a specific construct rather than other unintended constructs; Wright & Stone, 1999). Second, the scale used to evaluate the construct must be monotonic (i.e., higher scores represent a higher level of the construct). Each response category has at least 10% responses (Smith et al., 2002). Third, the items on the scale should adequately fit the Rasch model. Fourth, the scale's items must meet the local independence assumption (Baghaei & Pishghadam, 2008).

Overall QOLASD-C functioning

First, we examined the overall functioning of the QOLASD-C scale. We computed person reliability and item reliability indices to determine the consistency of ratings across children and items. The reliability is defined as the ratio of true variance and observed variance. Person reliability indicates the replicability of children's placement on the construct if a similar set of items were used. Item reliability means the replicability of item placement along the construct if a similar sample of children with ASD were selected from the population. Values higher than 0.80 suggest stable results or high consistency across persons and items (Crocker & Algina, 1986).

Furthermore, we examined person and item separation indices. The separation indices are defined as the ratio of true standard deviation of the item or person parameters and the root mean squared error of the person or item parameter estimates. There is a one-to-one relationship between the reliability and separation where reliability $=$ Separation^2/(1 $+$ Separation^2). The person separation index represents the efficiency of the items to discriminate between children with high and low levels of QOL. The item separation index refers to how well the items on the scale function to measure the breadth of the construct. The value of the person and item separation indices range from 0 to infinity, with values higher than 3 being desirable (Duncan et al., 2003; Linacre, 2012a, b). If the person separation and reliability values are below the suggested cut-off value, more items should be added to the scale. A larger sample is needed if the item separation and reliability values are below the recommended cut-off value (Linacre, 2012a, b).

Next, we assessed unidimensionality (i.e., whether the observed variance explained by the measures roughly matches the expected variance in the model) of the QOLASD-C scale with principal component analysis (PCA) of the residuals. Multiple criteria were used. First, the percentage of variance explained by the Rasch model should account for a minimum of 50% of the total variance to indicate the unidimensionality of the construct (Linacre, 1992). PCA examines the components in the correlation matrix of residuals. The first contrast (i.e., the first PCA component) explains the largest possible amount of the variance in the residuals. The eigenvalue of unexplained variances in the first contrast should be less than 3.0 to indicate unidimensionality (Bond & Fox, 2015), especially for a short scale with less than 20 items. Then, we calculated the residual correlations for the items on the QOLASD-C scale to examine local independence which occurs when performance on the scale item does not cover with performance on other items (Borsboom, 2005). Furthermore, deattenuated correlations among item clusters for the person measure to measure errors were examined. Values above 0.70 indicate that a scale probably measures the same construct (Linacre, 2018). Residual correlation values less than 0.3 (absolute values) suggest local independence (Aryadoust et al., 2021). Finally, we examined the distribution patterns of average threshold values (i.e., Rasch modeling parameters) across all items.

QOLASD-C item characteristics

Second, we investigated the relations between the scale's items and the construct of QOL. We computed two fit indices: the outfit mean square (MNSQ) and the infit MNSQ to assess the fit between items on the scale and the Rasch model by identifying potential unexpected response patterns (Bond & Fox, 2013). The outfit index (outlier-sensitive fit) focuses on unexpected responses on items that are very easy or very difficult for a person, whereas the infit index (inlier-sensitive fit) focuses on unexpected responses near a person's or item's score or responses that are targeted to the person (Linacre, 2002). Both indices are based on squared residuals between what is observed and expected in the Rasch model (DiStefano et al., 2014). Because the outfit index is sensitive to residuals from very unexpected responses and the infit index is less affected by extreme outlying residuals than outfit (Waterbury, 2020), we reported both infit and outfit MNSQ.

The expected value of both indices for each item is 1.0, with range values between 0.8 and 1.2 for high-stakes situations (Wright et al., 1994). Values of item fit indices outside the range values listed previously may suggest a lack of fit between the item and the model and, thus, the items can be removed from the scale. Additionally, we examined the discriminating ability of items (i.e., the ability of an item to differentiate between children with different levels of QOL) by computing item-total correlations. Items with item-total correlation values of less than 0.3 were considered to have the poor discriminating ability (Nunnally & Bernstein, 1994).

Person and item analysis

First, we estimated logit scores for children with ASD and the scale's items to examine how persons and items function together. A higher logit score obtained by a child on the QOLASD-C scale indicated a higher level of QOL, whereas an item with a higher logit score indicated that the item was difficult to agree on by parents. We placed each child's scoring information and each scale's item on an equal interval logit scale using a person-item map (i.e., Wright Map; Boone & Noltemeyer, 2017). The person-item map provides a visual display of how each child and each scale's item are placed on a continuum and, consequently, allows the identification of items with different levels of difficulty and children with ASD with various levels of QOL. We also examined whether the range of item difficulty levels matched the range of ratings assigned to the QOL of children with ASD (Boone & Noltemeyer, 2017).

We plotted the expected responses categories for children with different levels of QOL. Then, we explored how precise the scale can measure children with different QOL levels. The item precision (1/variance of estimates), also called item information, differs across different QOL levels. This index is rather small and rarely reported in practice. Test information is formed by summing the item information underlying a scale and visualized in a plot. Researchers may observe peak(s) or horizontal lines depending on specific scales (Baker, 2001).

Next, we conducted DIF analyses to determine if the QOLASD-C scale was biased across children's gender and race/ethnicity. We computed an average item measure that was compared across subgroups of children. First, we examined the DIF contrast or the difference in item difficulty levels between groups of children. Values of 0.5 logits or higher represent the noticeable level of DIF (Linacre, 2006). Second, we analyzed the probability value illustrating the statistical significance of the DIF contrast being observed if item bias occurred by chance. A Bonferroni correction was used to control multiple testing effects across the 16 items. Items should have a contrast value of at least 0.5 logits with a p-value lower than 0.003 to show DIF (i.e., 0.05/16).

RESULTS

QOLASD-C scale functioning

The person reliability index of the QOLASD-C scale was 0.93. This value indicated the replicability of person's responses if a parallel set of items were used (Wright & Masters, 1982). Moreover, the QOLASD-C scale had a decent item reliability index of 0.98, suggesting that items can be placed along the same logit scale across samples of similar children selected from the population of children with ASD whose QOL is rated by their parents. Both reliability indices suggested that the QOLASD-C scale yields reproducible person and item measure orders (i.e., their locations on the continuum). Furthermore, the person separation index was 3.70, indicating that items are sensitive enough to distinguish children into different ability groups. The item separation index was 7.66, suggesting that item hierarchy (i.e., high/low level of item difficulty) can be confirmed efficiently, and no items need to be added to the scale to measure the construct of QOL. Persons and items can both be separated along the construct.

The variance explained by the Rasch model accounted for 55.8% of the total variance, which was above the recommended cut-off value of 50%. The PCA of standardized residuals showed that the eigenvalue value of the second dimension was slightly higher (2.28) than the recommended value of 2, suggesting that the largest possible second dimension had a strength of 2 items, which was less than the cut-off point of 3 for a short survey scale. Thus, the second dimension was not reflective of a construct other than QOL. The eigenvalues of other dimensions were smaller than 2. Furthermore, deattenuated correlations were above 0.86 indicating the scale measures one concept. Therefore, our results revealed that the assumption of unidimensionality tentatively holds.

Almost all the residual correlation values were between −0.30 and − 0.30 indicating local independence was generally held. Three pairs of items had item residual correlations of 0.32. In other words, the parents' responses to one item are not related to their responses to other items. Additionally, the analysis of the response frequencies showed that more than 10% of responses were reported for each response category. Approximately one-third of parent ratings were in the *moderately agree* category (33%) or *moderately disagree* category (36%). The remaining ratings were distributed in the *strongly agree* category (17%) and *strongly disagree* category (13%).

The average threshold values (i.e., latent QOL level) across QOLASD-C scale items were: −2.27 for item ratings ranging from 1 to 2; −0.18 for item ratings from 2 to 3; and 2.45 for item ratings from 3 to 4. These values showed that the thresholds for all response categories increased monotonically in the expected direction. Figure 1 shows the probability curves for the QOLASD-C 4-point Likert scale. The diagram showed that the model-implied response category probabilities of each response category depending on the QOL level has a unique peak meaning that a specific response category is the most likely rating for a child's level of QOL. For example, children with ASD who had a low level of QOL were more likely to receive a rating of 1 (i.e., *strongly disagree*), whereas children with ASD who had a high level of QOL were more likely to receive a score of 4 (i.e., *strongly agree*). Similar patterns can be identified for the other response categories. Overall, the scale had a well-functioning response scale for all response categories (i.e., 1, 2, 3, and 4 s in the figure).

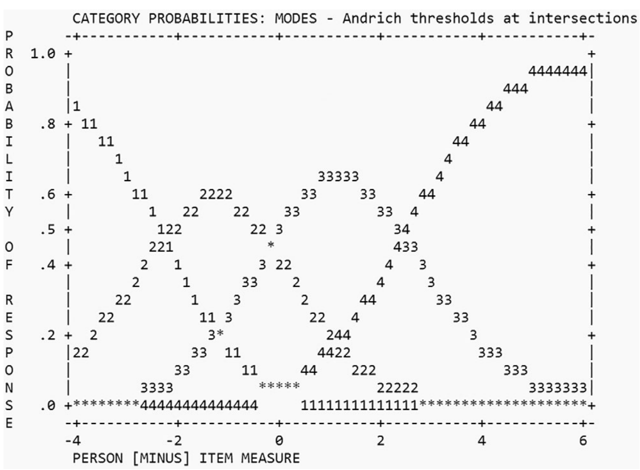

FIGURE 1 QOLASD-C probability curves for the 4-point Likert scale.

TABLE 1 QOLASD-C item statistics.

Item number	Infit	Outfit	Item-to-total-correlation	Item difficulty level	Gender DIF contrast (*p*-value)	Ethnicity DIF contrast (*p*-value)
IR1 My child enjoys playing with groups of children.	0.97	0.95	0.79	0.57	0.00 (1.000)	−0.06 (0.472)
IR2 My child likes to do many activities with others.	0.90	0.89	0.76	0.51	0.20 (0.012)	0.10 (0.238)
IR3 My child shows pleasure when interacting with other children.	0.94	0.93	0.77	0.22	−0.06 (0.442)	0.07 (0.401)
IR4 My child enjoys family activities.	1.04	1.03	0.72	−0.14	−0.16 (0.040)	−0.18 (0.025)
IR5 My child shows pleasure when learning new skills.	0.89	0.88	0.77	−0.04	−0.09 (0.269)	0.13 (0.115)
IR6 My child enjoys spending time with family members.	1.03	1.04	0.72	−0.40	0.00 (1.000)	−0.17 (0.041)
SD1 My child is able to express likes.	0.93	0.91	0.78	0.14	−0.03 (0.727)	0.03 (0.699)
SD2 My child shows preferences for places he or she would like to go.	0.96	0.97	0.72	0.02	0.17 (0.029)	0.18 (0.027)
SD3 My child can initiate several tasks independently.	1.00	0.99	0.75	0.27	0.11 (0.160)	0.16 (0.049)
SD4 My child selects his or her clothes for the day.	1.08	1.07	0.73	−0.05	−0.10 (0.207)	0.03 (0.714)
SD5 My child selects what he or she wants to eat.	0.94	0.95	0.74	−0.34	0.00 (1.000)	−0.12 (0.137)
SD6 My child shows pleasure about a particular activity.	0.92	0.94	0.74	−0.24	0.13 (0.100)	−0.03 (0.747)
EWB1 My child is generally happy.	0.85	0.85	0.80	0.19	0.00 (1.000)	0.08 (0.306)
EWB2 My child is relaxed when at home.	1.16	1.18	0.66	−0.50	−0.03 (0.714)	−0.38 (<0.001)
EWB3 My child sleeps well.	1.14	1.17	0.67	0.30	−0.13 (0.109)	−0.23 (0.005)
EWB4 My child likes going to school.	1.11	1.09	0.73	0.09	0.03 (0.701)	0.37 (<0.001)

Abbreviations: EWB, emotional well-being; IR, interpersonal relationships; SD, self-determination.

Item characteristics

Table 1 displays the item characteristics. The Infit and Outfit MNSQ indices were within the recommended guidelines indicating excellent item fit to the Rasch model. All item-to-total correlations were positive and ranged from 0.66 to 0.80, which suggests good discriminating ability or the ability of the items to differentiate between children with low and high levels of QOL. The medium to strong relationships also suggested that a child's QOL was perceived as being higher when they demonstrated a specific behavior (described by the item) of QOL.

Person and item analysis

Calibrated scores both for item measures and for children measures were placed on a common logit scale and displayed on a person-item map shown in Figure 2. Higher logit scores indicate higher levels of item difficulty (i.e., difficulty to "agree" that the item under consideration reflects their child's QOL) and higher levels of person ability (i.e., QOL of children with ASD). A value of "0" represents the middle point with a mean of 0. Positive values "1 to 6" represent the number of standard deviations above the mean, whereas negative values represent the number of standard deviations below the mean.

The right side of the Wright map displays the item difficulty levels of the QOLASD-C scale (i.e., item measure). The items at the bottom of item distribution (or below 0 logits) were easier for parents to agree on when evaluating their children's QOL, while the items at the upper end of the item distribution (above 0 logits) were harder for parents to agree on when evaluating their children's QOL. Items displayed in Figure 2 illustrate a narrow range of item difficulty levels (range from −0.50 to 0.57 logits) with values centering around a mean of 0. In general, certain items measuring interpersonal relationships (e.g., "My child enjoys playing with groups of children") were more difficult for parents to agree on, whereas some items measuring emotional well-being (e.g., "My child is relaxed when at home") were easier for parents to agree on. Furthermore, the examination of the item content from the Wright map indicates that items

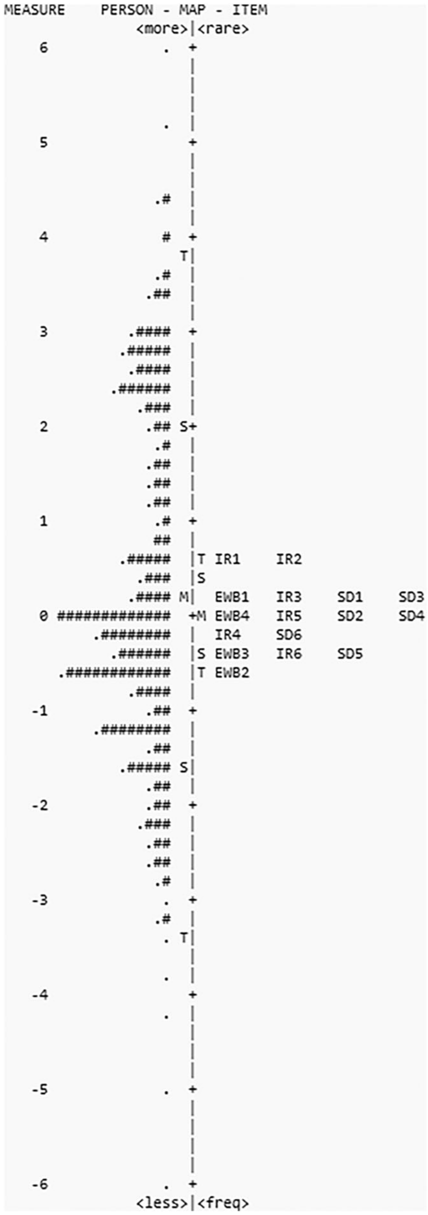

FIGURE 2 Wright person-item map for QOLASD-C items ($N = 1847$).

with different difficulty levels in each content area were evenly distributed on the scale. However, there were some overlaps in item contribution, meaning that certain items in the same content area were placed on the same line on the graph. For example, Item IR2 and Item IR4 had the same difficulty level and may not provide unique information to the scale.

The left side of the Wright map represents a child's estimated score on the QOLASD-C scale. Higher and positive values indicate a higher level of QOL, whereas lower and negative values indicate a lower level of QOL. Results displayed in Figure 2 show a wide distribution of QOL scores ranging from 6 standard deviations below the mean (−6.27 logits) to 6 standard deviations above

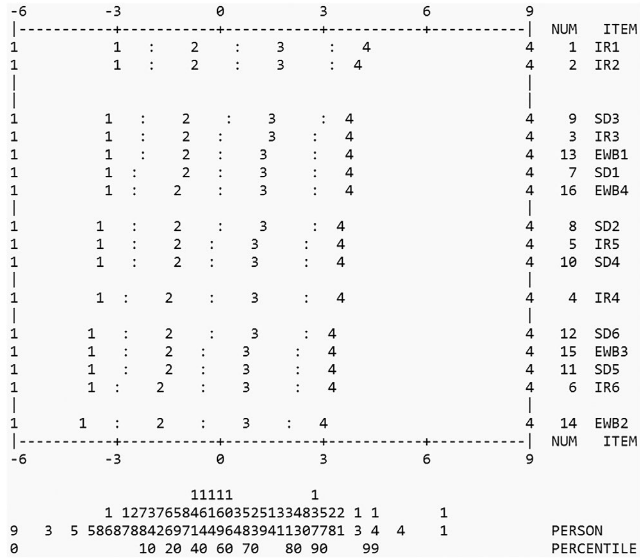

FIGURE 3 Expected response categories for QOLASD-C items.

the mean (6.45 logits). These values suggest that children rated by the parents included in the study sample had various levels of QOL with an average measure of 0.2 logits. In general, the comparison of item and person measures revealed (a) that items functioned better to measure children with medium levels of QOL and (b) their limited ability to precisely measure levels of QOL of children with very low or high levels of QOL (beyond +/− 1 standard deviation).

Figure 3 illustrates the expected response categories on the QOLASD-C scale for children with different levels of QOL. The x-axis displays children's QOL (i.e., logit scores). Below the x-axis, a number of children at each measure level (i.e., logit values) and corresponding percentiles are displayed. For instance, there were 169 children at around 0 with a person percentile of 60%. The y-axis displays the items from the QOLASD-C scale ordered by item difficulty level (high to low). Values indicate the ordinal scale on the QOLASD-C scale (i.e., 1 to 4). The response scales are of equal distance apart indicating the spread of responses across all categories and all items showed an expected monotonic increase in the average level of QOL estimates as the ratings moved from lower to higher response categories. The colons indicate the threshold values from one response category to the adjacent response category. After surpassing the threshold value, a parent would be expected to rate the next highest response category on the scale. For example, for a child at the mean of the person measure of 0.20 logits (the solid line), their parent would be expected to endorse a rating of 2 (*moderately disagree*) for Item IR1 and a rating of 3 (*moderately agree*) for Item EWB3.

The test information function displayed in Figure 4 illustrates the region of the QOL that was measured most precisely (i.e., the peak). Test information peaked at −1 which is consistent with moderate difficulty levels of

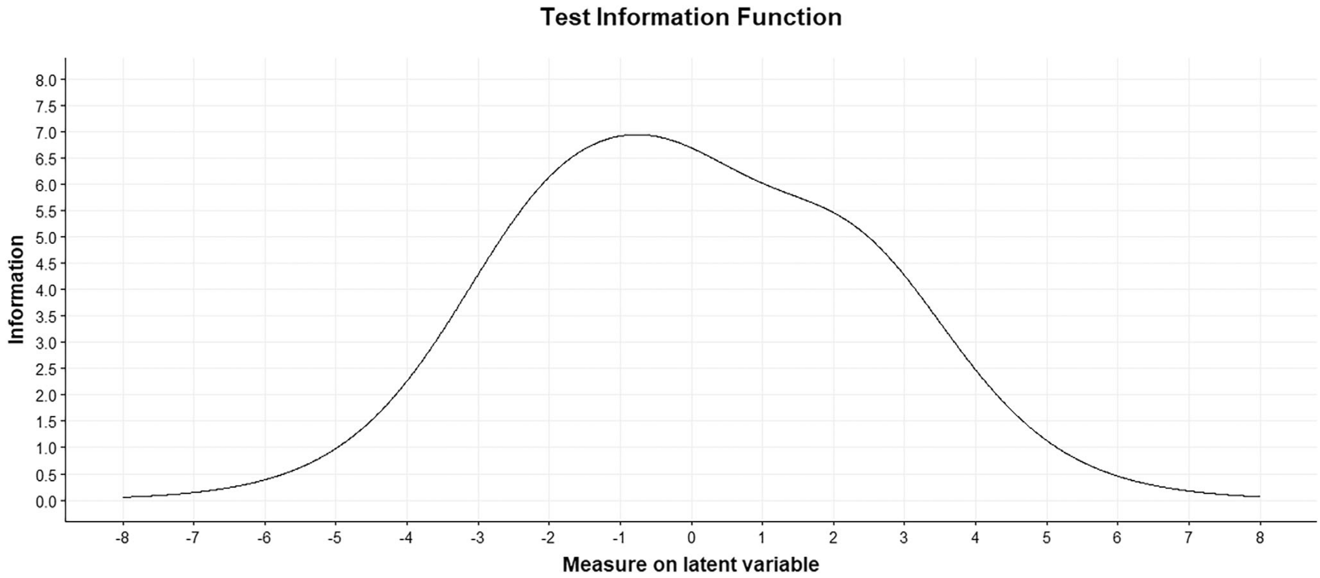

FIGURE 4 Test Information Curve. The x-axis indicates the latent ability levels from children (i.e., the QOL levels).

items. Therefore, the QOLASD-C scale provides more accurate estimates for children with moderate QOL levels. DIF results revealed that all scale items were invariant across groups of children based on gender and race/ethnicity (see Table 1). DIF contrast absolute values were below 0.20 for gender subgroups and below 0.38 for race/ethnicity subgroups. However, two items exhibited significant DIF *p*-values although the DIF contrast values were less than 0.5 logits (i.e., "My child is relaxed when at home," $p < 0.0001$, DIF contrast $= -0.38$; "My child likes going to school," $p < 0.0001$, DIF contrast $= 0.37$). Therefore, no items exhibit DIF after considering the contrasts and statistical estimates together.

DISCUSSION

Our purpose in this study was to examine the QOLASD-C scale's functioning, the characteristics of the items comprising the scale, and the item functioning across subgroups of children with ASD based on gender and race/ethnicity using Rasch modeling. Results suggested that the QOLASD-C scale met all the required assumptions including unidimensionality, monotonality, and local independence. All items had decent item quality as reflected by item fit and discrimination. In addition, the scale is comprised of items with moderate difficulty levels and functioned better to measure children with medium levels of QOL than children with very low or high levels of QOL. Test information curve also indicated similar conclusions. DIF results revealed that the scale items were invariant across children based on gender and race/ethnicity.

Several findings of this study warrant further discussion. The first finding is that some items (e.g., "My child is relaxed when at home") related to emotional well-being were easier for parents to agree on. One potential explanation for this finding is that parents are familiar with and able to identify the wide range of emotions such as happiness, sadness, sleep patterns, or anger experienced by children in the home setting (Hwang et al., 2015) and, therefore, consider these items more relevant to their QOL. Aspects related to the emotional development of children with ASD have been recognized as one of the early and most pressing concerns of parents of children with ASD (Guinchat et al., 2012; Qian et al., 2012) and the negative effects associated with deficits in emotional development on interpersonal relationships and QOL have been documented in the literature (Ikeda et al., 2016).

The second finding is that some items (e.g., "My child enjoys playing with groups of children," "My child likes to do many activities with others") related to interpersonal relationships were more difficult for parents to agree on when evaluating children's QOL. Although parents of children with ASD are aware of their children's challenges in developing and maintaining interpersonal relationships (e.g., Barnhill et al., 2000; Ho et al., 2012; Spence, 2003; Viljoen et al., 2021), these items' difficulty may be related to the limited number of opportunities for children to engage in social interactions. Researchers suggested that the stigma associated with a diagnosis of ASD, and the parents' concerns related to the mistreatment of their children by community members restricts the number of activities outside the home such as parties, social gatherings, recreational activities in which families participate (Askari et al., 2015; Fox et al., 2002; Lee et al., 2008).

It is noteworthy that two items on the scale (i.e., "My child enjoys playing with groups of children" and "My child is generally happy") showed the highest item-total correlation and, thus, had the greatest ability to discriminate between children with different levels of QOL. This finding is somewhat expected considering the critical contribution of interpersonal relationships and emotional well-being to children's QOL. Researchers have shown that when children participate in social activities, they not only can develop meaningful interpersonal relationships and improve their emotional well-being but also enhance their QOL (Askari et al., 2015; Ikeda et al., 2016; Solish et al., 2010). For example, children with ASD who require substantial and very substantial levels of support and engage in few interpersonal relationships experience lower levels of QOL compared to children who need support and engage in more interpersonal relationships (Kamio et al., 2012; Pisula et al., 2015). Engagement in interpersonal relationships also influences children's emotional well-being. Specifically, children and adolescents with ASD who require substantial and very substantial levels of support have shown lower levels of satisfaction with interpersonal relationships and poor emotional well-being (Lamport & Zlomke, 2014; Pisula et al., 2015; Pollmann et al., 2010).

The third finding is the narrow range of item difficulty level distribution. Although the results show acceptable scale functioning in measuring QOL and good discriminating ability of scale items to differentiate between children with low and high levels of QOL, it would be preferably to include items with a wider range of difficulty levels to capture children with various levels of QOL, especially those with low QOL. Therefore, the QOLASD-C scale may be revised by adding more items with higher item difficulty levels to spread respondents along a continuum from low to high QOL. This revision is supported by the test information curve and it would have practical implications because it would allow practitioners not only better to identify children with low QOL but also design individualized interventions and supports to enhance the QOL of these children.

The fourth finding is that all QOLASD-C scale items were invariant across groups of children based on gender and race/ethnicity without DIF items. DIF analysis allowed us to determine whether the association between QOL and children's demographic characteristics may be attributed to measurement bias rather than reflect a true association between these variables. As the QOLASD-C is a newly designed scale for children with ASD, we were unable to identify any DIF studies using similar scales for children with ASD. However, DIF analysis on the QOL scales for typical adolescents and children has been widely conducted. Like the results reported in the current study, these scales are free of gender DIF (e.g., Caronni et al., 2017; Oluboyede et al., 2017; Vélez et al., 2016). Based on our review, ethnicity-based DIF analysis has not been studied. Therefore, it is of significance and novelty to build such invariance across the majority and minority groups, which aligns with the goal of promoting diversity, equity, and inclusion in the QOL research. Overall, our study provides empirical evidence that the scale items function similarly for boys and girls and for children from majority and minority groups. The scale can be used with confidence to evaluate the QOL of all children for whom the scale was designed without the potential for bias due to these two characteristics.

The results of this study reveal several strengths of the QOLASD-C scale. The scale is useful for identifying children's overall QOL and differentiating between children with low and high QOL without the potential bias due to gender and race/ethnicity. Moreover, the scale is brief and can be completed by parents quickly and without training. However, practitioners should be aware that the items comprising the QOLASD-C function better when measuring average levels of QOL, and they may be less precise when measuring lower and higher levels of QOL. Thus, we recommend that practitioners use the QOLASD-C as an initial screening measure. If the scale is used to evaluate QOL as a treatment outcome for children with ASD, then we recommend it be used in conjunction with other reliable and valid measures assessing treatment effectiveness on individual target outcomes.

The findings of this study should be interpreted with caution due to several limitations. First, the sample included in this study was not representative of the larger population of children with ASD in terms of gender and race/ethnicity and the results may not generalize to the entire population of children with ASD. However, it is noteworthy that DIF results remain valid even when the sample is not representative of the target population (Embretson, 1996). Future research may be conducted to examine DIF for other demographic characteristics, such as age and socio-economic status. Second, the Wright map indicated that a few items related to interpersonal relationships made the same contribution to the scale and did not provide unique information to the measurement of QOL. These items could be reviewed in a subsequent revision of the scale to ensure that they make a unique contribution to the measurement of QOL using the QOLASD-C scale. A third limitation is the scale's ability to better measure average levels of QOL rather than precisely measure the lower and higher level of QOL.

Future studies may conduct more in-depth examinations on the total score obtained using the QOLASD-C scale. All item ratings are summed to create a total score representing a child's level of QOL. Researchers have raised concerns about summing scale responses when ordinal data are used (Bond & Fox, 2013; Smith et al., 2002) because the summed scores do not account for different levels of item scale difficulty. Thus, it is necessary to conduct additional studies investigating optimal cut-off scores using Rasch procedures and compare them with the existing QOLASD-C scale cut-off score (Chezan, Liu, Drasgow, et al., 2022; Stone, 2001).

CONCLUSIONS

In summary, this study has provided additional empirical evidence to support using the QOLASD-C as a valid and reliable measure to evaluate QOL in children with ASD. This is the first study that provides empirical evidence to document that the scale functions acceptably, provides consistent ratings of QOL across children and scale items, the items have good discriminating ability, and they can distinguish effectively between children with high and low levels of QOL. In addition, the scale does not provide evidence of DIF across subgroups of children based on gender and race/ethnicity. Thus, we suggest that the QOLASD-C scale has strong psychometric properties and can be used both as a screening measure and as a QOL outcome measure in combination with existing measures to guide the development and implementation of interventions for children with ASD.

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CONFLICT OF INTEREST STATEMENT

The author(s) declared no potential conflicts of interest with respect to the research, authorship, or publication of this article.

DATA AVAILABILITY STATEMENT

Data are available upon request. No new data are generated.

ETHICS STATEMENT

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. The study was approved by the Human Subjects Research Committee at Old Dominion University (# 1693810-1). Participants signed an electronic informed consent prior to the study.

ORCID

Jin Liu https://orcid.org/0000-0001-5816-2422

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