Evaluating the use of the Child and Adolescent Intellectual Disability Screening Questionnaire (CAIDS-Q) to estimate IQ in children with low intellectual ability

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Abstract

In situations where completing a full intellectual assessment is not possible or desirable the clinician or researcher may require an alternative means of accurately estimating intellectual functioning. There has been limited research in the use of proxy IQ measures in children with an intellectual disability or low IQ. The present study aimed to provide a means of converting total scores from a screening tool (the *Child and Adolescent Intellectual Disability Screening Questionnaire*: *CAIDS-Q)* to an estimated IQ. A series of linear regression analyses were conducted on data from 428 children and young people referred to clinical services, where FSIQ was predicted from *CAIDS-Q* total scores. Analyses were conducted for three age groups between ages 6 and 18 years. The study presents a conversion table for converting *CAIDS-Q* total scores to estimates of FSIQ, with corresponding 95% prediction intervals to allow the clinician or researcher to estimate FSIQ scores from *CAIDS-Q* total scores. It is emphasised that, while this conversion may offer a quick means of estimating intellectual functioning in children with a below average IQ, it should be used with caution, especially in children aged between 6 and 8 years old.

Keywords: estimating IQ; intellectual disability, *Child and Adolescent Intellectual Disability Screening Questionnaire (CAIDS-Q)*

Abbreviations: Full Scale IQ (FSIQ); *Child and Adolescent Intellectual Disability Screening Questionnaire (CAIDS-Q)*

1.1 Introduction

Children with an intellectual disability have significant limitations in their cognitive and adaptive functioning, which means that they are likely to require additional support (British Psychological Society [BPS], 2001). In order to diagnose an intellectual disability, formal assessment of intellectual and adaptive functioning is required, and the former needs to be undertaken by an appropriately qualified applied psychologist (BPS, 2001). There are, however, a number of situations where undertaking formal intellectual assessment may not be feasible. These include difficulties using standardised assessments with very young children or those with associated disabilities that preclude the administration of an assessment in a standardised way (Kurita, Osada, Shimizu, & Tachimori, 2003). The child may be uncooperative, display behaviours that challenge, or be experiencing physical or mental ill health that impacts significantly on performance (Moss & Hogg, 1997). There may also be practical difficulties such as limited or no access to an appropriately qualified psychologist to conduct the assessment, or long waiting times and heavy case-loads which prevent timely assessment (Crawford, Allan, & Jack, 1992).

At times, the professional may also feel that a reasonable estimate of IQ is all that is required. This may be on an individual basis, for example, where the individual is being followed up after undergoing previous comprehensive assessment or where a global estimate of IQ forms only one aspect of a full evaluation (Kaufman & Kaufman, 2001). There will also be occasions where estimates of IQ will be used for estimating and describing population characteristics (Moss & Hogg, 1997) or to identify those potentially at risk, such as screening children in educational settings (Sonnander, 2000). Clinical researchers may also utilise IQ estimates (Spinks et al., 2009) in order to stratify participants appropriately or match groups in terms of participants' intellectual functioning. Here, conducting full intellectual assessments on large populations is unlikely to be practicable because of the time and

resources required. In all of the above situations, clinicians and researchers may need alternative or interim methods of estimating IQ (Kaufman & Kaufman, 2001).

There have been several suggestions for estimating IQ in situations where full intellectual assessment is not possible, desirable or practical. One is to use demographic, e.g. age, gender, years of formal educational, and occupation to form a prediction equation that converts this information into an estimate of IQ (Crawford, Millar, & Milne, 2001). This method is often used in the context of estimating pre-morbid functioning in clinical settings, however, is associated with large standard errors of prediction. This method is also not likely to be particularly useful in estimating IQ in children in whom demographic characteristics are effectively those of the parents. Another suggestion is to use academic performance, for example, SAT scores to derive IQ prediction equations (Frey & Detterman, 2004). While academic performance is a strong predictor of IQ in general population samples, it is unlikely to be as discriminating in those with lower intellectual abilities where academic performance may exhibit a floor effect. Furthermore, few standardised measures of academic achievement may be available in younger age groups.

In terms of methods appropriate to the estimation of IQ in individuals with low IQ, two methods have been previously employed. These consist of using either adaptive functioning information, such as age appropriate verbal communication, cleaning and dressing self, and expressing needs to others (e.g. Bakare, Ubochi, Okoroikpa, Aguocha, & Ebigbo, 2009); or using short forms of intellectual assessments (e.g. Crawford, Anderson, Rankin, & MacDonald, 2010) or brief intellectual assessments (Saklofske, Caravan, & Schwartz, 2000), such as the *Wechsler Abbreviated Scale of Intelligence- Second Edition (WASI-II*: Wechsler, 2011). A number of authors have discussed the relative advantages and disadvantages of these methods in general (e.g. Kaufman & Kaufman, 2001; McKenzie, Murray, Murray, & Murray, 2013; Spinks et al., 2009), but with relatively less attention on

their utility when used with people with an intellectual disability. Research with adults suggests that such measures overestimate the IQ of those with an assessed FSIQ of below 85 (Spinks et al., 2009). There has, however, been very limited research examining the performance of such tools with children with an intellectual disability.

In this paper, therefore, we evaluate the possibility that a screening tool for intellectual disability could serve as an alternative predictor of IQ in a prediction equation for those with low intellectual functioning. A series of studies have begun to explore the use of screening tools as indicators of intellectual disability in children and young people referred to clinical services. Previous research has found the *Child and Adolescent Intellectual Disability Screening Questionnaire (CAIDS-Q*) to have favourable psychometric properties in relation to construct, convergent and discriminative validity, and inter-rater reliability (McKenzie, Paxton, Murray, Milanesi, & Murray, 2012). The *CAIDS-Q* was initially developed purely as a screen for intellectual disability, meaning that the intention was for the scale to be used to make dichotomous 'likely to have intellectual disability' versus 'not likely to have intellectual disability' discriminations. The use of the scale in this way has been supported by studies reporting sensitivity and specificity values at the cut-off point for intellectual disability of 82 to 97% and 83 and 85% respectively, depending on the age of the child (McKenzie et al., 2012; McKenzie, Murray & Murray, 2013).

Subsequent research has explored the use of the scale for other research and clinical applications beyond its initially intended purpose as a screening tool. Based on non-parametric item response theory analyses, Murray, McKenzie, Booth & Murray (2013) found evidence that the *CAIDS-Q* scores can be used to order individuals according to level of functional ability. In terms of BPS intellectual disability severity classifications, Murray & McKenzie (2014) found that although the scale could provide a heuristic for estimating which category young people aged 12-18 would be placed in, it could not do so with a degree of

accuracy required for higher stakes decisions such as final clinical diagnosis or resource provision.

McKenzie et al. (2013) also compared the performance of the *CAIDS-Q* in a population of clinically referred children to a 7- subtest short form of the *Wechsler Intelligence Scales for Children—fourth edition (WISC-IV*: Wechsler, 2003) which was proposed by Crawford et al. (2010). It was found that both the *CAIDS-Q* and the *WISC-IV* short form performed well at correctly classifying the individuals as having an intellectual disability or not (as assessed according to the three diagnostic criteria), showing similar levels of accuracy of 88% and 91% correct classification respectively. The authors concluded that both methods can offer clinically useful indices of whether a young person had an intellectual disability or not. A perceived advantage of the *CAIDS-Q* was that, unlike the *WISC-IV* short form, the administrator was not required to have a particular qualification or level of training.

Collectively these studies would suggest that the CAIDS-Q could have utility in situations where a quick estimate of FSIQ is required, for example in clinical research, but where restricted or no access to an appropriately qualified psychologist precludes the use of short form intellectual assessments. Further impetus for exploring this question formally comes from the fact that, in general, proxy measures of IQ perform poorly with people with below average intellectual functioning (Spinks et al., 2009; but see McKenzie et al., 2013).

The present study, therefore, aims to provide a means of converting *CAIDS-Q* total scores to an estimated IQ in a group of children and young people referred to clinical services. As children's development over time can impact on assessed intellectual functioning (Siminoff et al., 2006), the results are presented stratified by age.

2. Method

The study employed pre-existing data which were gathered as part of the series of validation studies for the *CAIDS-Q* (see McKenzie et al., 2012 for details). Permission to use these data had previously been obtained from the Caldicott Guardian (who serves the function on behalf of individual National Health Service areas in Scotland of overseeing the use of pre-existing data for which individual patient consent cannot be obtained) and the relevant clinicians in the participating services.

2.1 Measures

Screening tool: the *CAIDS-Q* was used to derive estimated IQ scores in the current study. This is a seven item screening tool, which was initially designed as a means of providing a quick and accurate indication of whether an individual was likely to have an intellectual disability or not. It can be completed with the individuals themselves or by someone who knows them well. In the present study, the CAIDS-Q items were completed from pre-existing information in clinical case notes which in turn had been obtained by the clinician (usually a clinical psychologist) either directly from the child or indirectly from parents, carers or teachers. The exact details of who provided the information are not known, as this information was not collected at the time.

The CAIDS-Q asks about literacy, support needs, self-care and social relationships and has a 'yes/no' scoring format. These scores are then converted to a total percentage score, which is compared against a cut-off score to identify whether the young person is likely to have an intellectual disability. It is permissible for up to two items to be missing for an individual, however, to maximise the accuracy of IQ estimates, for the current analyses we assumed the administration of all seven items. As noted above, the *CAIDS-Q* has been found to have good psychometric properties including sensitivity and specificity (McKenzie et al., 2012; 2013). It correlates highly with both FSIQ (McKenzie et al., 2012) and adaptive

functioning scores (McKenzie & Murray, 2013). It takes approximately 5 minutes to administer and does not require the user to have a particular professional background or qualification.

Intellectual assessment: Data on FSIQ were obtained from *WISC-IV* assessments conducted independently by clinicians in the participating services.

Demographic information: information was also gathered about the gender of the young person and age at the time of the assessment.

2.2 Participants

Data were used from a total of 428 participants for the purpose of the study. Table 1 provides information about the gender, age and diagnosis of the total sample and the subgroups, which are stratified according to age.

Insert table 1 about here

2.3 Multivariate Imputation

Missing data were dealt with by using multivariate imputation implemented in the R package *mice* (multivariate imputation by chained equations: van Buuren & Groothuis-Oudshoorn, 2011). Multiple imputation produces parameters that are more efficient and less biased than methods such as deletions or mean imputations (Schafer & Graham, 2002). Unlike these methods, it also incorporates uncertainty due to missingness into parameter confidence intervals (Rubin, 1987). The analysis proceeded in several stages. First, several imputed datasets were created in which the missing data values were imputed. Here we used 5

imputed datasets because beyond 3 imputed datasets there are only small increments in precision gained from further imputations, particularly when missingness is low (Carlin, 2003). Next, the statistical analysis was conducted on the 5 imputed datasets separately to yield a regression model for each dataset. Finally, these estimates were pooled across the datasets in order to yield a single regression coefficient and associated standard error using Rubin's (1987) formulae.

2.4 Main Analysis

A series of linear regression analyses were conducted with *CAIDS-Q* total score predicting FSIQ. Analyses were conducted for each age group. Prediction intervals were computed for each predicted FSIQ score. Prediction intervals should be distinguished from confidence intervals. The latter concern the degree of uncertainty in predicted values of y ($\hat{y}$) as an estimator for the conditional mean E(Y|X=x). However, prediction intervals concern $\hat{y}$ as an estimator of specific values of the random variable Y, which must, therefore, also take into account the variance of the conditional distribution Y|(X=x). As a result, prediction intervals will always be wider than confidence intervals.

3. **Results**

Descriptive statistics are provided in Table 1. In addition, Figure 1 shows the distribution of *CAIDS-Q* scores in the sample.

Insert Figure 1 about here

The amount of missingness was small. In the youngest age group, there were 2 cases of missing *CAIDS-Q* item-level data and 7 cases of missing FSIQ data. In the middle age group, there were 4 cases of missing FSIQ data. In the oldest age group, there were 7 cases of

missing CAIDS-Q item-level data and 7 cases of missing FSIQ data. The results of the pooled regression model for each age group, with associated equations for calculating an estimated IQ score are provided in Table 2.

Insert table 2 about here

Table 3 provides the predicted FSIQs and associated 95% prediction intervals for CAIDS-Q scores from 0 to 7, stratified by age. As the between-imputation variance was small and missing data few, the results in Table 3 were based on a single randomly selected imputation.

Insert table 3 about here

4. Discussion

The study aimed to provide a means for clinicians and researchers to convert *CAIDS-Q* scores to estimated FSIQ scores in order to give an indication of general intellectual ability in situations where administering a full intellectual assessment was not desirable, feasible or practical. While all of the regression models yielded statistically significant results, statistical significance is not sufficient justification for using the resulting equations for prediction. For example, in the worst performing model, that relating to the youngest age group, only 18.7% of the variance in FSIQ was explained by *CAIDS-Q* scores. This may be for a number of reasons. As there is more rapid development of younger children, both full intellectual assessments and screening assessments are less accurate at a younger age (e.g. Siminoff et al., 2006; Bornholt, Spencer, Ouvier, & Fisher, 2004), although this tends to apply to pre-school children. By contrast, some authors have found IQ to be relatively stable in children of school age and above, both with (Whitaker, 2008) and without an intellectual disability (e.g. Yule, Gold, & Busch, 1982). It may, therefore be that the poorer performance of the model for the younger children in the present study reflects the fact that some of the *CAIDS-Q* items may be less discriminating with younger children. For example, many children aged six may have some difficulty with reading and writing, regardless of whether they have an intellectual disability or not because this is a new skill that is being learnt at school.

Indeed, the *CAIDS-Q*, while being found to have sensitivity and specificity levels above the levels deemed to be acceptable for screening tools (Glascoe, 2005) and to correlate significantly with IQ in those age between 6 and 8, performed more poorly than with those aged 8 years and over (McKenzie et al., 2013). This would suggest that caution should be exercised when estimating the FSIQ of children under eight years old based on the *CAIDS-Q* total scores.

The models for the older group were stronger, explaining just over 60% of the variance for both groups. There are, however, still limitations in the precision of these estimates as reflected in the standard errors of the intercepts and regression coefficients for *CAIDS-Q* scores, and in the prediction intervals for the predicted values of FSIQ for different *CAIDS-Q* scores. It is advisable to take this uncertainty into account when estimating FSIQ based on *CAIDS-Q* by considering the prediction intervals given in Table 3 alongside the predicted values. The width of these intervals suggests that the conversion should not be used if very precise estimates of FSIQ are required at the level of the individual. In general the user should always consider whether the conversion provides precise enough estimates for the intended purpose. In addition, because the *CAIDS-Q* was designed to identify those individuals who are likely to have an intellectual disability and the conversion equations were derived based on a sample of individuals with low intellectual functioning, it should not be used to predict FSIQ in more high functioning populations. As can be seen from Table 2, the predicted FSIQ based on the *CAIDS-Q* demonstrates a floor effect. The minimum predicted FSIQ, even if the individual scores zero on the *CAIDS-Q*, is 47.95 in the oldest group and 63.69 in the youngest group. In other words, because of this floor effect, the *CAIDS-Q* prediction equation will estimate a FSIQ score ranging from a minimum of between approximately 48 and 64 depending on the age of the child. This means that calculating an estimated FSIQ from a *CAIDS-Q* score is likely to overestimate the cognitive functioning of those with the lowest IQs, particularly in the youngest age group.

The conversion may, however, be useful for purposes such as characterising a sample in terms of 'FSIQ-equivalent' scores, imputing missing FSIQ data, matching research participants for intellectual ability, or other situations where only an approximate estimate of FSIQ is required. In terms of future directions, it may be possible to identify other predictors that can be integrated into the prediction equations presented in the current study in order to

improve the precision of prediction. For example, the *CAIDS-Q* prediction equation could be supplemented with a brief cognitive test to produce a 'hybrid' prediction equation that includes both *CAIDS-Q* scores and a brief cognitive measure. Unfortunately, and in part what motivated the current study, many of the cognitive measures currently used with individuals with low intellectual ability exhibit floor effects (Whitaker & Gordon, 2012). Therefore, a cognitive measure that is appropriate for measuring the lowest levels of intellectual ability will be required to provide precise prediction. This limitation also highlights the issue of predicting IQ where the criterion measure itself may not be particularly reliable.

5. Conclusion

The study presents a conversion table for converting *CAIDS-Q* total scores to estimates of FSIQ, with corresponding 95% prediction intervals to allow the clinician or researcher to estimate FSIQ scores from *CAIDS-Q* total scores. However, such conversions should be used with caution and avoided altogether in any high stakes decision-making contexts.

Conflict of Interest

The first author is one of the developers of the CAIDS-Q and receives a small income from its sale. The second author is a relative (daughter) of the first author.

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Table 1

Participant information (gender, age at assessment and diagnosis) for the total sample and by age group.

	Gender[a]		**Age**	**Intellectual Disability**		**Full Scale IQ**				**CAIDS-Q score**	
	Male	**Female**	**Months**	**Yes**	**No**						
	Number (%)	**Number (%)**	**Mean (SD)**	**Number (%)**	**Number (%)**	**Mean (SD)**	**Range**	**Skew**	**Mean (SD)**	**Range**	**Skew**
Total sample (n=428)	280 (66)	145 (34)	131.4 (41)	198 (46)	231 (54)	72.8 (21.8)	40-138	0.6	3.4 (2.6)	0-7	0
Ages 6 to 7 years 11 months (n=117)	83 (71)	34 (29)	81.7 (7)	52 (44)	65 (56)						
Ages 8 to 11 years 11 months (n= 128)	80 (63.5)	46 (36.5)	118.4 (13.3)	59 (46)	69 (54)						
Ages 12 to 18 years (n= 183)	117 (65)	64 (35)	173.9 (17.2)	87 (47.5)	96 (52.5)						

[a]Four participants had missing data on gender.

Table 2:
The results of the pooled regression model for each age group, with associated equations for calculating an estimated IQ score

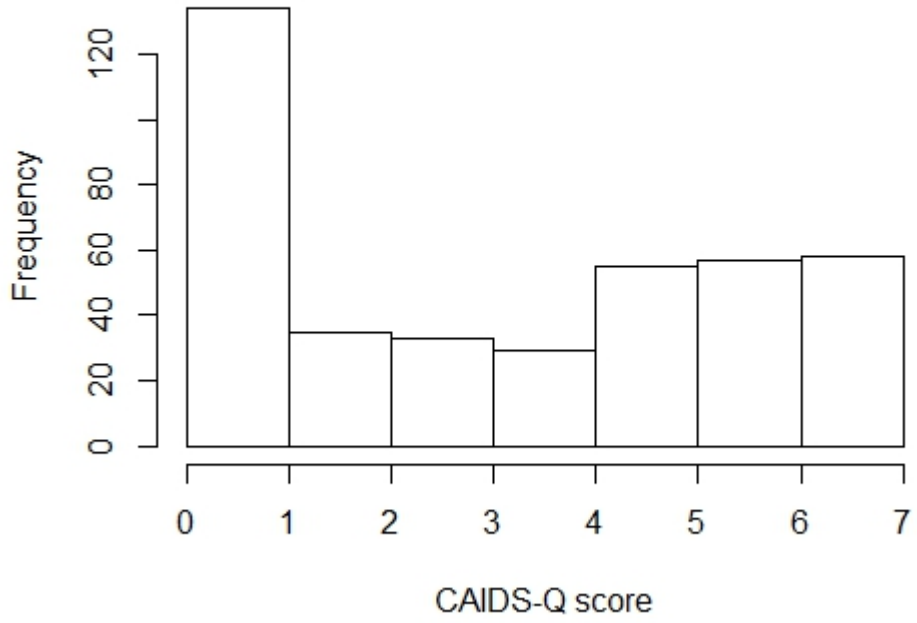
Age Group	*F(df)*	*P*	R^2	Intercept (SE)	95% CI for Intercept	$B_{CAIDS-Q}$ (SE)	95% CI for $B_{CAIDS-Q}$	Equation for calculating estimated FSIQ
Ages 6 to 7 years 11 months	24.8 (1,108)	<.001	0.16	63.81 (3.08)	57.70-69.93	4.20 (0.84)	2.52-5.87	FSIQ = 63.81 + (4.20 x CAIDS-Q score)
ID only	1.30 (1,49)	0.26	0.03	-				
Ages 8 to 11 years 11 months	188.1 (1,122)	<.001	0.61	49.99 (2.30)	45.44-54.54	7.06 (0.51)	6.04-8.08	FSIQ = 49.99 + (7.06 x CAIDS-Q score)
ID only								
Ages 12 to 18 years	279.6 (1,168)	<.001	0.62	48.34 (1.52)	45.34-51.54	5.75 (0.34)	5.07-6.43	FSIQ = 48.34 + (5.75 x CAIDS-Q score)

[a]Based on randomly selected singly imputed dataset.

Table 3:

Predicted FSIQs and associated 95% prediction intervals for CAIDS-Q scores from 0 to 7 stratified by age

	Ages 6 to 7 years 11 months			Ages 8 to 11 years 11 months			Ages 12 to 18 years		
CAIDS-Q Score	**Predicted FSIQ**	**95% Prediction Interval lower**	**95% Prediction Interval upper**	**Predicted FSIQ**	**95% Prediction Interval lower**	**95% Prediction Interval upper**	**Predicted FSIQ**	**95% Prediction Interval lower**	**95% Prediction Interval upper**
0	64.38	23.68	105.07	49.74	18.467	81.01	47.42	23.90	70.95
1	68.38	27.84	108.91	56.76	25.58	87.94	53.52	30.06	76.98
2	72.38	31.94	112.82	63.78	32.67	94.89	59.61	36.19	83.02
3	76.38	35.97	116.80	70.80	39.72	101.88	65.70	42.31	89.10
4	80.39	39.94	120.84	77.82	46.75	108.90	71.80	48.41	95.18
5	84.39	43.83	125.00	84.84	53.74	115.95	77.89	54.49	101.29
6	88.39	47.67	129.12	91.86	60.69	123.03	83.98	60.54	107.42
7	92.40	51.43	133.36	98.88	67.62	130.14	90.07	66.58	113.57


Frequency
0
20
40
60
80
120
0
1
2
3
4
5
6
7
CAIDS-Q score