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# To what extent does *g* impact on conceptual, practical and social adaptive functioning in clinically referred children?

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## Abstract

*Background* Previous analyses have found variable results when evaluating the size of the association between intellectual ability and adaptive functioning in individuals with impaired function.
*Methods* We assessed the association between intellectual ability measured as a latent higher-order *g* and three different areas of adaptive functioning in a sample of clinically referred individuals with low IQ.
*Results* Regressing *g* on conceptual, practical and social adaptive functioning yielded standardised regression coefficients of 0.65, 0.60 and 0.51 respectively.
*Conclusions* Results suggests that even at low levels of ability, increments in *g* still have important consequences for human functioning. Further, the influence of *g* may not be equally strong across different areas of human functioning.

**Keywords** behavioural measurement methods, intellectual disability, learning disability, methodology in research

## Introduction

Adaptive functioning is an important clinical construct indexing the ability of a person to function effectively in the world (e.g. Tassé *et al.* 2012). In particular, it forms the basis for one of the three criteria for intellectual disability (ID). These criteria are significant limitations in intellectual functioning and adaptive behaviour, and childhood onset (Schalock *et al.* 2007). The first criterion makes clear the cognitive origin of the disability, while the second reflects that these cognitive deficits are manifested as difficulties in aspects of human functioning that affect everyday living.

Conceptually, intellectual and adaptive functioning are considered correlated but distinct constructs (Su *et al.* 2008). The consensus model of adaptive functioning is a three-dimensional model including practical, conceptual and social adaptive functioning (Tassé *et al.* 2012). Our understanding of ID can be enhanced by knowing how these three domains of adaptive functioning are (possibly differentially) related to intellectual functioning. Previous studies that have attempted to quantify the magnitude of this association have found variable results. Estimates of the correlation between adaptive functioning and intellectual ability have ranged from almost zero in some cases up to as high as 0.77 in others (e.g. Rozkowski & Bean 1980; Sparrow *et al.* 1984a,b; de Bildt *et al.* 2005). This variability can be attributed to several sources, the majority of which would tend to reduce the association meaning that on balance, empirical studies may be apt to underestimate the importance of intellectual ability for adaptive functioning.

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First, the association will be affected by type of sample utilised. The association will be very low in highly able samples because participants will be scoring at ceiling on the measure of adaptive functioning (e.g. Moss & Hogg 1997). For example, Sparrow *et al.* (1984a,b) reported correlations ranging from 0.07 to 0.36 between non-verbal intellectual ability as measured by the Kaufman Assessment Battery for Children (K-ABC; Kaufman & Kaufman 1938) and the domains of adaptive functioning measured by the Vineland adaptive behaviour scales in a sample of children who participated in the standardisation of the two instruments. The correlation between the instrument and full scale IQ measured by either the Wechsler Adult Intelligence Scale (WAIS: Wechsler 1955) or the revised edition (WAIS-R: Wechsler 1981) administered to a sample of adults with an ID ranged from 0.31 to 0.54 with the domains of adaptive functioning. The latter, more impaired sample, thus yielded a higher correlation between adaptive functioning and intellectual ability.

The correlation between intellectual ability and adaptive functioning can also be attenuated even in individuals with low ability due to range restriction arising from simultaneous selection on the constructs of interest in the analysis, that is, intellectual ability and adaptive functioning (e.g. see Sackett & Yang 2000). Samples including only individuals who have ID may, for example, yield attenuated associations relative to samples including some individuals with low IQ but without a diagnosis of ID. This is because ID diagnosis imposes simultaneous selection criteria whereby individuals receive the diagnosis only if they have both low adaptive functioning and low intellectual ability. This kind of selection can result in a lower correlation between these two constructs within the population of individuals who have an ID. Unless statistical corrections are made, empirical studies may, therefore, underestimate the association between intellectual ability and adaptive functioning if they base their analyses only on data from those with a diagnosis of ID. Restricting analyses to, for example, only participants who are in the mild or moderate or severe category without statistical correction may further attenuate the association. This may explain the relatively low correlations for those with a mild or moderate ID of 0.18 and 0.36 respectively reported by de Bildt *et al.* (2005).

The association could also be underestimated by sub-optimal psychometric operationalisations of intellectual ability. Previous studies have primarily used Full Scale IQ (FSIQ), a unidimensional scale score, to estimate intellectual ability (though see Su *et al.* 2008 for an exception). Contemporary models of intellectual ability, however, describe its structure as multilayered, with a structure that includes both a general ability factor (*g*) and more specific ability factors such as verbal ability, perceptual ability and spatial ability (Johnson & Bouchard 2005; McGrew 2009). Further, the use of an observed sum score conflates systematic and measurement error variance, which can downwardly bias associations of intellectual ability with external criteria. Specifying intellectual ability as a higher-order or bi-factor confirmatory factor model can address this issue (e.g. see Murray & Johnson 2013). This allows the associations of both a general factor (*g*) and specific ability factors (e.g. verbal ability, spatial ability etc.) with adaptive functioning to be investigated.

However, an additional complication is that the best validated and most commonly used measures of intellectual ability show substantial floor effects in individuals with an ID (Whitaker & Gordon 2012). That is, an individuals with a large range of abilities are given the same (minimum) scaled score of 1 because the test cannot differentiate different levels of ability below a certain level. Unfortunately, many individuals with an ID have ability levels below this threshold. Thus, the associations among subtests used to estimate *g* and specific abilities in a Confirmatory Factor Analysis (CFA) model may themselves be distorted by the poorer measurement properties of intellectual ability tests at low levels, particularly, when the sample are exclusively or primarily of low IQ. This will have a knock-on effect on the correlation between these ability factors and adaptive functioning. Floor effects are an issue that affect different intellectual ability assessments to different degrees. Thus, the specific choice of intellectual assessment can affect the extent to which it correlates with adaptive functioning.

Although floor effects and lower limits on the range of ability that can be measured cannot be addressed directly in the absence of measures of intellectual ability that extend into the lowest ranges of ability, it is possible to use a statistical proxy and

model the censoring that occurs at the minimum possible value on intellectual ability subtests (e.g. Muthén 1989).

The aim of the present study was to estimate the association between intellectual ability and conceptual, practical, and social adaptive functioning in ID, taking into account these different sources of variability in the association to the extent that this is possible. We therefore, estimate the effect of *g* on dimensions of adaptive functioning using a sample with a broader range of intellectual functioning from severe ID to no ID. We also use a higher-order model of intellectual ability to estimate *g* and a tobit model to account for the limited range of scores possible at the low end of currently available intellectual assessments.

## Methods

### Data collection

Pre-existing data were gathered from the case notes of children referred to child and adolescent mental health and ID services in four regions in Scotland on: intellectual ability as measured by the Wechsler Intelligence Scale for Children – Fourth Edition (WISC-IV: Wechsler 2003); adaptive functioning as measured by the Adaptive Behaviour Assessment System – Second Edition (ABAS-II: Harrison & Oakland 2003) parent/caregiver form for ages 5–21. The scale yields standardised scores for three subdomains: conceptual, practical and social and the full scale (the general adaptive composite score: GAC); age at assessment; gender; diagnosis of ID. Permission to collect the data was obtained from the Caldicott Guardians in each region.

### Participants

Data were collected for 510 children (338 boys, 169 girls, three for whom gender information was not available), 237 of whom had a diagnosis of ID. The mean age was 136.9 months (SD = 38.04). Age of assessment was missing for eight participants. In our sample, all case notes of children referred to seven services, from four out of 14 health board areas in Scotland were sampled. The services were chosen because they represented areas of Scotland ranging from predominantly rural to predominantly urban and geographical areas representing North, South and Central Scotland. Of the services, two were child ID services, two were child and adolescent mental health (CAMH) services and three services provided child ID and CAMH services within the same overarching service. Cases were included in the current research if information was available in the case notes in relation to: intellectual ability (as measured by the WISC-IV) and adaptive functioning (as measured by the ABAS-II). Not all cases were specifically referred for an assessment of ID, but all cases that were included had been assessed in relation to intellectual and adaptive functioning. Specific subsamples were used for different aspects of the analysis, as described in the following sections.

### Analysis

We used structural equation modelling to first establish a measurement model for *g* and then a full structural model to establish how *g* related to the three domains of adaptive functioning. Data from 456 participants that had WISC-IV subtest data were used for both models, even though this resulted in large proportions of missingness for the adaptive functioning variables as this was available for only 102 participants. This translated into covariance coverages (i.e. the percentage of cases available for a pair of variables) of only 22% for the three adaptive functioning variables.

We used maximum likelihood (ML) estimation to account for this missingness, because this allows the information in the observed cases about the missing cases to be utilised. This method yields unbiased parameter estimates and close to optimal type 1 errors in model rejection when data are missing completely at random (MCAR) or missing at random (MAR) (e.g. see Enders & Bandalos 2001). MCAR refers to the case where missingness on an outcome variable is independent of both the value of the outcome variable and the values of the other observed variables. MAR refers to the case where missingness on an outcome can be related to values on the other observed variables but not to the value of the outcome variable itself. Even when data are not missing at random (NMAR), ML still performs better than traditional methods of dealing with missing data because the bias tends to be isolated to

a subset of parameters, rather than affecting the entire model (Enders 2010). It is not possible to conduct a definitive of test the MAR assumption statistically; however, its tenability can be evaluated considering how the data were sampled and why a case might have missing data on either the WISC-IV subtests or adaptive functioning.

In the present study cases would not have been initially sampled for a number of reasons. In respect of child ID services, an individual may not have had information recorded in relation to intellectual and/or adaptive functioning if the person's level of ID was at such a level that formal assessment would not have been possible, but it would be clear that the person had ID, for example those with a profound ID. In respect of CAMH services, where an individual had been referred to the service for a reason that was unrelated to concern about ID or cognitive functioning, for example anxiety or depression, no assessment of intellectual or adaptive functioning would have been carried out. A common reason for adaptive functioning scores, specifically, to not be available in the current research would be if this was measured using an alternative measure of adaptive functioning such as the Vineland Adaptive Behavior Scales (Sparrow *et al.* 2005). This is unlikely to be related to an individual's level of adaptive functioning.

As a sensitivity check related to missingness in the current sample, we also report the parameter estimates from our structural model fit only to the subsample of 102 individuals with both adaptive functioning and intellectual ability data. This is small for structural equation modelling; however, necessary sample size depends on several features of the data and model. These were favourable for the present analysis as expected factor loadings were high and the size of the model not overly large (e.g. Jackson *et al.* 2013). Thus, the sample size is small but likely adequate for our analyses. However, as a further sensitivity check we also report the correlations based on observed scores, taking FSIQ as an estimate of *g*, again, in only the subsample of 102 individuals with adaptive functioning data.

We used robust ML as our estimation method to account for the skewed nature of the indicators, given that the sample was mostly scoring near the lower end of the scales. For scaling and identification, the first indicator of each first-order factor was fixed to 1.0 and the variance of the second-order *g* fixed to 1.0. Model fit was evaluated using Tucker-Lewis Index (TLI), comparative fit index (CFI), root mean square error of approximation (RMSEA). Models were judged to be of good fit when TLI and CFI values were >0.95 (Hu & Bentler 1999); RMSEA values were <0.08 (Schermelleh-Engel *et al.* 2003). All models were estimated in *Mplus 6.11* (Muthén & Muthén 2010).

### Measurement model for intellectual ability

Confirmatory factor analysis was used to establish an appropriate measurement model for intellectual ability. We adopted a model of *g* based on the proposed scoring structure of the WISC-IV (a higher-order model). Alternative measurement models based on the Cattell-Horn-Carroll (CHC) theory for the WISC-IV have been suggested and have received some empirical support. For example Keith *et al.* (2006) reported that a CFA model of the WISC-IV based on CHC theory was better fitting than one based on its scoring structure when analysing the WISC-IV standardisation data. We adopt the measurement model based on the scoring structure here because it has generally been shown to fit well in both clinical and non-clinical samples (Bodin *et al.* 2009; Chen *et al.* 2009). In addition, the CHC theory model is less parsimonious than the scoring structure model, and a less parsimonious model can appear to fit better than a more parsimonious model, even when the true model is the latter (Murray & Johnson 2013). We would not expect substantial differences in the correlations of *g* with the dimensions of adaptive functioning dependent on which of these alternative models is adopted, because in both models *g* is a dominant source of item variance. In addition, estimates of *g* are generally highly correlated across different models, provided that the model specification is sensible and the indicators are sufficiently diverse and large in number (e.g. Johnson *et al.* 2008).

### *g* as a predictor of conceptual, practical social and adaptive functioning

After establishing an appropriate measurement model for *g*, a full model was specified in which *g*

**Table 1** Descriptive statistics for intellectual ability and adaptive functioning variables

| Variable | *n* | Mean | SD | Min. | Max. |
|---|---|---|---|---|---|
| Vocabulary | 430 | 5.99 | 3.72 | 1 | 18 |
| Similarities | 430 | 7.12 | 4.03 | 1 | 19 |
| Comprehension | 422 | 5.99 | 3.77 | 1 | 19 |
| Block Design | 431 | 6.69 | 3.59 | 1 | 19 |
| Picture Concepts | 410 | 7.25 | 3.71 | 1 | 18 |
| Matrix Reasoning | 390 | 6.63 | 3.28 | 1 | 15 |
| Digit Span | 426 | 5.97 | 3.47 | 1 | 19 |
| Letter-Number Sequencing | 303 | 6.21 | 3.60 | 1 | 14 |
| Symbol Search | 393 | 6.51 | 3.46 | 1 | 19 |
| Coding | 426 | 5.85 | 3.44 | 1 | 19 |
| Conceptual | 102 | 62.13 | 17.84 | 5 | 120 |
| Social | 102 | 69.01 | 18.35 | 8 | 120 |
| Practical | 102 | 58.15 | 20.59 | 4 | 120 |

Intellectual ability scores are Wechsler Intelligence Scale for Children – Fourth Edition (WISC-IV) scale scores and adaptive functioning scores are Adaptive Behaviour Assessment System – Second Edition (ABAS-II) domain standard scores.

predicted the three domains of adaptive functioning: conceptual, practical and social. These were measured as single indicators and allowed to correlate in the model. We were utilising data from individuals at the low end of the intelligence continuum, therefore, we expected there to be substantial floor effects (Whitaker & Gordon 2012). As this could affect the correlation of *g* with the domains of adaptive functioning, we estimated a model in which the observed indicators of the measurement model for *g* were treated as censored from below, using a tobit model.

**Table 2** Pearson's correlations between the adaptive function components and Full Scale IQ (FSIQ)

| | *r* | df | *P* |
|---|---|---|---|
| Conceptual | 0.64 | 97 | <0.01 |
| Social | 0.56 | 97 | <0.01 |
| Practical | 0.64 | 97 | <0.01 |

FSIQ is measured on the Wechsler Intelligence Scale for Children – Fourth Edition (WISC-IV) and the adaptive functioning scores are measured as standard scores for the Adaptive Behaviour Assessment System – Second Edition (ABAS-II) domains.

## Results

Descriptive statistics are provided in Table 1 for the WISC-IV subtests and the adaptive functioning domains. As different WISC-IV subtests have different measurement scales, it is necessary to convert them on to the same scale for comparison and for creating index scores. This conversion is based on distributional information from the standardisation sample of the test and results in scaled scores for the subtests with a possible range from 1 to 19 with a population mean of 10 and standard deviation of 3. Full scale IQ scores have a population mean of 100 and standard deviation of 15 with a minimum value of 40. Adaptive functioning scores are standard scores for the three domains measured by the ABAS-II. These scores are constructed to have a mean of 100 and a standard deviation of 15.

The bivariate correlations between the adaptive function components and FSIQ based on observed scores are shown in Table 2. These suggested that conceptual, practical and social adaptive functioning are highly correlated with each other and with intellectual ability in our sample.

Fit statistics for the measurement model for *g*, estimated using robust ML estimation (Model 1), are provided in Table 3. The model was a good fit by all fit criteria. Figure 1 shows the full model including both the measurement model for intellectual ability and the adaptive functioning variables (Model 3). As numerical integration is required in

**Table 3** Model fit statistics

| Model | Satorra-Bentler $\chi^2$ | df | TLI | CFI | RMSEA (90% CI) | AIC | BIC |
|---|---|---|---|---|---|---|---|
| Measurement model for *g* (Model 1) | 112.29 | 31 | 0.95 | 0.97 | 0.08 (0.06–0.09) | 19 339.82 | 19 478.38 |
| *g* predicting adaptive functioning (Model 2) | 149.15 | 58 | 0.96 | 0.97 | 0.06 (0.05–0.07) | 21 773.30 | 21 922.94 |
| *g* predicting adaptive functioning accounting for censoring (Model 3) | – | – | – | | – | 21 124.62 | 21 314.25 |
| Model 1 in reduced sample | 45.97 | 31 | 0.96 | 0.97 | 0.08 (0.02–0.12) | 3 318.96 | 3 400.96 |
| Model 2 in reduced sample | 87.44 | 58 | 0.96 | 0.97 | 0.07 (0.04–0.10) | 5 709.80 | 5 830.55 |
| Model 3 in reduced sample | – | – | – | – | – | 5 500.22 | 5 620.97 |

TLI, Tucker-Lewis Index; CFI, comparative fit index; RMSEA, root mean square error of approximation; CI, confidence interval; AIC, Akaike Information Criteria; BIC, Bayesian Information Criteria.

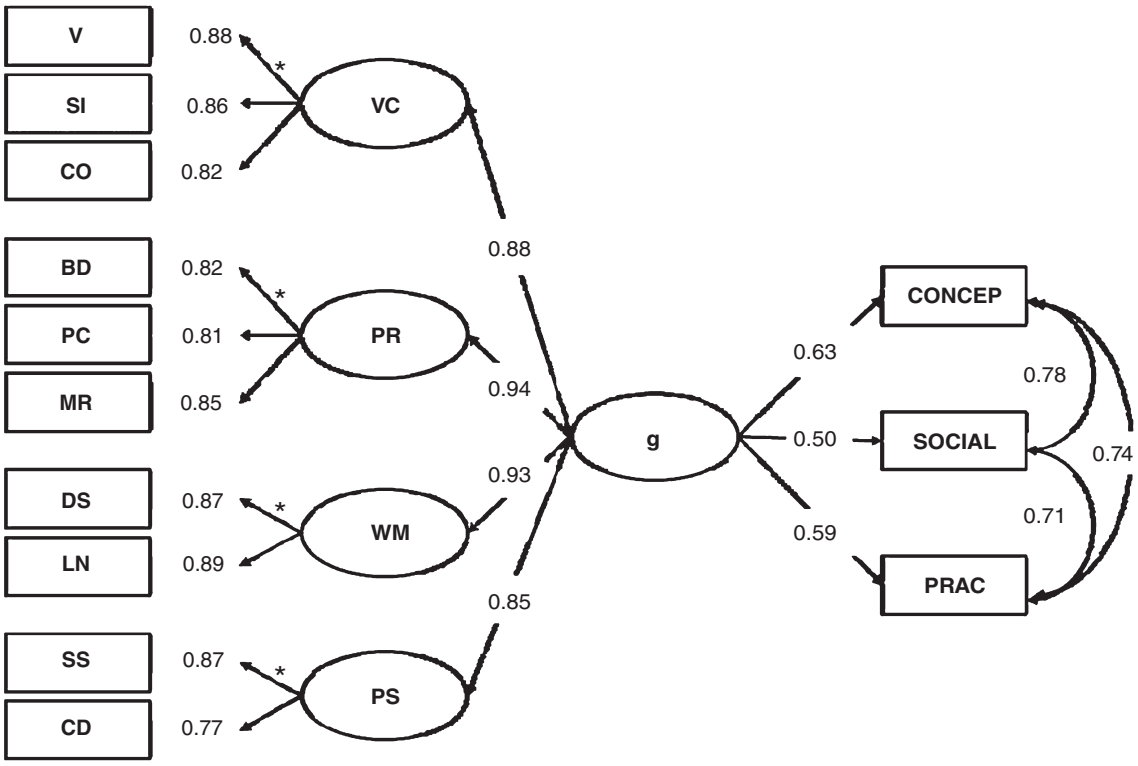


**Figure 1** Parameter estimates for Model 3: *g* as a predictor of conceptual, social and practical adaptive functioning. V, Vocabulary; SI, Similarities; CO, Comprehension; BD, Block Design; PC, Picture Concepts; MR, Matrix Reasoning; DS, Digit Span; LN, Letter-Number Sequencing; SS, Symbol Search; CD, Coding; VC, Verbal Comprehension; PR, Perceptual Reasoning; WM, Working Memory; PS, Processing Speed; CONCEP, Conceptual adaptive functioning; SOCIAL, Social adaptive functioning; PRAC, Practical adaptive functioning. For visual clarity we have represented the three observed adaptive functioning variables as directly predicted by *g*; however, technically, these are treated as single indicator latent variables and it is these latent variables that are predicted by *g*. Variables constrained for scaling and identification purposes are marked with an asterisk.

the estimation of this full model, absolute fit indexes are not available, but AIC and BIC for this model are reported in Table 3 and these can be compared with the model estimated using robust ML estimation but with no treatment of the censoring (Model 2) to get a sense of how good the absolute fit of Model 3 might be if it were possible to obtain absolute fit indexes. AIC and BIC for the measurement models of *g* are also reported for completeness. In Model 2, the standardised regression coefficients of *g* on conceptual, practical and social adaptive functioning were 0.71, 0.65 and 0.55 respectively. In Model 3, these parameters were 0.63, 0.59 and 0.50 respectively. In Model 2 estimated in the reduced sample of individuals with data on adaptive functioning, these paths were 0.67, 0.64 and 0.55 respectively. In Model 3 estimated in this reduced sample these paths were 0.62, 0.60 and 0.52 respectively.

## Discussion

In the present study, general intellectual ability (*g*) as estimated as a latent higher-order factor correlated reasonably strongly with different aspects of adaptive function, supporting the coherence of the ID construct and its diagnostic criteria. Conceptual functioning was most strongly related and social functioning least related to *g*. In content, the conceptual domain is closest to *g* in measuring skills traditionally considered to strongly reflect intelligence, for example items relating to reading and writing. In contrast, the social domain contains items on social relationships, emotion recognition and expression, which may have an affective basis that is independent of IQ (e.g. Rojahn *et al.* 1995).

The present study was not able to directly address some outstanding issues in the question of how *g* impacts on adaptive functioning at low levels of IQ. First, the WISC-IV is subject to floor effects (Whitaker & Gordon 2012). In the present study we used a statistical method, which attempts to account for the impact of censoring on parameter estimates; however, it is not a substitute for using measures of intelligence that span a fuller range of ability. In addition, it is important to note that the precise magnitude of the association between *g* and adaptive functioning will always be affected by the range of ability of participants. In fact, the sampling method and resulting cases sampled more generally can affect estimates. A simple random sample (or a statistical correction that successfully mimics this situation) from the population is the ideal in terms of achieving unbiasedness. In practice, however, simple random sampling is rarely achievable and instead researchers tend to rely on convenience samples (e.g. Hunt & Madhyastha 2008). If, as a result of non-random sampling, cases or partial data on cases are unobserved according to a missing not at random mechanism, this can lead to biased estimates of population parameters. In the present study, for example, we noted that there may be a higher probability of having completely or partially missing data on the variables of interest at the highest and lowest levels of adaptive functioning. This is because our sample was collected retrospectively from clinical services and from a clinical point of view, there is least utility in assessing the construct when ID is not suspected (at high levels) or when functioning is so low that conducting an assessment of adaptive functioning is not possible. This may account for some a small number of the missing adaptive functioning scores among the cases sampled in the present study. If this unobserved data were available and included in the analysis, it is possible that it would affect parameter estimates. However, the most common reason for missing adaptive functioning scores among the cases sampled was the use of an alternative measure of adaptive functioning to the ABAS-II and the choice of adaptive function measure is not likely to be related to adaptive functioning level. Thus, although a missing not at random data is possible, it is likely not the predominant reason for missing adaptive functioning data among the cases sampled.

On the assumption that our results are not substantially biased by the methodological challenges outlined above, the fact that intellectual ability was strongly related to adaptive functioning in this sample, using a robust model of *g* implies that, even at low levels of ability, increments in intelligence are predictive of important aspects of human functioning. In the normal range of intelligence, ability level is associated with educational, occupational and social success (Gottfredson 1997; Deary *et al.* 2007; von Stumm *et al.* 2010) and mortality (Calvin *et al.* 2011). While it can't be inferred on the basis of

general population results such as these that similar correlates exist in those with ID, the correlations of *g* with adaptive functioning, suggest that even at lower levels, differences in *g* are still important. For example, it is possible that differences in adaptive functioning partly mediate the association between intellectual ability and life expectancy in those with ID (Patja *et al.* 2000; Bittles *et al.* 2002).

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