Estimating Cognitive Gaps Between Indigenous and Non-Indigenous Australians*

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Abstract

Improving cognitive skills of young children has been suggested as a possible strategy for equalising opportunities across racial groups. Using data on 4-5 year olds in the Longitudinal Survey of Australian Children, we focus on two cognitive tests: the Peabody Picture Vocabulary Test (PPVT) and the 'Who Am I?' test (WAI). We estimate the test score gap between Indigenous and non-Indigenous children to be about 0.3 to 0.4 standard deviations, suggesting that the typical Indigenous 5 year-old has a similar test score to the typical non-Indigenous 4 year-old. Between one-third and two-thirds of the Indigenous/non-Indigenous test score gap appears to be due to socio-economic differences, such as income and parental education. We review the literature on test score differences in Australia, and find that our estimated gaps are lower than most of those found in the literature. This implies that the test score gap between Indigenous and non-Indigenous children may widen over the lifecycle, a finding that has implications for policies aimed at improving educational opportunities for Indigenous children.

Keywords: cognitive ability, racial differentials, early childhood
JEL Codes: I20, J15

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1. Introduction

In the domains of income, educational attainment, health and life expectancy, very large gaps separate racial groups in many countries. This is particularly true for Indigenous and non-Indigenous Australians, whose outcomes differ markedly on almost all social indicators. One factor that might underlie (or at least be correlated with) these differences in social attainment are differences in cognitive abilities. Since better performance on these tests is correlated with better outcomes later in life, it is possible that understanding the black/white test score gap in Australia will help reduce other social gaps.

In terms of educational achievement, Indigenous children have been shown to underperform non-Indigenous children in tests administered in grades 3, 5, 7 and 9 (Frigo et al. 2003; Commission for Children and Young People 2002; Rothman 2003). Across Australian states, Indigenous students are between 10 and 30 percent less likely to meet nationally agreed minimum acceptable standards of literacy and numeracy attainment (DEST 2002).

The Indigenous/non-Indigenous educational gap also extends beyond test scores. One in eight Indigenous Australians between 5 and 9 years of age never attend school or are frequently transient between schools (McGarrigle and Nelson 2006). Only 17% of Indigenous Australians have completed year 12, compared to 38% of non-Indigenous

Australians.[1] And Indigenous Australians also have significantly lower levels of post-secondary schooling than non-Indigenous Australians (DEST 2004).

Our aim is to contribute to this literature in two respects. First, we look at cognitive skills at very young ages, building upon work that has been done on investigating the black-white test score gap in the United States. And second, we ask to what extent these racial gaps can be explained by socio-economic differences. For example, do Indigenous Australians have lower scores merely because they are poorer?

To preview our results, we find that the gap in test scores between Indigenous and non-Indigenous children is about 0.3 to 0.4 standard deviations. The gap is slightly larger when using the 'Who Am I?' test (a test of school readiness) than when measured using the Peabody Picture Vocabulary Test (a test of language skills). The racial test score gaps are also slightly larger among girls than among boys. While these gaps are substantial, they fall towards the lower end of racial gaps that have been observed in other Australian studies. Controlling for socio-economic factors such as income and parental education reduces the Indigenous/non-Indigenous gap by between one-third and two-thirds.

The remainder of this paper is structured as follows. Section 2 reviews the literature on test score differences. Section 3 discusses the data. Section 4 presents findings on

[1] Since year 12 completion rates have been rising over time, and the Indigenous population is younger on average than the non-Indigenous population, this comparison understates the true gap in educational attainment between the two groups.

the size of the controlled and uncontrolled gaps, and the final section concludes.

2. Previous Research

In this literature review, we survey the available evidence how test score performance differs across racial and income groups. We first discuss the existing Australian studies, before turning to survey the more extensive UK and US literature, and then briefly discussing the issue of racial bias in testing.

2.1 Australian Studies

Several studies have analysed the test score gaps between Indigenous and non-Indigenous Australians. At the outset, therefore, it is useful to compile the results of these studies. Note that our focus here is on studies that look at test score gaps, measured by the difference in mean scores. Broader reviews of Indigenous education outcomes in Australia may be found in DEST (2002, 2003, 2005) and Mellor and Corrigan (2004).

We identified studies that showed the mean test score for Indigenous and non-Indigenous students, and the standard deviation for all students. Standardizing effect sizes in terms of standard deviations is a common approach in this literature, as it allows studies using differently scaled tests to be compared with one another. To

make this more concrete, it is useful to see how standard deviations translate into commonly used percentile measures. For example, assuming a normal distribution of test scores, a group that is 0.5 standard deviations below the mean would be at the 31st percentile, a group that is 1 standard deviation below the mean would be at the 16th percentile, and a group that is 1.5 standard deviations below the mean would be at the 7th percentile.

Alternatively, some readers may prefer to interpret our results on an IQ scale, where a difference of one standard deviation is equivalent to 15 IQ points. Since the mean for IQ tests is typically set at 100, a group that is one standard deviation below the mean would have an average IQ of 85.

The studies that we review in Table 1 are limited in two respects. First, we are unable to identify any studies that look at the test score gap beyond high school.[2] Second, since the studies do not typically provide standard errors on the gap, we are unable to say much about the precision with which they are estimated.[3] Nonetheless, all are based upon sample sizes of at least several thousand, and some are based on sample sizes over twenty thousand.

[2] Three possible studies that might be used to look at the test score gap among adults are the 1984 National Social Science Survey, the 1996 Survey of Aspects of Literacy, and the 2006 Adult Literacy and Life Skills Survey. Unfortunately, the 1984 survey is unusable because only 10 out of 2576 respondents were Indigenous, and the 1996 and 2006 surveys are unusable because the Australian Bureau of Statistics does not tabulate the results by Indigenous status, nor does it release Indigenous identifiers in the CURF microdata.

[3] These results are not adjusted for other demographic characteristics. For grade 7 gaps in Queensland, Bradley et al. (2007) include local area controls, and find that Indigenous students are 0.66-0.80 standard deviations below non-Indigenous students from an English-speaking background.

Table 1: Test score gaps between Indigenous and Non-Indigenous Children in Various Studies

Age at time of testing	Gap (standard deviations)	Sample	Study
4-5	0.3 for vocabulary 0.4 for school readiness	About 4000 children in the 2004 LSAC	Leigh and Gong (2008) *[This study]*
8-12	0.9 for years 3, 5 and 7 reading 0.8 for year 3 numeracy 1.0 for year 5 numeracy 1.2 for year 7 numeracy	About 3000 children in year 3; 27,000 in year 5; and 26,000 in year 7. All tested in Queensland in 2000.	Commission for Children and Young People (2002)
14-15	0.6-0.7 for reading 0.6 for mathematics	About 28,000 grade 9 students in the 1995 and 1998 Longitudinal Surveys of Australian Youth	Rothman (2002)
15-16	0.8 for reading 0.9 for mathematics 0.8 for science	About 5000 students aged 15-16 years in the 2000 PISA survey (Indigenous oversample)	De Bortoli and Cresswell (2004)

Note: Sample in Commission for Children and Young People (2002) is a 10 percent stratified random sample of Queensland children in grade 3, and all Queensland children in grades 5 and 7. Standard deviation in De Bortoli and Cresswell (2004) is based on the distribution across all participating countries. Standard deviation in Rothman (2002) is based on the distribution across five test cohorts. Standard deviation in Commission for Children and Young People (2002) is assumed to be 70, based on one of the authors' calculations with similar Queensland microdata (see Leigh 2007).

The results in Table 1 suggest that the test score gap between Indigenous and non-Indigenous children in Australia is between 0.3 and 1.2 standard deviations, with many estimates close to one standard deviation.

Apart from those listed above, one of the most thorough analyses of Indigenous educational outcomes in Australia is Zubrick et al. (2006). Since the authors look at the share of Indigenous and non-Indigenous children above certain benchmarks, their

results are not comparable to those shown in Table 1. But their study provides troubling evidence on three points. First, they show that in Western Australia, the Indigenous/non-Indigenous gap in student attainment (as measured by teacher ratings of students' educational performance) was similar in 1965-66 and 2001-04. Second, they provide evidence that on national tests, the gap widens between grade 3 and grade 7.[4] And third, they show that in terms of educational attainment, the disparity between Indigenous and non-Indigenous students is substantially greater in Australia than in Canada, New Zealand and the United States.

Another important Australian study is Bradley et al. (2007), who use microdata from Queensland students in grades 5 and 7, and demonstrate that the test score gap between English-speaking non-Indigenous students and Aboriginal students widens by 0.12 to 0.34 standard deviations per year. Since their study follows the same children, it provides important evidence that cohort effects are not responsible for the larger gaps in higher grades that other studies have observed.[5] Bradley et al. find similar gaps across male and female students, and across literacy and numeracy tests. They also note that Torres Strait Islander students tend to perform better on literacy and numeracy tests than Aboriginal students.

Other Australian studies have focused on the relationship between early-age test

[4] For further discussion on this point, see Stanley et al. (2005).

[5] The Indigenous/non-Indigenous test score gaps observed by Bradley et al. persist even after controlling for the average experience of teachers employed at the school, the total number of teacher hours per week for the school, and the size of the school. This suggests that to the extent that school quality affects the racial test score gap in Australia, it is not operating solely through these measures.

scores and socio-economic status. Najman et al. (1992) focused on results from the Denver Developmental Screening Test and the Peabody Picture Vocabulary Test. In a sample of around 3600 5-year old Brisbane children, they found a significant negative bivariate relationship between test scores and various socioeconomic indicators, including maternal education and family income. In subsequent work using a multiple regression framework, Najman et. al (2004) found that family income had stronger predictive power than other socioeconomic indicators, including maternal education. Similar results have been found for tests administered to 10-year old and 14-year old children (Rothman 2003).

2.2 International Studies

In the United States, a significant literature focuses on understanding the 'black-white test score gap'. Typically, studies find that the gap between blacks and whites, or between Hispanics and whites, is in the range of 0.5 to 1.0 standard deviations (Fryer and Levitt 2004, Jeanne Brooks-Gunn 2003, Jencks and Phillips 1998). In a meta-analysis of eight national surveys, conducted between 1965 and 1996, Phillips et al. (1998) find that the weighted black-white test score gap is 0.9 standard deviations for mathematics and reading, and 1.0 standard deviations for vocabulary.

In the United Kingdom, similar gaps have been observed (Gillborn and Mirza 2000, Gillborn 1997, Runneymede 1998, McNally and Blanden 2006). For example,

Demank (2000) reported that difference in GCSE attainment between blacks and whites was in the order of 0.5 of standard deviations in 1988, and 0.7 standard deviations in 1995.

Over the lifecycle, there is evidence that the US black-white test score gap grows larger. Fryer and Levitt (2004) show that from kindergarten to third grade, the black-white gap in mathematics grows from 0.6 to 0.9 standard deviations, and the black-white gap in reading grows from 0.4 to 0.8 standard deviations. On average, the black-white test score gap grows by 0.1 standard deviations per school year. Using administrative data from Texas, Hanushek and Rivkin (2006) find that the black-white test score gap increases from grades 3 to 8, though at a slower pace than that observed from kindergarten to third grade.

Other studies also find an increase in the black-white test score gap over the lifecycle (Phillips, Crouse and Ralph 1998; Carneiro and Heckman 2003). One possible factor may be a general divergence between high-performing and low-performing students (Beck, McKeown, and Kucan 2002.) As Hirsch (2003) has noted: ‘A high-performing first-grader knows about twice as many words as a low-performing one and, as these students go through the grades, the differential gets magnified. By 12th grade, the high performer knows about four times as many words as the low performer.’

In contrast to the Australian evidence, which suggests that the

Indigenous/non-Indigenous test score gap has remained relatively unchanged since the 1960s, US evidence suggests that the black-white test score gap in that country has narrowed over recent decades (Campbell, Hombo, and Mazzeo 2000; Carneiro and Heckman 2003; Neal 2004). Comparing cohorts born between 1948 and 1978, Phillips, Crouse and Ralph (1998) found that black-white gaps narrowed by 0.014 standard deviations per year for mathematics, 0.020 standard deviations for reading, and 0.010 standard deviations for vocabulary. For cohorts born after 1978, they find little evidence that the black-white test score gap has narrowed. Similarly, Lee (2002) reported that the back-white reading and mathematics gaps decreased by 0.2 to 0.5 standard deviations respectively for tests administered between 1971 and 1999.

While estimating the raw black-white test score gap has the virtue of simplicity, it would be a mistake to assume that this gap reflects the causal impact of race on test scores. For example, black children are likely to grow up with parents who are poorer and family income is negatively correlated with IQ (Duncan 1994; Duncan, Yeung, Brook-Gunn and Smith 1998). How much of the raw gap is due to controlling for these other factors? Most studies find that holding constant socioeconomic status reduces the gap by between one-third and one-half (Smith 1997; Mayer 1998; Duncan and Marginson 2005), with much of the reduction being due to the inclusion of parental income. However, as Duncan and Marginson (2005) point out, the inability to adjust for a full set of genetic factors means that these are probably an upper bound estimate on the effect of socioeconomic status.

2.3 Racial Bias in Testing

Jencks (1998) defines three types bias that may arise when psychometricians create and administer a test. *Labelling bias* arises when tests that are designed to measure a specific skill (eg. vocabulary) is mis-labelled as a measure of something else (eg. innate intelligence). *Content bias* is a consequence of using a biased measure to measure something that could be measured in an unbiased manner (eg. attempting to measure vocabulary skills in France and England using only a list of English words would be a form of content bias against the French children). *Methodological bias* arises if a test is administered in a manner that systematically disadvantages one particular group.

Discussing evidence on whether the Peabody Picture Vocabulary Test (PPVT) is biased against black American children, Jencks finds relatively little evidence in favour of either content bias or methodological bias. On the issue of content bias, he points out that if black and white children spoke distinct languages, then the PPVT should show a much larger gap for some words than others. Yet the available evidence suggests that black children learn the same words as white children, but at an older age. For example, Jensen (1980) found a 0.98 correlation between the share of white children who know a PPVT word and the share of slightly older black children who know the same word. On the issue of methodological bias, Jencks notes that the

evidence on whether the tester's race affects students' outcomes is mixed, but the impact is clearly small.

While evidence on test bias from the United States is useful, it is hardly conclusive. Unfortunately, we have not been able to locate any comprehensive studies of test score bias in the case of Indigenous children. One factor to bear in mind when interpreting our results is the fact that there exist distinct Indigenous languages. In the LSAC, 5 percent of Indigenous children (and 10 percent of non-Indigenous children) did not speak English at home. This is similar to the results from the 2001 Census, which found that 5 percent of Indigenous people aged 5-14 spoke an Indigenous language (AIATSIS 2005, 85). In the case of children for whom English is not a first language, a test of English vocabulary (such as the PPVT) will understate the child's overall language ability. While the contents of the 'Who Am I?' test (WAI) are not language-specific (de Lemos 2002), a version of the test that is administered in English is likely to disadvantage children who only speak an Indigenous language. Yet since 95 percent of Indigenous children in our sample speak English at home (a greater share than in the non-Indigenous sample), the use of Indigenous languages is unlikely to significantly bias the results.

3. Data Description

Data used for this analysis is drawn from Wave 1 of LSAC survey conducted in 2004. The Longitudinal Study of Australian Children (LSAC) gathers comprehensive, national Australian data on all the important domains of a child's life — their experiences within their families and communities, their health, their child care experiences, and the early years of their education for two cohorts of about 5,000 children who were aged 0-1 and 4-5. Here, we use the older sample of children, aged 4-5. LSAC provides substantial information covering various aspects of children's development, including health, motor skills, social competence, language, literacy, and numeracy. The survey also identifies whether a child is Indigenous, using the question 'Is the child of Aboriginal or Torres Strait Islander origin?'. (Although the survey allows us to separately identify Indigenous people as Aboriginal, Torres Strait Islander, or both, we do not pursue this approach given the small number of Torres Strait Islander children in our sample.[6])

Since our focus is on the Indigenous sub-sample within LSAC, it is useful to consider whether this group is representative of Indigenous children and their families. In a careful analysis of the Indigenous population in LSAC, Hunter (2006) points out that the survey's sampling frame probably under-sampled remote Indigenous populations, since it explicitly excluded postcodes that covered Indigenous land. Formal

[6] For children who are Torres Strait Islander, or both Aboriginal and Torres Strait Islander, we have only 14 observations with valid PPVT scores, and 22 observations with valid WAI scores.

comparisons of LSAC Indigenous respondents with Indigenous respondents in the 2002 National Aboriginal and Torres Strait Islander Survey and the 2002 General Social Survey yield few significant differences, but there is some suggestive evidence that the remote Indigenous sample is not perfectly representative of the target population. However, the urban Indigenous sample appears to be fairly representative of Indigenous Australian children living in major cities. In our analysis, we therefore present results that include all respondents, and those that exclude respondents living in remote areas (whether they are Indigenous or non-Indigenous). When interpreting our results, readers should bear in mind that the LSAC was not specifically designed for comparing Indigenous and non-Indigenous children, and our results are necessarily less precise than they might be if the survey included a larger (and more representative) sample of Indigenous children.

We use two measures of cognitive skills. The first is the Peabody Picture Vocabulary Test (PPVT), a measure of listening comprehension for spoken words in standard English, and a screening test for verbal ability. The main part of the test involves items presented in picture plates, arranged in a multiple-choice format. Children are asked to 'select the picture that best illustrates the meaning of the stimulus word presented orally by the examiner' (Dunn and Dunn 1997). The LSAC administers the PPVT-III Form IIA. The second test is the 'Who Am I?' test (WAI), an Australian-designed test that assesses a child's ability to perform ten tasks, covering copying, writing and drawing (ACER 1999). More information on the contents of the

two tests is provided in Appendix 1.

Table 2 shows summary statistics for Indigenous and non-Indigenous respondents. In total, there are 4,983 children in the sample, though not all took the PPVT and WAI tests. For those who took the tests, the mean score was 64 for both tests, and the standard deviation was 8. 51% of the studied children are boys and 83% are 4 year olds. 88% of children have siblings in the household and 47% of them have younger siblings in the household. 3% of the children are Indigenous and 90% of the full sample speak English at home. The children are from relatively young families; the average ages of mothers and fathers at the time when their children are aged 4-5 are 34 and 37 years, respectively. The average family income is $1305 per week. 16% of children are from single parent families. The education levels of the parents are also summarized in the table.[7]

Table 2 also shows summary statistics separately for Indigenous and non-Indigenous respondents. There are clear differences in the socio-economic characteristics of the two groups: Indigenous children tend to come from poorer families, they tend to have younger and less well-educated parents, and a higher share of Indigenous children are in remote areas. Appendix 2 provides further summary statistics; separating the sample into remote and non-remote respondents.

[7] Although our results control only for socioeconomic factors (and not behavioral variables), it is worth noting that there are also significant differences in – for example – the use of childcare. At the time of the second interview, 70 percent of the parents of non-Indigenous children had childcare arrangements, as compared with 55 percent of parents of Indigenous children.

Table 2: Summary statistics (standard deviations in parentheses)

	All		Indigenous		Non-indigenous	
Variable	**Mean**		**Mean**		**Mean**	
Peabody Picture Vocabulary Test score	64.052	(7.87)	61.760	(8.41)	64.127	(7.85)
'Who Am I?' test score	63.979	(7.97)	60.639	(7.28)	64.093	(7.97)
Dummy for child's Indigenous status	0.034					
Dummy, 1 if child is male	0.514		0.551		0.512	
Child's age at time of second interview	4.171	(0.38)	4.210	(0.41)	4.169	(0.38)
Dummy for child speaking English	0.898		0.949		0.896	
Birth weight (g)	3398.798	(586.79)	3327.478	(562.04)	3401.331	(587.56)
Dummy, 1 if sibling in household	0.883		0.949		0.880	
Dummy, 1 if younger sibling in household	0.471		0.565		0.470	
Family weekly income ($)	1304.931	(884.85)	870.592	(505.86)	1320.359	(891.52)
Dummy, 1 if both parents in the household	0.845		0.674		0.851	
Mother's age at time of second interview	34.449	(5.31)	31.822	(6.47)	34.541	(5.24)
Dummy, 1 if mother received higher education	0.280		0.081		0.286	
Dummy, 1 if mother received a certificate	0.268		0.341		0.266	
Dummy, 1 if mother received a diploma	0.088		0.052		0.090	
Dummy, 1 if mother did not finish year 12	0.216		0.422		0.208	
Father's age at time of second interview	37.284	(6.06)	35.406	(6.06)	37.339	(6.00)
Dummy, 1 if father received higher education	0.279		0.073		0.285	
Dummy, 1 if father received a certificate	0.383		0.479		0.380	
Dummy, 1 if father received a diploma	0.081		0.031		0.083	
Dummy, 1 if father did not finish year 12	0.159		0.396		0.152	
Dummy, 1 if in areas moderately accessible or worse	0.229		0.493		0.219	

4. Estimating Test Score Gaps

A straightforward way to see the raw test score gaps between Indigenous and non-Indigenous respondents is from the summary statistics for the PPVT and WAI tests in Table 2. On the PPVT test, Indigenous children score 2.3 points lower than non-Indigenous children. On the WAI test, Indigenous children score 3.5 points lower than non-Indigenous children. Since the standard deviation of both tests is about 8, the score gap can be converted into standard deviations by dividing by 8. Thus the raw gap is about 0.3 standard deviations for the PPVT test, and about 0.4 standard deviations for the WAI test.[8]

Figures 1 and 2 present kernel density plots of the test scores for Indigenous and non-Indigenous children. In both cases, the distribution of test scores for Indigenous children sits to the left of the distribution of test scores for non-Indigenous children, and the distribution of test scores is more dispersed for Indigenous children.

[8] On the PPVT test, there are 3647 non-Indigenous and 113 Indigenous children with non-missing test scores. On the WAI test, there are 3825 non-Indigenous and 130 Indigenous children with non-missing test scores.

Figure 1: Distribution of Peabody Picture Vocabulary Test Scores for Indigenous and Non-Indigenous Children

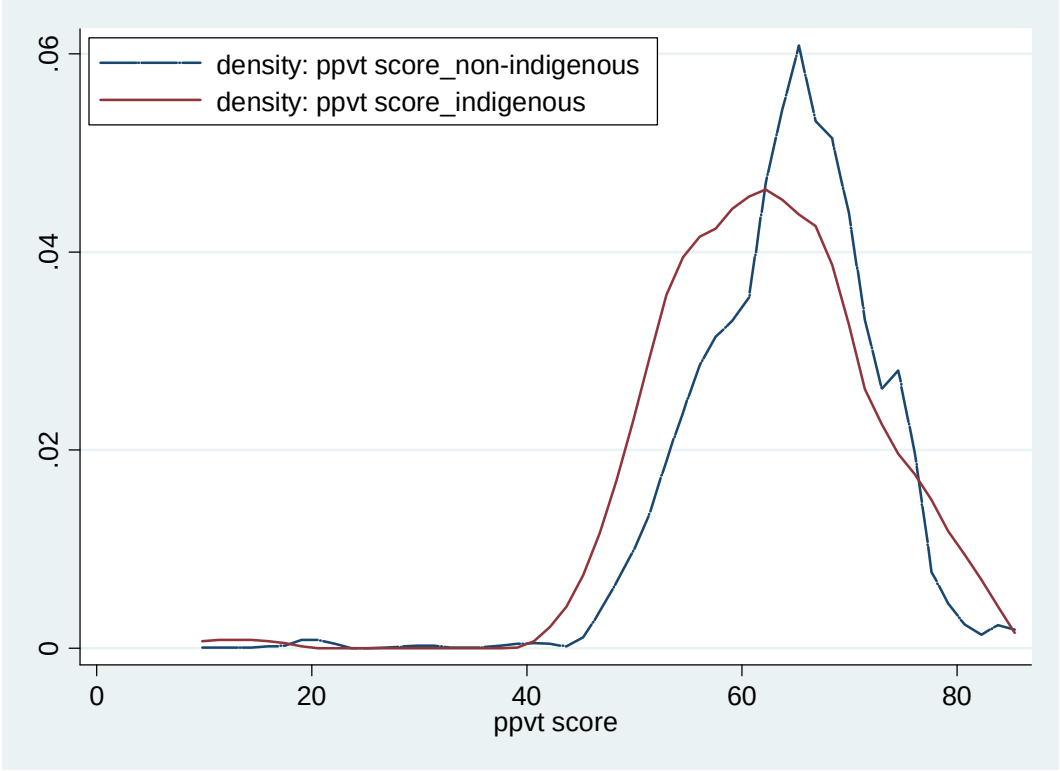
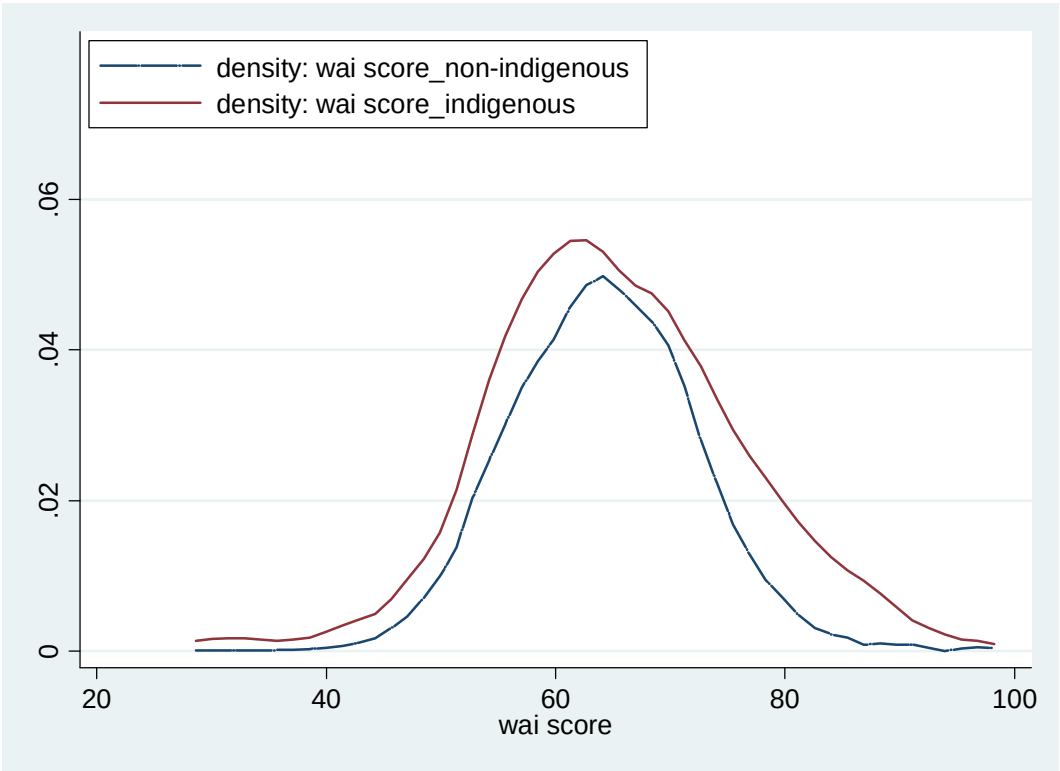


Figure 2: Distribution of *Who Am I?* Test Scores for Indigenous and Non-Indigenous Children



We caution that the test score gaps between Indigenous and non-Indigenous children should not be regarded as causal, since they may reflect other characteristics (such as income or parental education) that are correlated with both Indigenous status and test scores.

In what follows, we estimate a series of models, each of which follows a common pattern. In the first column, we estimate the relationship between test scores and Indigenous status, controlling only for the age and sex of the child. Since age and sex are (by assumption) uncorrelated with Indigenous status, we regard this first column as the 'raw' test score gap. In the second column, we include a control for family income. In the third column, we include a set of socioeconomic controls that may correlated with both Indigenous status and test scores: language spoken at home, having both parents present, parental education, mother's age, presence of siblings, and whether siblings are older or younger. In the fourth column, we add a control for child's birth weight (our rationale for adding this separately is that it may be either a confounding covariate or a channel through which Indigenous status affects student achievement). Lastly, in the fifth column, we exclude remote area respondents from the sample, due to the potential unreliability of the remote area Indigenous sub-population (see above).

Our regressions take the following form. Where y_i is the child's test score, the model is:

$$y_i = \alpha + x_i'\beta + \varepsilon_i \qquad (1)$$

Where $x_i^{'}$ is a vector of explanatory variables, α and β are parameters, and ε_i is the error term in the linear model. The coefficients in (1) give the marginal effect of the corresponding variables on the test score y_i, other things equal.

Tables 3 and 4 show the results using the two test scores. Overall, our models explain up to 18 percent of the variation in the PPVT, and up to 21 percent of the variation in the WAI test. In each case, controlling for the child's age and sex (column 1) makes no substantive difference to the raw gap shown in Table 3, which is 0.3 standard deviations for PPVT and 0.4 standard deviations for the WAI test.

One way of expressing the gap is in terms of percentiles. Assuming that test scores are normally distributed, these results imply that the typical Indigenous student is between the 34th and 38th percentile of the distribution. Alternatively, we can compare the Indigenous coefficient with the age coefficient, which is similar in size, and opposite-signed. This suggests that a typical Indigenous 5-year old has a similar level of performance on the tests to a typical non-Indigenous 4-year old.

How much of the observed gap is due to other characteristics that are correlated with both Indigenous status and test score outcomes? In the second column, we control for the log of family income, which decreases the Indigenous/non-Indigenous gap by 0.05

to 0.1 standard deviations.[9] In the third column, we add additional socio-economic controls. This has a greater impact on the gap for PPVT (which measures language skills) than WAI (which measures school readiness). With a basic set of socioeconomic controls, the Indigenous/non-Indigenous test score gap for PPVT becomes statistically insignificant, while the gap for WAI remains reasonably large and statistically significant. Focusing only on the point estimates, it appears that income and other socioeconomic controls explain about two-thirds of the language test score gap between Indigenous and non-Indigenous children, and about one-third of the school readiness test score gap.

In the fourth column, we add a control for birth weight. Although children who were born as heavier babies have higher test scores, we find that controlling for birth weight makes little difference to the Indigenous coefficient, compared to the specification in column 3.

Lastly, we exclude remote area respondents from our sample, so that the comparison is between Indigenous and non-Indigenous children in non-remote areas. This has little impact on the point estimate of the Indigenous/non-Indigenous test score gap (comparing columns 4 and 5, the PPVT gap grows wider, and the WAI gap shrinks), but does affect the precision of our estimates. When remote respondents are excluded, there is no statistically significant test score gap. However, this may reflect the weak

[9] Though note that this may not purely reflect the causal impact of income. For example, the income coefficient might also reflect an impact of parental employment on child outcomes.

statistical power of our test, rather than the absence of any underlying differences.

The results on other variables are also interesting in their own right. On both tests, girls score higher than boys: by about 0.1 standard deviations in PPVT, and by about 0.5 standard deviations in the WAI test. As mentioned above, 5-year olds outperform 4-year olds on both tests. Children from richer families and children who were born as heavier babies also do better.

To conserve space, we do not report the coefficients on the other controls (full results are available from the authors on request), but one that is worth noting is the coefficient denoting children from an English-speaking home. Children from an English-speaking home score 7 points higher on the PPVT than children from a non-English speaking home. But children from an English-speaking home score 2 points *lower* on the WAI than children from a non-English speaking home. This suggests that while children from a non-English speaking background have a substantially smaller vocabulary of English words, they are slightly better able to copy and draw.

In terms of vocabulary, where both Indigenous children and children from a non-English speaking background underperform, we can compare the magnitude of the two gaps. Our results suggest that the English-speaking/non-English speaking gap on the PPVT is three to eight times larger than the Indigenous/Non-Indigenous

gap.

Table 3: Scores on the Peabody Picture Vocabulary Test

	[1]	[2]	[3]	[4]	[5]
Indigenous	-2.384***	-1.526**	-0.867	-0.778	-0.965
	[0.747]	[0.737]	[0.709]	[0.707]	[0.939]
Male	-0.845***	-0.869***	-0.895***	-0.995***	-1.121***
	[0.261]	[0.257]	[0.243]	[0.244]	[0.276]
Age	2.099***	2.157***	2.349***	2.386***	2.471***
	[0.354]	[0.347]	[0.330]	[0.329]	[0.375]
Log family income		2.369***	0.890***	0.877***	0.675**
		[0.202]	[0.245]	[0.244]	[0.269]
Birth weight (grams)				0.001***	0.001***
				[0.000]	[0.000]
SES Controls	No	No	Yes	Yes	Yes
Include Remote Area Respondents	Yes	Yes	Yes	Yes	No
Observations	3580	3580	3580	3580	2747
R-squared	0.015	0.052	0.153	0.159	0.182
Indigenous Gap (SDs)	-0.3	-0.2	-0.1	-0.1	-0.1
95% Confidence Interval for Indigenous Gap (SDs)	-0.5,-0.1	-0.4,0.0	-0.3,0.1	-0.3,0.1	-0.4,0.1

Note: Standard errors in brackets. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively. SES controls are indicator variables for speaking English at home, having both parents present, presence of a sibling in the home, whether that sibling is younger, and being in a remote area, plus a quadratic in mother's age, four indicator variables for mother's education, and four indicator variables for father's education. Indigenous Gap is the Indigenous coefficient divided by the standard deviation for the combined group (7.87).

Table 4: Scores on the *Who Am I?* Test

	[1]	[2]	[3]	[4]	[5]
Indigenous	-3.500***	-2.930***	-2.010***	-1.929***	-1.221
	[0.655]	[0.653]	[0.651]	[0.649]	[0.880]
Male	-4.517***	-4.517***	-4.542***	-4.641***	-4.751***
	[0.234]	[0.232]	[0.228]	[0.228]	[0.261]
Age	5.362***	5.374***	5.397***	5.420***	5.790***
	[0.310]	[0.307]	[0.303]	[0.302]	[0.349]
Log family income		1.484***	0.589***	0.568**	0.430*
		[0.181]	[0.228]	[0.228]	[0.252]
Birth weight (grams)				0.001***	0.001***
				[0.000]	[0.000]
SES Controls	No	No	Yes	Yes	Yes
Include Remote Area Respondents	Yes	Yes	Yes	Yes	No
Observations	3955	3955	3955	3955	3052
R-squared	0.152	0.166	0.196	0.202	0.212
Indigenous Gap (SDs)	-0.4	-0.4	-0.3	-0.2	-0.2
95% Confidence Interval for Indigenous Gap (SDs)	-0.6,-0.3	-0.5,-0.2	-0.4,-0.1	-0.4,-0.1	-0.4,0.1

Note: Standard errors in brackets. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively. SES controls are indicator variables for speaking English at home, having both parents present, presence of a sibling in the home, whether that sibling is younger, and being in a remote area, plus a quadratic in mother's age, four indicator variables for mother's education, and four indicator variables for father's education. Indigenous Gap is the Indigenous coefficient divided by the standard deviation for the combined group (7.97).

In Tables 5-8, we separately analyse the Indigenous/non-Indigenous test score gap for boys and girls. For both the PPVT and WAI tests, we observe that the Indigenous/non-Indigenous test score gap is larger for girls than for boys. On the PPVT, the Indigenous gap (with only the age control) is 0.5 standard deviations for girls, and 0.2 standard deviations for boys. On the WAI, the Indigenous gap (with only the age control) is 0.5 standard deviations for girls, and 0.4 standard deviations for boys. In general, the gaps are statistically significant, with the exception of the PPVT gap for boys, which is not significant in any specification.

Overall, these results suggest that Indigenous girls have poorer language skills than non-Indigenous girls, and are less well prepared for school. By contrast, Indigenous boys are less well prepared for school than non-Indigenous boys, but do not underperform on vocabulary.

Table 5: Girls' Scores on the Peabody Picture Vocabulary Test

	[1]	[2]	[3]	[4]	[5]
Indigenous	-3.632***	-2.788**	-2.209**	-2.142**	-1.462
	[1.116]	[1.097]	[1.055]	[1.054]	[1.352]
Age	2.091***	2.072***	2.390***	2.364***	2.545***
	[0.506]	[0.495]	[0.472]	[0.471]	[0.538]
Log family income		2.418***	0.931***	0.910***	0.522
		[0.280]	[0.338]	[0.338]	[0.366]
Birth weight (grams)				0.001**	0.001**
				[0.000]	[0.000]
SES Controls	No	No	Yes	Yes	Yes
Include Remote Area Respondents	Yes	Yes	Yes	Yes	No
Observations	1748	1748	1748	1748	1344
R-squared	0.016	0.056	0.158	0.16	0.175
Indigenous Gap (SDs)	-0.5	-0.4	-0.3	-0.3	-0.2
95% Confidence Interval for Indigenous Gap (SDs)	-0.7,-0.2	-0.6,-0.1	-0.5,0.0	-0.5,0.0	-0.5,0.2

Note: Standard errors in brackets. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively. SES controls are indicator variables for speaking English at home, having both parents present, presence of a sibling in the home, whether that sibling is younger, and being in a remote area, plus a quadratic in mother's age, four indicator variables for mother's education, and four indicator variables for father's education. Indigenous Gap is the Indigenous coefficient divided by the standard deviation for the combined group (7.91).

Table 6: Boys' Scores on the Peabody Picture Vocabulary Test

	[1]	[2]	[3]	[4]	[5]
Indigenous	-1.353	-0.49	0.119	0.225	-0.692
	[1.006]	[0.995]	[0.960]	[0.956]	[1.315]
Age	2.101***	2.230***	2.223***	2.350***	2.334***
	[0.495]	[0.488]	[0.464]	[0.464]	[0.529]
Log family income		2.318***	0.885**	0.891**	0.902**
		[0.292]	[0.359]	[0.358]	[0.402]
Birth weight (grams)				0.001***	0.001***
				[0.000]	[0.000]
SES Controls	No	No	Yes	Yes	Yes
Include Remote Area Respondents	Yes	Yes	Yes	Yes	No
Observations	1832	1832	1832	1832	1403
R-squared	0.011	0.044	0.151	0.159	0.188
Indigenous Gap (SDs)	-0.2	-0.1	0.0	0.0	-0.1
95% Confidence Interval for Indigenous Gap (SDs)	-0.4,0.1	-0.3,0.2	-0.2,0.3	-0.2,0.3	-0.4,0.2

Note: Standard errors in brackets. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively. SES controls are indicator variables for speaking English at home, having both parents present, presence of a sibling in the home, whether that sibling is younger, and being in a remote area, plus a quadratic in mother's age, four indicator variables for mother's education, and four indicator variables for father's education. Indigenous Gap is the Indigenous coefficient divided by the standard deviation for the combined group (7.82).

Table 7: Girls' Scores on the *Who Am I?* Test

	[1]	[2]	[3]	[4]	[5]
Indigenous	-4.175***	-3.541***	-2.715***	-2.640***	-0.906
	[0.988]	[0.981]	[0.976]	[0.975]	[1.263]
Age	5.312***	5.265***	5.341***	5.318***	5.939***
	[0.445]	[0.440]	[0.434]	[0.433]	[0.492]
Log family income		1.707***	0.805**	0.784**	0.548
		[0.252]	[0.314]	[0.314]	[0.337]
Birth weight (grams)				0.001**	0
				[0.000]	[0.000]
SES Controls	No	No	Yes	Yes	Yes
Include Remote Area Respondents	Yes	Yes	Yes	Yes	No
Observations	1933	1933	1933	1933	1501
R-squared	0.076	0.098	0.136	0.138	0.153
Indigenous Gap (SDs)	-0.5	-0.5	-0.4	-0.3	-0.1
95% Confidence Interval for Indigenous Gap (SDs)	-0.8,-0.3	-0.7,-0.2	-0.6,-0.1	-0.6,-0.1	-0.4,0.2

Note: Standard errors in brackets. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively. SES controls are indicator variables for speaking English at home, having both parents present, presence of a sibling in the home, whether that sibling is younger, and being in a remote area, plus a quadratic in mother's age, four indicator variables for mother's education, and four indicator variables for father's education. Indigenous Gap is the Indigenous coefficient divided by the standard deviation for the combined group (7.70).

Table 8: Boys' Scores on the *Who Am I?* Test

	[1]	[2]	[3]	[4]	[5]
Indigenous	-2.954***	-2.467***	-1.552*	-1.483*	-1.568
	[0.874]	[0.875]	[0.878]	[0.873]	[1.232]
Age	5.408***	5.461***	5.433***	5.539***	5.749***
	[0.432]	[0.430]	[0.426]	[0.424]	[0.497]
Log family income		1.241***	0.31	0.303	0.255
		[0.262]	[0.335]	[0.333]	[0.381]
Birth weight (grams)				0.001***	0.002***
				[0.000]	[0.000]
SES Controls	No	No	Yes	Yes	Yes
Include Remote Area Respondents	Yes	Yes	Yes	Yes	No
Observations	2022	2022	2022	2022	1551
R-squared	0.076	0.086	0.118	0.13	0.141
Indigenous Gap (SDs)	-0.4	-0.3	-0.2	-0.2	-0.2
95% Confidence Interval for Indigenous Gap (SDs)	-0.6,-0.2	-0.6,-0.1	-0.4,0.0	-0.4,0.0	-0.5,0.1

Note: Standard errors in brackets. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively. SES controls are indicator variables for speaking English at home, having both parents present, presence of a sibling in the home, whether that sibling is younger, and being in a remote area, plus a quadratic in mother's age, four indicator variables for mother's education, and four indicator variables for father's education. Indigenous Gap is the Indigenous coefficient divided by the standard deviation for the combined group (7.57).

Finally, we estimated similar models using as the dependent variable the outcome indices derived by Sanson et al. (2005). These indices are created by converting variables into z-scores, averaging each student's z-scores, and re-scaling the index to a mean of 100 and a standard deviation of 10. Where a variable is missing for a child, the index is based on the mean of the non-missing variables.[10] An advantage of using these indices is that they provide one way of addressing the possibility that low-performing Indigenous children are overrepresented among those who do not take the PPVT and WAI tests. The results from specifications using outcome indices as the dependent variable (instead of test scores) are qualitatively similar to those from the PPVT and WAI tests, and are shown in Appendix 3. Notably, the racial gap observed using the Social Index and the Learning Index are quite similar, suggesting that cognitive and non-cognitive outcome gaps are quite similar in the early years. However, it is possible that this pattern may not hold in later years, and it is also conceivable that policy interventions may have differential effects on cognitive and non-cognitive skills (see eg. Heckman, Stixrud and Urzua 2006).

[10] One potential problem with this approach is that it increases measurement error for students with more missing values. Sanson et al. (2005) deal with this as follows: 'In cases where one or more z-scores in a sub-domain were missing, a sub-domain score was still obtained by taking the average of all the available z-scores. However, when averaging, the standard deviation of the mean score increases as the number of scores averaged decreases. Hence children with more missing data for a sub-domain would tend to have scores further from the average value, without this being a reflection of their actual outcomes. To correct for this, a variable was calculated for each sub-domain with more than one variable, indicating the number of variables missing for each case. … These variables were used as grouping variables to divide the file by level of missingness for each sub-domain. A standard deviation score was then obtained for each level of missingness, which was used to divide the sub-domain score. This method of standardisation corrects for the greater standard deviation obtained when averaging fewer z-scores, without disguising any mean differences present in the data.'

5. Conclusion

Cognitive test scores are important not only in their own right, but also because as they affect educational and labour market outcomes in later life. At the mean, a 1 standard deviation increase in test scores raises the probability that a person will complete year 12 by 25-30 percent (Ryan 2006). Holding constant educational attainment and a variety of socioeconomic factors, a 1 standard deviation increase in test scores lowers the probability that a person will be unemployed by about 1½ percentage points (Marks and Fleming 1998a). Conditional on being employed, and holding constant educational attainment, a 1 standard deviation increase in test scores raises hourly wages by 2-7 percent (Marks and Fleming 1998b).

Studies of the test score gap between Indigenous and non-Indigenous children in Australia have generally found the gap to be around one standard deviation. In this paper, we use tests of cognitive skills that are administered to four and five year old Australian children. We find that the Indigenous/non-Indigenous test score gap in the early years is smaller – only around 0.3 to 0.4 standard deviations. This implies that the typical Indigenous child has a test score that lies between the 34th and 38th percentile of the distribution. The Indigenous/non-Indigenous test score gaps tend to be larger among girls than boys.

The fact that our estimates are at the lower range of what has been found in other

studies (outlined in Table 1) suggests that the racial test score gap may widen over the lifecycle. This accords with other studies that have suggested that the Indigenous/non-Indigenous test score gap widens between grades 3 and 7. To the extent that this finding is robust, it implies that policies targeted at improving school outcomes in the early years may reduce the racial test score gap in Australia.[11]

Not all of the test score gap between Indigenous and non-Indigenous children should be regarded as being causal. On the PPVT (a test of language skills), about two-thirds of the racial test score gap appears to be due to differences in socio-economic factors. On the WAI test (a test of school readiness), about one-third of the racial gap is due to differences in socio-economic factors. From a social policy perspective, this implies that policies to improve incomes and parental education may partly close the Indigenous/non-Indigenous test score gap, but are unlikely to bring Indigenous children's test scores up to parity with non-Indigenous children.

[11] Of course, interventions focused on early years may also be effective (see eg. Wise et al. 2005). However, evidence that the test score gap widens during school years suggests that interventions targeted at school-age Indigenous children could well have a significant impact.

References

Australian Council for Educational Research (ACER) 1999. *Who Am I?* Camberwell, VIC: ACER

Australian Institute of Aboriginal and Torres Strait Islander Studies (AIATSIS) 2005. *National Indigenous Languages Survey Report 2005*. Canberra: DCITA.

Beck, I.L., McKeown, M.G., and Kucan, L. 2002. 'Bringing words to life: Robust vocabulary instruction', New York: Guilford Press

Bradley, S., Draca, M., Green, C. and G. Leeves (2007) 'The magnitude of educational disadvantage of indigenous minority groups in Australia', *Journal of Population Economics*, 20, 547-569.

Brooks-Gunn Jeanne, Klebanov Pamela K., Judith Smith, Greg J. Duncan, and Kyunghee Lee 2003. 'The Black-White Test Score Gap in Young Children: Contributions of Test and Family', *Applied Developmental Science,* 7(4), 239–52

Campbell, J.M., Hombo, C.M., and Mazzeo, J. 2000. NAEP 1999 Trends in Academic Progress: Three Decades of Student Performance, NCES 2000469.

Carneiro, P., and J. Heckman. 2003. 'Human Capital Policy,' NBER Working Paper 9495. NBER: Cambridge, MA

Commission for Children and Young People. 2002. *Children and Young People in Queensland: A Snap Shot*. Available at www.childcomm.qld.gov.au

de Lemos, M. 2002. 'Patterns of Young Children's Development: An International Comparison of Development as Assessed by Who Am I?', Human Resources Development Canada Research Paper R-02-5E, Gatineau, Quebec, Canada: Human Resources Development Canada.

De Bortoli, L and Cresswell, J. 2004. 'Australia's Indigenous Students in PISA 2000: Results from an International Study'. ACER Research Monograph No 59. Melbourne: ACER

Demack Sean, Drew David and Grimsley Mike. 2000. 'Minding the Gap: ethnic, gender and social class differences in attainment at 16, 1988-95', *Race Ethnicity and Education*, 3(2), 117-43

Department of Education, Science and Training. 2002. *The National Report to Parliament on Indigenous Education and Training 2001* DEST: Canberra, ACT

Department of Education, Science and Training. 2003. *The National Report to Parliament on Indigenous Education and Training 2002* DEST: Canberra, ACT

Department of Education, Science and Training. 2004. *Review Into the Impact of Abstudy Policy Changes That Came Into Effect in 2000*. Discussion Paper for Consultations, DEST: Canberra, ACT

Department of Education, Science and Training. 2005. *The National Report to Parliament on Indigenous Education and Training 2003* DEST: Canberra, ACT

Duncan G. J., Brooks-Gunn, J., Klebanov, P. K. 1994. 'Economic Deprivation and Early Childhood Development', *Child Development*, 65(2), 296-318

Duncan G. J., Brooks-Gunn Jeanne. 1997. 'The effect of poverty on children', *The Future of Children: Children and Poverty*, 7(2), 55-71

Duncan G. J., Brooks-Gunn, J. 2000. 'Welfare Reform and Child Development', *Child Development*, 71(1), 188-196

Duncan G. J. and Magnuson K.A. 2005. 'Can Family Socioeconomic Resources Account for Racial and Ethnic Test Score Gaps?', *The Future of Children*, 15(1), 35-54.

Dunn, L.M and Dunn, L.M. 1997. 'Peabody Picture Vocabulary Test – Third Edition. Technical Specifications'. Circle Pines, MN: American Guidance Services Inc

Frigo T., Corrigan M., Adams I., Hughes P., Stephens M. and Woods D. 2003, 'Supporting English literacy and numeracy learning for Indigenous students in the early years', ACER Research Monograph 57. ACER: Melbourne

Fryer R.G. and Levitt, S. D. 2004, 'Understanding the Black-White Test Score Gap in the First Two Years of School', *Review of Economics and Statistics,* 86(2), 447–64

Gillborn D. 1997. 'Ethnicity and Educational Performance in the United Kingdom: Racism, Ethnicity, and Variability in Achievement', *Anthropology and Education Quarterly,* 28(3), 375-393.

Hanushek, E.A. and Rivkin, S.G. 2006. 'School Quality and the Black-White Achievement Gap', NBER Working Paper No. 12651. NBER: Cambridge, MA.

Heckman, J.J., Stixrud, J. and Urzua, S. 2006. 'The Effects of Cognitive and Noncognitive Abilities on Labor Market Outcomes and Social Behavior' *Journal of Labor Economics*, 24: 411–482

Hirsch E.D. 2003. 'Reading Comprehension Requires Knowledge of Words and the World**.** Scientific Insights into the Fourth-Grade Slump and Stagnant Reading Comprehension', *American Educator*, Spring, 10-29

Hunter, B. 2006. 'Benchmarking the Indigenous Sub-Sample of the Longitudinal Survey of Australian Children: Implications for the Longitudinal Study of Indigenous Children' Unpublished Report, Centre for Aboriginal Economic Policy Research – Australian National University: Canberra.

Jencks, C. 1998. 'Racial Bias in Testing', in The Black-White Test Score Gap, in C. Jencks and M. Phillips (Eds.), *The Black-White Test Score Gap* Washington, DC: The Brookings Institution Press, 55-85

Jencks C. and Phillips M. (Eds.) 1998. *The Black-White Test Score Gap*, Washington, DC: Brookings Institution Press

Jensen, A.R. 1980. *Bias in Mental Testing*. New York, Free Press

Jones, L. V., N. Burton, and E. Davenport (1982), 'Mathematics Achievement Levels of Black and White Youth', Chapel Hill: University of North Carolina, L. L. Thurstone Psychometric Laboratory

Lee J. 2002. **'**Racial and Ethnic Achievement Gap Trends: Reversing the Progress Toward Equity?', *Educational Researcher*, 31(1), 3–12

Leigh, A. 2007. 'Estimating Teacher Effectiveness From Two-Year Changes in Students' Test Scores', *mimeo*, Australian National University.

McGarrigle, J. and Nelson, A. 2006. 'Evaluating a school skills programme for Australian Indigenous children: A pilot study' *Occupational Therapy International* 13(1): 1–20

McLoyd Vonnie C. 1990. 'The Impact of Economic Hardship on Black Families and Children: Psychological Distress, Parenting, and Socioemotional Development'**,** *Child Development*, 61(2), 311-346

McNally S. and Blanden J. 2006. 'Mind the gap: child poverty and educational attainment', *Poverty 123*

Marks, G. and Fleming, N. 1998a. 'Factors Influencing Youth Unemployment in Australia: 1980-1994', Research Report Number 7, Melbourne: Australian Council for Educational Research.

Marks, G. and Fleming, N. 1998b. 'Youth Earnings in Australia 1980-1994: A

Comparison of Three Youth Cohorts', Research Report Number 8, Melbourne: Australian Council for Educational Research.

Mayer S. E. 1998. 'What money can't buy', Harvard University Press, Cambridge, MA

Mellor, S. and Corrigan, M. 2004. *The Case for Change: A review of contemporary research on Indigenous education outcomes*. Australian Council for Educational Research. Melbourne: ACER

Najman J. M., Bor W., Morrison J., Anderson M. and Williams G. 1992. 'Child Developmental Delay and Socio-Economic Disadvantage in Australia: A Longitudinal Study', *Social Science and Medicine*, 34 (8), 829-835.

Najman, J.M., Aird, R., Bor, W., O'Callaghan, M., Williams, G.M., Shuttlewood, G.J. 2004. 'The generational transmission of socioeconomic inequalities in child cognitive development and emotional health', *Social Science and Medicine,* 58, 1147-1158

Petterson S. M. and Burke, A.A. 2001. **'**Effects of Poverty and Maternal Depression on Early Child Development', *Child Development*, 72(6), 1794-1813

Phillips, M., J. Crouse, and J. Ralph, 1998. 'Does the Black-White Test Score Gap Widen after Children Enter School?' in C. Jencks and M. Phillips (Eds.), *The Black-White Test Score Gap* Washington, DC: Brookings Institution Press, 229-272

Phillips M., Brooks-Gunn J., Duncan, G. J., Klebanov, P. and Crane, J. 1998. 'Family Background, Parenting Practices, and the Black-White Test Score Gap', in The Black-White Test Score Gap, in C. Jencks and M. Phillips (Eds.), *The Black-White Test Score Gap* Washington, DC: Brookings Institution Press, 103–45

Phillips, M. 2000. 'Understanding Ethnic Differences in Academic Achievement: Empirical Lessons from National Data', in D. Grissmer and M. Ross (Eds.), 'Analytic Issues in the Assessment of Student Achievement', Washington, DC: U.S. Department of Education, National Center for Education Statistics, 103–132

Rothman, S. 2002. 'Achievement in Literacy and Numeracy by Australian 14-Year-Olds, 1975-1998', LSAY Research Report Number 29, ACER, Melbourne.

Rothman, S. 2003. 'The changing influence of socioeconomic status on student achievement: recent evidence from Australia' Paper presented at the annual meeting of the American Educational Research Association, Chicago, 21-25 April 2003.

Runneymede Trust. 1998. 'The Black and Ethnic Minority Young People and Educational Disadvantage', London

Ryan, C. 2006. ‘School achievement effects on subsequent educational attainment: results from a policy-induced natural experiment’, *mimeo*, Australian National University.

Sanson, A., Misson, S., Wake, M., Zubrick, S.R., Silburn, S., Rothman, S. and Dickenson, J. 2005. *Summarising Children’s Wellbeing: The LSAC Outcome Index LSAC Technical Paper #2*. Australian Institute of Family Studies

Schifferes, S. 2002. ‘Poverty 'unchanged' under Labour’ http://www.news.bbc.co.uk/1/hi/business/2846463.stm

Smith J.R., Brooks-Gunn, J., and Klebanov P. K. 1997. ‘Consequences of Living in Poverty for Young Children's Cognitive and Verbal Ability and Early School Achievement’, in Greg J. Duncan, Jeanne Brooks-Gunn, *Consequences of Growing Up Poor*, Russell Sage Foundation

Stanley F., Richardson S. and Prior M. 2005. *Children of the Lucky Country?*, Macmillan: Sydney

White K. R. 1982. ‘The relation between socioeconomic status and academic achievement’, *Psychological Bulletin*, 91, 461–81

Wise, S., da Silva, L., Webster, E. and Sanson, A. 2005. ‘The efficacy of early childhood interventions’ Research report no.14, Melbourne: Australian Institute of Family Studies.

Zubrick SR, Silburn SR, De Maio JA, Shepherd C, Griffin JA, Dalby RB, Mitrou FG, Lawrence DM, Hayward C, Pearson G, Milroy H, Milroy J, Cox A. 2006. The Western Australian Aboriginal Child Health Survey: Improving the Educational Experiences of Aboriginal Children and Young People. Perth: Curtin University of Technology and Telethon Institute for Child Health Research. Volume III, Chapter 5. Available at http://www.ichr.uwa.edu.au/waachs/.

Appendix 1: Contents of the PPVT and WAI Tests

Peabody Picture Vocabulary Test

A technical document for the PPVT (Dunn and Dunn 1997) describes the test as follows:

> 'Like the first two editions, the PPVT-III is an individually administered, norm-referenced, wide-range measure of listening comprehension for spoken words in standard English and a screening test of verbal ability for ages 2-1/2 through 90+ years. It is available in two parallel forms, Form IIIA and Form IIIB. Each form contains four training items followed by 204 test items divided into 17 sets of 12 items each. The sets are progressively difficult. Each item has four simple, black-and-white illustrations on a Picture Plate or page arranged in a multiple-choice format. The examinee's task is to select the picture considered to best illustrate the meaning of a stimulus word presented orally by the examiner. Items are administered by sets, and basals and ceilings are established by sets. Once a set is begun, all items in that set must be administered. The Basal Set is the lowest set with 1 or no errors in a set; the Ceiling Set is the highest set with 8 or more errors in a set.'

A sample 'basal set' is: 'sawing, wrapping, cage, exercising, claw, fountain, nest, delivering, frame, envelope'.

A sample 'ceiling set' is 'surprised, knight, swamp, globe, raccoon, awarding, selecting, interviewing, vine, dilapidated'.

***Who Am I?* Test**

The Development Assessment Manual for the *Who Am I?* test (de Lemos and Doig 1999) states:

> 'The purpose of *Who Am I?* is to provide a picture of a child's development at the time of assessment. The various levels assigned to a child's individual responses provide a picture of development when these level values are totalled.'

The *Who Am I?* test involves the following ten exercises:

- copying a circle
- copying a cross
- copying a square
- copying a triangle
- copying a diamond
- writing numbers
- writing letters
- writing words
- writing a sentence
- drawing picture of self

Appendix 2: Summary Statistics by Remote Status

Table A1: Summary statistics (Indigenous children, standard deviations in parentheses)

Variable	Remote area		Non-remote area	
Peabody Picture Vocabulary Test score	62.715	(9.04)	60.974	(7.85)
'Who Am I?' test score	60.316	(6.66)	60.917	(7.82)
Dummy, 1 if child is male	0.574		0.529	
Child's age at time of second interview	4.279	(0.45)	4.143	(0.35)
Dummy for child speaking English	0.926		0.971	
Birth weight (g)	3388.147	(606.59)	3268.543	(512.59)
Dummy, 1 if sibling in household	0.941		0.957	
Dummy, 1 if younger sibling in household	0.662		0.471	
Family weekly income ($)	906.529	(527.32)	835.682	(485.35)
Dummy, 1 if both parents in the household	0.691		0.657	
Mother's age at time of second interview	31.212	(6.04)	32.406	(6.86)
Dummy, 1 if mother received higher education	0.106		0.058	
Dummy, 1 if mother received a certificate	0.348		0.333	
Dummy, 1 if mother received a diploma	0.015		0.087	
Dummy, 1 if mother did not finish year 12	0.470		0.377	
Father's age at time of second interview	35.102	(8.32)	35.723	(6.68)
Dummy, 1 if mother received higher education	0.061		0.085	
Dummy, 1 if mother received a certificate	0.551		0.404	
Dummy, 1 if mother received a diploma	0.020		0.043	
Dummy, 1 if mother did not finish year 12	0.327		0.468	

Table A2: Summary statistics (non-Indigenous children, standard deviations in parentheses)				
Variable	**Remote area**		**Non-remote area**	
Peabody Picture Vocabulary Test score	64.780	(7.58)	63.937	(7.91)
'Who Am I?' test score	63.368	(7.65)	64.298	(8.04)
Dummy, 1 if child is male	0.515		0.511	
Child's age at time of second interview	4.175	(0.38)	4.168	(0.37)
Dummy for child speaking English	0.968		0.876	
Birth weight (g)	3396.729	(585.88)	3402.624	(588.12)
Dummy, 1 if sibling in household	0.884		0.879	
Dummy, 1 if younger sibling in household	0.473		0.469	
Family weekly income ($)	1109.098	(651.97)	1379.704	(939.56)
Dummy, 1 if both parents in the household	0.837		0.657	0.856
Mother's age at time of second interview	33.405	(5.33)	34.860	(5.17)
Dummy, 1 if mother received higher education	0.198		0.311	
Dummy, 1 if mother received a certificate	0.333		0.247	
Dummy, 1 if mother received a diploma	0.070		0.095	
Dummy, 1 if mother did not finish year 12	0.239		0.200	
Father's age at time of second interview	36.428	(6.27)	37.590	(5.91)
Dummy, 1 if mother received higher education	0.154		0.320	
Dummy, 1 if mother received a certificate	0.493		0.349	
Dummy, 1 if mother received a diploma	0.071		0.086	
Dummy, 1 if mother did not finish year 12	0.186		0.143	

Appendix 3: Using Outcome Indices in Place of Test Scores

In Tables A3 to A5, we replicate our analysis using the overall, learning, and social outcome indices as the dependent variable. For details of the derivation of the indices, see Sanson et al. (2005). The standard deviation on all three indices is approximately 10, so the Indigenous/non-Indigenous gap can be calculated simply by dividing the Indigenous coefficient by 10.

Table A3: Test Score Gaps Using the Overall Index

	[1]	[2]	[3]	[4]	[5]
Indigenous	-5.669***	-4.436***	-3.459***	-3.377***	-2.263**
	[0.834]	[0.820]	[0.817]	[0.813]	[1.124]
Male	-3.485***	-3.487***	-3.515***	-3.657***	-3.583***
	[0.304]	[0.297]	[0.291]	[0.291]	[0.331]
Age	1.105***	1.133***	1.233***	1.271***	1.224***
	[0.404]	[0.394]	[0.388]	[0.386]	[0.443]
Log family income		3.218***	1.520***	1.493***	1.225***
		[0.233]	[0.292]	[0.291]	[0.321]
Birth weight (grams)				0.002***	0.001***
				[0.000]	[0.000]
SES Controls	No	No	Yes	Yes	Yes
Include Remote Area Respondents	Yes	Yes	Yes	Yes	No
Observations	4023	4023	4023	4023	3103
R-squared	0.045	0.088	0.127	0.135	0.128

Note: Standard errors in brackets. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively. SES controls are indicator variables for speaking English at home, having both parents present, presence of a sibling in the home, whether that sibling is younger, and being in a remote area, plus a quadratic in mother's age, four indicator variables for mother's education, and four indicator variables for father's education.

Table A4: Test Score Gaps Using the Learning Index

	[1]	[2]	[3]	[4]	[5]
Indigenous	-4.565***	-3.494***	-2.344***	-2.260***	-2.395**
	[0.826]	[0.816]	[0.810]	[0.806]	[1.121]
Male	-4.217***	-4.219***	-4.251***	-4.395***	-4.598***
	[0.301]	[0.296]	[0.289]	[0.288]	[0.330]
Age	2.226***	2.250***	2.417***	2.456***	2.775***
	[0.400]	[0.393]	[0.384]	[0.383]	[0.442]
Log family income		2.798***	1.018***	0.991***	0.634**
		[0.232]	[0.290]	[0.288]	[0.320]
Birth weight (grams)				0.002***	0.002***
				[0.000]	[0.000]
SES Controls	No	No	Yes	Yes	Yes
Include Remote Area Respondents	Yes	Yes	Yes	Yes	No
Observations	4023	4023	4023	4023	3103
R-squared	0.061	0.094	0.139	0.148	0.155

Note: Standard errors in brackets. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively. SES controls are indicator variables for speaking English at home, having both parents present, presence of a sibling in the home, whether that sibling is younger, and being in a remote area, plus a quadratic in mother's age, four indicator variables for mother's education, and four indicator variables for father's education.

Table A5: Test Score Gaps Using the Social Index

	[1]	[2]	[3]	[4]	[5]
Indigenous	-5.458***	-4.272***	-3.360***	-3.319***	-2.930**
	[0.848]	[0.836]	[0.833]	[0.832]	[1.149]
Male	-2.427***	-2.429***	-2.452***	-2.523***	-2.211***
	[0.309]	[0.303]	[0.297]	[0.298]	[0.338]
Age	0.051	0.077	0.12	0.138	-0.033
	[0.410]	[0.402]	[0.395]	[0.395]	[0.452]
Log family income		3.097***	1.526***	1.512***	1.436***
		[0.237]	[0.298]	[0.298]	[0.328]
Birth weight (grams)				0.001***	0.001**
				[0.000]	[0.000]
SES Controls	No	No	Yes	Yes	Yes
Include Remote Area Respondents	Yes	Yes	Yes	Yes	No
Observations	4023	4023	4023	4023	3103
R-squared	0.025	0.065	0.103	0.105	0.099

Note: Standard errors in brackets. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively. SES controls are indicator variables for speaking English at home, having both parents present, presence of a sibling in the home, whether that sibling is younger, and being in a remote area, plus a quadratic in mother's age, four indicator variables for mother's education, and four indicator variables for father's education.