

Exploring the association between IQ and differential life outcomes: results from a longitudinal sample of monozygotic twins

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Abstract

A large body of research has revealed that measures of IQ are highly predictive of a wide swath of life outcomes. However, most studies examining these associations have employed correlational statistical techniques which tend to confound environmental and genetic influences. The current study addresses this gap in the literature by making use of a monozygotic twin difference scores approach to explore the association between IQ and a variety of outcome measures, including general health, substance use, relationships, sexual behaviors, educational attainment, economic well-being, and criminal justice contacts. Analysis of monozygotic twin pairs from the National Longitudinal Study of Adolescent Health (Add Health) revealed that between-twin differences in IQ have little effect on the majority of the examined outcome measures. The implications of these findings and suggestions for future research are discussed.

Keywords: Add Health, IQ, Life outcomes, MZ difference scores, Twins.

Explorando a associação entre QI e diferentes desfechos de vida: resultados de uma amostra longitudinal de gêmeos monozigóticos

Resumo

Um grande número de pesquisas tem revelado que as medidas de QI são altamente preditivas de uma ampla faixa de desfechos de vida. No entanto, a maioria dos estudos que examinam essas associações tem empregado técnicas estatísticas correlacionais que tendem a confundir influências ambientais e genéticas. O presente estudo aborda esta lacuna na literatura através do uso de uma abordagem de pontos de diferença entre gêmeos monozigóticos para explorar a associação entre QI e uma variedade de resultados medidos, incluindo saúde geral, uso de drogas, relacionamentos, comportamento sexual, nível educacional, bem-estar econômico e ligação com justiça criminal. A análise de gêmeos monozigóticos do *National Longitudinal Study of Adolescent Health (Add Health)* revelou que, entre gêmeos, as diferenças de QI têm pouco efeito sobre a maioria dos resultados examinados. As implicações dessas descobertas e sugestões para futuras pesquisas são discutidas.

Palavras-chave: Add Health, QI, Desfechos de vida, Pontos de diferença MZ, Gêmeos.

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Explorando la asociación entre CI y diferentes desenlaces de vida: resultados de una muestra longitudinal de gemelos monocigóticos

Resumen

Un gran número de investigaciones ha demostrado que las medidas de CI son altamente predictivas de una amplia franja de vidas resultantes. Sin embargo, la mayoría de los estudios que analizan estas asociaciones han empleado técnicas estadísticas de correlación que tienden a confundir las influencias ambientales y genéticas. El presente estudio está direccionado a esta laguna en la literatura haciendo uso de un abordaje de puntos de diferencias de gemelos monocigóticos para explorar la asociación entre coeficiente intelectual y una gran variedad de resultados medidos, incluyendo la salud general, el uso de drogas, relaciones, comportamientos sexuales, el nivel educativo, el bienestar económico, y contactos con la justicia penal. El análisis de parejas de gemelos monocigóticos del *National Longitudinal Study of Adolescent Health (Add Health)* reveló que, entre gemelos, las diferencias de CI tienen poco efecto en la mayoría de los resultados examinados. Se discuten las implicaciones de estos hallazgos y se dan sugerencias para futuras investigaciones.

Palabras clave: Add Health, CI, Desenlaces de la vida, Puntos de diferencia de MZ, Gemelos.

Introduction

A wide range of IQ measures have been found to be robust predictors of an array of social, behavioral, and general-life outcomes. Extensive lines of research have identified a direct or indirect association between IQ scores and various outcomes that range from epidemiological factors (Batty, Deary, & Gottfredson, 2007) to delinquent behavior (Moffitt & Silva, 1988; Lynam, Moffitt, & Stouthamer-Loeber, 1993) to economic well-being (Zagorsky, 2007). In addition to the predictive ability of IQ scores, a large number of studies have found IQ to be relatively stable over the life course (Deary, Strand, Smith, & Fernandes, 2007; Deary, Whalley, Lemmon, Crawford, & Starr, 2000). Studies have also examined the factors that explain variation in IQ measures in general. Findings from these studies have revealed that genetic factors play a direct role in creating variation in IQ for children, adolescents, and adults (Bouchard & McGue, 1981; McCartney, Harris, & Bernieri, 1990; Posthuma, De Geus, Bleichrodt, & Boomsma, 2000). Collectively, these results indicate that between 30 and 80 percent of the variance in IQ can be explained by genetic differences (Deary, Johnson, & Houlihan, 2009; van der Sluis, Willemsen, de Gues, Boomsma, & Posthuma, 2008), with the influence of heritability increasing with age (Bartels, Rietveld, Van Baal, & Boomsma, 2002; Bergen, Gardner, & Kendler, 2007).

Based on these findings, genetic and environmental factors need to be taken into

account when attempting to examine the potential effects of IQ. One methodological approach that can be used to control for the potentially confounding influence of genetic and environmental factors is the monozygotic (MZ) difference scores approach. The MZ difference scores approach allows researchers to control both genetic and shared environmental influences by using MZ twin pairs to examine *unique* environmental differences between twins, commonly known as nonshared environmental influences. Since MZ twins are genetically identical and typically reared in the same household by the same parents the only factors that can influence differences in outcomes between them are environmental factors that are *unique* for each twin. By examining differences between twins, researchers are able to isolate the effect of child-specific factors, net of the effect of genetics and environmental factors that are shared by both twins. While this method cannot establish causality, it appears to be one of the best alternatives to a true experimental design (Vitaro, Brendgen, & Arseneault, 2009). The current study employs the MZ difference scores approach to estimate the influence of between-twin differences in IQ on a range of outcome measures germane to adulthood.

IQ and behavioral outcomes

A wealth of research that spans multiple disciplines has examined the potential influence that IQ has on virtually every single phenotype that can be measured. While a complete review

of the studies examining the effects of IQ on these phenotypes is beyond the scope of the current study, it is possible to loosely group these studies into six general categories: those that examine health-related outcomes, those that examine alcohol use, those that examine sexual behaviors, those that examine educational outcomes, those that examine economics/wealth, and those that examine criminal justice outcomes. Below, we provide a very brief overview of the literature bearing on the nexus between IQ and these various outcome categories.

First, an emerging field of research, referred to as cognitive epidemiology, has generated empirical evidence bearing directly on the association between IQ and general health (Deary, 2009). One of the more consistent findings to emerge from this line of inquiry is the robust association between IQ scores and all-cause mortality (Deary & Batty, 2006). Studies have identified a well-specified negative stepwise association in which lower levels of IQ significantly predict higher risk of mortality (Batty, Deary, & Gottfredson, 2007; Batty, Wennerstad et al., 2009). Additional studies have attempted to identify factors that may mediate the relationship between IQ and mortality. Such studies have found a negative association between early IQ scores and risk of developing a number of health related risk factors such as high blood pressure (Batty, Deary, Schoon, & Gale, 2007; Starr et al., 2004), cardiovascular disease (Batty, Deary, Benzeval, & Der, 2010; Batty, Shipley et al., 2009), obesity (Chandola, Deary, Blane, & Batty, 2006), and cancer (Batty, Shipley et al., 2009). Taken together, the results generated from this line of research have highlighted the connection between IQ and health-related outcomes.

Second, IQ has also been found to be a significant predictor of alcohol use and abuse. A number of studies have found that childhood IQ is negatively associated with age at onset of drinking (Fleming, Kellam, & Brown, 1982) and the prevalence of alcohol induced hangovers (Batty, Deary, & Macintyre, 2006). Other studies have reached mixed conclusions in regards to overall alcohol intake (Batty et al., 2008), heavy alcohol consumption (Mortensen, Sorensen, & Gronbaek, 2005), and toxic levels of alcohol consumption (Wennberg, Andersson, & Bohman, 2002). These mixed findings have been attributed to small sample sizes and highly

selective research samples (Batty et al., 2008). While the evidence is not clear-cut regarding the link between IQ and alcohol use/abuse, there appears to be enough supporting evidence to warrant further examination.

Third, IQ has been shown to be associated with risky sexual behaviors. Specifically, a large number of studies have found that adolescents with higher IQ scores tend to have sexual intercourse for the first time later in life compared to adolescents with lower IQ scores (Halpern, Joyner, Udry, & Suchindran, 2000; Harden & Mendle, 2011). Other studies have indicated that adolescents with lower IQ scores experience a higher risk of contracting sexually transmitted diseases than their higher IQ counterparts (Cheng & Udry, 2005; von Ranson, Rosenthal, Biro, Lewis, & Succop, 2000) and are more likely to become pregnant at an early age (Shearer et al., 2002). These findings suggest that IQ may play a role in affecting the propensity to engage in risky sexual behaviors.

The fourth area of research has examined the impact of IQ on educational achievement. Not surprisingly, this line of research has produced unequivocal evidence of a strong positive association between IQ and highest level of education achieved (Caspi, Wright, Moffitt, & Silva, 1998; Herrnstein & Murray, 1994; Jensen, 1999). This association remains significant even after controlling for socioeconomic factors (Colom & Flores-Mendoza, 2007; Nagoshi & Johnson, 2005; Thienpont & Verleye, 2004) and other potentially confounding environmental factors (Fergusson, Horwood & Ridder, 2005; Jensen, 1999).

Fifth, previous empirical research has found a positive relationship between IQ and financial success (Brown & Reynolds, 1975; Fergusson et al., 2005; Herrnstein & Murray, 1994; Caspi et al., 1998; Zagorsky, 2007), perhaps because of the positive association between IQ and education. Somewhat controversially, however, some scholars have also made the argument that nation-to-nation differences in economic growth and wealth is the result of IQ differences across nations (Lynn & Vanhanen, 2002). The key point, though, is that IQ most likely plays a prominent role in determining financial well-being as well as income.

Sixth, there has been a significant amount of attention focused on the potential association

between IQ and criminal involvement. Empirical research has been consistent in revealing that IQ is negatively associated with various measures of crime, delinquency, and antisocial behavior. For example, findings have revealed that, on average, delinquent juveniles and criminals score significantly lower on IQ tests than non-delinquents and non-criminals (Herrnstein & Murray, 1994; Kandel et al., 1989; Kratzer & Hodgins, 1999; Wilson & Herrnstein, 1985). Recently, however, studies using youth cohorts from New Zealand have found that IQ was largely unrelated to later offending, arrests, and criminal convictions (Fergusson et al., 2005; Moffitt et al., 2011). Specifically, the association between IQ and adult criminal outcomes was not significant after controlling for early childhood behavioral problems and family background. These recent results seem to indicate that any relationship between IQ and contact with the criminal justice system may be the result of confounding environmental factors.

The current study

The current study adds to the extant literature examining the effects of IQ on various outcome measures in two important ways. First, the current study examines the effects of IQ on a wide range of life outcomes that span from adolescence to adulthood. Second, the current study employs an MZ difference scores methodology to help isolate the effects that between-twin differences in IQ have on between-twin differences on each of the examined outcome measures. To do so, we analyze a sample of MZ twin pairs drawn from the National Longitudinal Study of Adolescent Health (Add Health).

Methods

Sample

The Add Health study is a longitudinal and nationally representative sample of American youths who were enrolled in grades seven through 12 during the 1994-1995 school year (Udry, 2003). Four waves of data were collected over the span of 14 years. The first wave, collected in 1994, included approximately 90,000 youths from 52 middle schools and 80 high schools that were selected using multistage stratified sampling techniques. Self-report questionnaires were completed in school by the youths and included questions

about the adolescents' social and family lives, scholastic achievements, and involvement in different activities. In order to gather more detailed information about some of the respondents, a subsample of 20,745 youths and 17,700 of their primary caregivers (typically the mother) also completed an in-home questionnaire. The wave 1 in-home interview garnered information from the respondent and his or her caregiver on such issues as drug and alcohol use, romantic and sexual relationships, personality traits, and cognitive abilities, among others (Harris et al., 2003).

The second wave of data collection commenced in 1996 when questionnaires were administered to 14,738 of the adolescents who were interviewed during the first wave. The topics and issues covered in the second wave of questionnaires were similar to the first wave as the participants were still predominantly adolescents. Between 2001 and 2002, the third wave of questionnaires was provided to 15,197 respondents. Given that the majority of the youth had now entered early adulthood the questions in the third wave covered age-appropriate topics such as marriage, employment history, sexual history, and contact with the criminal justice system. The final wave of data collection occurred in 2007-2008 when respondents were between 24 and 34 years old. The items in the wave 4 questionnaires covered numerous aspects of adult life including diagnoses of diseases, drug and alcohol use, relationship and sexual history, family status, educational attainment, religious practices, and income (Harris et al., 2003).

A significant advantage of the Add Health study is that siblings were oversampled for inclusion in the sample. This sampling process netted more than 3,000 kinship pairs, including twin pairs, half-sibling pairs, and full sibling pairs. Importantly, the demographic characteristics of the sibling pairs sample did not differ substantively from the overall nationally representative sample (Jacobson & Rowe, 1998). The final analytical sample was restricted to 289 MZ twin pairs ($N = 578$ individual MZ twins) nested within the sibling pairs sample.

Measures

IQ

At the beginning of the wave 1 in-home interview, respondents completed an abridged

version of the Peabody Picture Vocabulary Test - Revised (PPVT-R). The test involved the respondent choosing an illustration, from a set of four, that best matched a word read aloud by the interviewer. The test included 78 different items and the raw scores were standardized by age. Importantly, researchers have employed this measure as a method of tapping respondent IQ in past analyses using the Add Health data (Beaver & Wright, 2011; Rowe, Jacobson, & Van den Oord, 1999).

Outcome measures

Health-related behaviors

Three measures of health derived from the Wave 4 interview were included in the current study. First, respondents were asked to report their perception of their own health in general. This single item was reverse coded such that 1 = poor, 2 = fair, 3 = good, 4 = very good, and 5 = excellent. Second, respondents were asked to indicate how often they ingested fast food and non-diet soda beverages during the week preceding the interview. Responses to these two items were summed to form the bad diet index ($r = .235$, $p = .000$) where higher values indicate greater consumption of fast food and high-sugar beverages. Third, a measure of mental health based on an item which asked respondents to indicate if they had ever been diagnosed by a nurse, doctor, or other medical professional as having depression was included. The depression item was coded dichotomously such that 1 = yes and 0 = no.

Alcohol & drug use

Two measures of drug and alcohol use from wave 4 were included in the current study. First, an index tapping alcohol use was created by summing two questions that asked how many days in the past year respondents drank five or more drinks in a row (four or more drinks in a row if the respondent was female) and how many days in the past year they were drunk or high on alcohol. Responses to these items were summed to form the heavy alcohol use index ($\alpha = .850$) where higher scores indicate more frequent alcohol use. Second, drug use by respondents at wave 4 was captured by an illicit drug use index which was created by summing five dichotomous items asking respondents if they had ever used cocaine, crystal meth, marijuana, steroids, and/or other types of illegal drugs. Higher scores on the illicit drug use index ($\alpha = .897$)

indicate more varied use of illegal drugs.

Relationships, sexual behavior, & family

We included six measures of social relationships, sexual behavior, and family outcomes from wave 4. To tap social relationship outcomes, we employed two measures. First, we included a continuous item which asked respondents to indicate the number of sexual or romantic partners they were involved with at the time of data collection. Second, we included a categorical item indicating the respondent's dissatisfaction with his/her current relationship (1 = very happy, 2 = fairly happy, 3 = not too happy).

In terms of sexual behavior outcomes, we included two different measures. The first sexual behavior measure is derived from three items which asked respondents if they ever had vaginal, oral, or anal sex. Responses to these dichotomous items were summed to create the sexual activity index ($\alpha = .395$), where higher scores indicate more varied sexual experiences. The second sexual behavior measure is a continuous item which represents the total number of partners with whom the respondent has had vaginal intercourse. Higher values of this measure indicate a greater number of past sexual partners.

In order to explore differential outcomes in family related items we included two different measures of family outcomes from wave 4. First, we included a continuous item to which respondents provided the total number of times they were, or got someone else, pregnant. Second, we created a continuous measure based on four items tapping the extent to which the respondent was dissatisfied as a parent. Respondents who reported having a child indicated their level of agreement, on a five-point scale, with the assertions that they were happy in their role as a parent (reverse coded), felt close to their child (reverse coded), saw their child as a major source of stress, and felt overwhelmed as a parent. All items were coded such that higher scores indicated greater parental dissatisfaction and were summed to form the parental dissatisfaction index ($\alpha = .584$).

Educational attainment

A single measure of educational attainment was included in the current study. During the wave 4 interview, respondents were asked to indicate the highest level of education

that they had completed. The single item measure was coded such that higher scores indicate higher levels of educational attainment.

Economic well-being

The current study employed three measures relevant to economic well-being at wave 4. First, we included a continuous item which asked respondents to indicate the number of jobs they had held since 2001. The measure was coded such that higher values indicate a greater number of jobs. Second, we included a measure of the respondent's personal income. The income measure was based on the respondent's report of the prior year's (i.e., 2003) income tax return and was converted to a z-score prior to inclusion in the analyses. The final economic measure is a continuous index constructed from seven different items tapping the extent to which respondents had money problems over the past year. For example, respondents indicated whether they were unable to pay their rent or mortgage, whether they had their utilities shut off due to non-payment of bills, whether they were worried that food would run out, and whether they had received welfare or food stamps. The seven dichotomous items were summed to create the money problems index ($\alpha = .716$) where higher scores indicate more economic problems.

Contact with the criminal justice system

Two measures from wave 4 pertaining to contact with the criminal justice system were included in the current study. The first measure is a dichotomous item asking respondents if they had ever been arrested (1 = yes, 0 = no). Similarly, the second measure is also a dichotomous item indicating whether the respondent had ever been incarcerated in an adult or juvenile correctional facility (1 = yes, 0 = no).

Control variables

Maternal attachment

A two-item maternal attachment scale was created from the wave 1 data which taps the emotional connection between mother and child. Respondents were asked to rate, on a five-point scale, how close they felt to their mother and how much they felt their mothers cared for them. Responses to these items were summed to form the wave 1 maternal attachment index ($\alpha = .640$). Higher scores on the maternal attachment index indicate that the

mother and child were more emotionally attached. Past researchers have also used these items as indicators of maternal attachment (Beaver, 2008; Haynie, 2001).

Maternal involvement

The current study included a maternal involvement index which has been used by prior researchers (Shields & Beaver, 2011). During the wave 1 interview, respondents were asked to indicate which of 10 different activities they had engaged in with their mothers during the past four weeks. Examples of such activities included shopping, playing a sport, talking about life, discussing personal problems, and working on a school project. Responses to these dichotomous items were summed to create the maternal involvement index ($\alpha = .553$), with higher scores representing greater levels of involvement.

Maternal disengagement

In order to tap levels of maternal disengagement we included an index based on five items from the wave 1 interviews. Respondents indicated how warm and loving their mother was, how much they communicated with their mother, the overall quality of their relationship with their mother, how much their mother encouraged independence, and whether their mother discussed ethical issues. Responses to these items were summed to form the maternal disengagement index ($\alpha = .836$) where higher values indicate more maternal disengagement. This measure of maternal disengagement has also been employed by past researchers analyzing the Add Health data (Beaver, 2008; Shields & Beaver, 2011).

Parental permissiveness

We included a measure of parental permissiveness based on seven items derived from the wave 1 interviews. For example, respondents were asked whether their parents allowed them to make their own decisions about curfews, friends, clothing, and diet. Responses to these items were summed to form the parental permissiveness index ($\alpha = .632$) where greater values indicate higher levels of parental permissiveness.

Delinquent peers

In order to control for the influence of delinquent peers we included an index derived from three items asked during the wave 1

interview. Respondents were asked to report how many of their closest friends had smoked at least one cigarette a day, smoked marijuana more than once a month, and drank alcohol at least once a month. Responses to these items were summed to form the delinquent peers index ($\alpha = .756$). This index has also been used by past researchers employing the Add Health data (Beaver, 2008; Wright, Beaver, DeLisi, & Vaughn, 2008).

Analytical strategy

The current study employs the MZ difference scores approach to explore the effect of IQ differences between twins on a variety of outcomes related to adulthood. The method entails first randomly identifying an individual twin from each pair in the data as 'Twin 1', and then identifying his/her co-twin as 'Twin 2'. The next step involves creating a difference score for each twin pair where Twin 2's score on each measure is subtracted from Twin 1's score on the corresponding measures. Consequently, we employed these steps and calculated difference scores for IQ, the wave 4 outcome measures, and the control variables. Following the lead of past researchers who have employed the MZ difference scores method in analyzing the Add Health data (Beaver, 2008), we used ordinary least squares (OLS) regression analysis and listwise deletion techniques which resulted in an analytical sample that ranges from 48 to 166 twin *pairs*.

The analyses in the current study were then carried out in a related series of steps. First, we constructed the difference scores for each measure as outlined above. Second, we generated descriptive statistics for both the untransformed variables (i.e., prior to the construction of the difference scores) and for the difference scores. Third, we calculated the cross-twin correlations on each measure using the untransformed variables. The final step in the analysis involved creating two separate OLS regression equations for each outcome of interest. The first OLS regression equation included the IQ difference score as the only predictor variable. The second OLS regression equation, however, assessed the association of the IQ difference score with each outcome measure, net of the effect of the control variables (i.e., maternal attachment, maternal involvement, maternal disengagement, parental permissiveness, and delinquent peers). These control variables were selected because they

represent socialization measures that may confound any associations between IQ and the outcome measures.

Results

Given that difference scores are not intuitively interpretable and in order to provide an overall picture of the twins' scores on each variable included in the analyses, we calculated the descriptive statistics for the untransformed variables. These descriptive statistics are displayed in Table 1 under the column heading 'Untransformed Variables'. In terms of IQ, it can be seen that this sample of MZ twins is close to the conventional average on IQ and has a similar dispersion in the distribution of IQ scores (Rushton & Jensen, 2005).

In order for the MZ difference scores method to provide meaningful results, it is necessary that the twins included in the data display variation in the measures employed in the analysis (Beaver, 2008). Consequently, we assessed the variation between the twins on the measures of interest in two separate ways. First, we assessed the variation from the mean on each difference score by examining the standard deviation of each measure. As shown in Table 1, while each measure's difference score is close to zero the standard deviations indicate sufficient variation. The second manner in which we assessed variability was by analyzing cross-twin correlations for each measure. Cross-twin correlations were estimated by correlating Twin 1's score with Twin 2's score on each untransformed variable. As illustrated in Table 1, the correlation coefficients for almost all of the measures are statistically significant at the .05 level. While these correlations are statistically significant, only one measure, IQ, had a correlation coefficient that exceeded $r = .700$. This necessarily means that less than one-half of the variance in one twin's score is explained by their co-twin's score on that same measure.

The results of the OLS regression analyses, which assessed the association between IQ and the different outcome measures, are displayed in Table 2. Each row of Table 2 represents a single OLS equation predicting the outcome measure. The outcome measures are listed in the first column under the heading 'Wave 4 Outcome measures (difference scores)'. Model 1 represents the equations wherein the IQ difference score was the only predictor included in the equation.

Table 1 - Descriptive statistics for the untransformed variables, difference scores, and cross-twin correlations

	Untransformed Variables		Difference Scores		Cross-twin Correlation	Number of Twin Pairs
	Mean	SD	Mean	SD		
IQ (Wave 1)	96.478	13.109	-.114	9.455	.737*	220
Outcome measures (Wave 4)						
<i>Health</i>						
General health	3.716	.941	.069	1.050	.368*	217
Bad diet	13.675	13.299	-1.795	15.459	.321*	215
Depression	.147	.355	.065	.447	.227*	217
<i>Alcohol & Drug Use</i>						
Heavy alcohol use	1.861	2.609	-.500	2.776	.351*	217
Illicit drug use	.859	1.127	-.038	1.125	.491*	211
<i>Relationship, Sexual, & Family</i>						
Nmbr. of current relationships	.186	.498	.037	.670	.101	214
Relationship dissatisfaction	1.378	.609	.044	.800	.166	138
Sexual activity	2.275	.740	.019	.849	.335*	209
Nmbr. of sex partners	9.322	15.102	.492	15.173	.462*	197
Nmbr. of pregnancies	1.235	1.325	.176	1.359	.467*	216
Parental dissatisfaction	1.378	.609	-.057	3.031	.273*	70
<i>Educational Attainment</i>						
Highest level of education	5.913	2.273	-.014	1.918	.620*	217
<i>Economic Well-Being</i>						
Nmbr. of jobs since 2001	3.433	2.423	.039	2.626	.462*	204
Income	.002	.573	-.016	.648	.348*	200
Money problems	.380	.895	.061	1.122	.190*	214
<i>Contact with the CJS</i>						
Ever arrested	.250	.433	.043	.470	.393*	212
Ever incarcerated	.137	.344	-.074	.675	.205*	217
Control variables (Wave 1)						
Maternal attachment	9.479	1.061	-.083	1.173	.386*	252
Maternal involvement	3.947	1.986	.285	2.070	.447*	253
Maternal disengagement	8.925	3.256	.088	3.590	.395*	251
Parental permissiveness	5.002	1.673	-.112	1.819	.413*	269
Delinquent peers	2.560	2.705	.011	2.246	.657*	268

* $p < .05$, two-tailed test.

Viewing the findings in Model 1 overall, it can be seen that differences in IQ between MZ twins at wave 1 were generally unrelated to the outcome measures at wave 4. Indeed, IQ was significantly associated with only one outcome measure, income (Beta = $-.190$, $p = .022$). Curiously, within each twin pair the twin scoring lower on the IQ measure at wave 1 reported higher levels of personal income at wave 4. While this is an interesting finding, it should be taken with caution given that Model 1 included only one predictor variable.

The right-hand portion of Table 2 displays the results of the more conservative regression equations that control for the potentially

confounding influences of nonshared socialization factors. Consequently, the statistics displayed in Model 2 represent the association between the IQ difference scores and each outcome measure, net of the effect of the control variables (the effects of the control variables are not shown but are available upon request). Similar to Model 1, Model 2 illustrates that the differences in levels of IQ between twins as adolescents were generally not statistically associated with differences in the measured outcomes as adults. Notably, however, there are three outcome measures that were significantly associated with IQ in Model 2. First, IQ had a statistically significant effect

Table 2 - The association between wave 1 IQ difference scores and wave 4 outcome measures

Wave 4 Outcomes (difference scores)	Model 1						Model 2					
	b	B	SE	p	R ²	N	b	B	SE	p	R ²	N
<i>Health</i>												
General health	.001	.010	.009	.898	-.006	166	.003	.024	.009	.791	-.019	137
Bad diet	.157	.099	.124	.206	.004	165	.267	.175	.134	.048	.026	136
Depression	-.003	-.056	.004	.475	-.003	166	-.005	-.110	.004	.215	.005	137
<i>Alcohol & Drug Use</i>												
Heavy alcohol use	-.012	-.038	.023	.628	-.005	166	.008	.028	.025	.747	.040	137
Illicit drug use	.012	.105	.009	.184	.005	161	.015	.125	.010	.153	.054	135
<i>Relationship, Sexual, & Family</i>												
Nmbr. of current relationships	-.008	-.109	.005	.168	.006	163	-.003	-.054	.006	.542	.004	135
Relationship dissatisfaction	.005	.059	.008	.555	-.006	103	.006	.085	.009	.455	.027	82
Sexual activity	-.009	-.105	.007	.186	.005	159	-.008	-.103	.007	.259	-.005	132
Nmbr. of sex partners	-.118	-.072	.135	.383	-.002	149	-.023	-.019	.113	.842	.001	123
Nmbr. of pregnancies	.005	.040	.010	.615	-.005	165	.009	.076	.011	.398	-.013	137
Parental dissatisfaction	.083	.252	.042	.052	.048	60	.075	.290	.034	.034	.197	48
<i>Educational Attainment</i>												
Highest level of education	.027	.142	.015	.068	.014	166	.024	.120	.017	.179	.006	137
<i>Economic Well-Being</i>												
Nmbr. of jobs since 2001	.006	.023	.021	.780	-.006	154	.017	.067	.024	.472	-.014	128
Income	-.011	-.185	.005	.022	.028	153	-.012	-.207	.005	.025	.017	126
Money problems	.006	.050	.009	.528	-.004	164	.008	.078	.010	.380	.003	136
<i>Contact with the CJS</i>												
Ever arrested	.001	.021	.004	.796	-.006	162	.002	.042	.004	.634	.053	134
Ever incarcerated	-.001	-.037	.004	.640	-.005	166	-.002	-.045	.004	.616	-.018	137

on one health item, bad diet (Beta = .175, $p = .048$). This finding indicates that within the twin pairs, the twin with the higher IQ at wave 1 reported poorer diet choices at wave 4. Second, IQ was statistically associated with parental dissatisfaction in Model 2. As a reminder, the questions composing the parental dissatisfaction index were only asked to those respondents who indicated that they had a child. Consequently, the sample size associated with the parental dissatisfaction equation is quite low relative to the other equations in Model 2. With this caveat in mind, it can be seen that IQ had a statistically significant effect (Beta = .290, $p = .034$) on levels of parental dissatisfaction. This finding therefore indicates that the twin with the higher IQ at wave 1, relative to his/her co-twin, reported higher levels of parental dissatisfaction as a parent at wave 4. Third, corresponding to the results displayed in Model 1, the final variable to reach statistical significance in Model 2 was personal income. More specifically, within the twin pairs, the twin with lower IQ at wave 1 reported a higher personal income at wave 4.

Discussion

Previous studies have identified a robust and consistent association between IQ and a host of outcome measures including epidemiological factors (Deary, 2009), substance use and abuse (Batty et al., 2008), economic well-being (Zagorsky, 2007), and educational achievement (Caspi et al., 1998). Additionally, previous studies have recognized that these associations are typically the result of both genetic and environmental influences (Gottfredson & Deary, 2004). However, few studies have attempted to disentangle such influences. The current study aimed to partially address this gap in the literature by using an MZ difference scores approach.

The results of the current study indicate that IQ differences between twins generally are unrelated to differences in the examined outcome measures. To illustrate, outcomes such as overall health (Batty, Deary, & Gottfredson, 2007; Deary, 2009), alcohol use (Batty et al., 2006) and sexual behavior (Halpern et al., 2000; Harden & Mendle, 2011) have been found to be associated with IQ in previous studies, but were not associated in the current study. Only income, poor diet choices, and parental dissatisfaction were found to be

associated with IQ when an MZ difference score technique was used to isolate the influence of nonshared environmental factors.

Given that IQ is a significant predictor of life outcomes across a wide range of heterogeneous studies, we are left to speculate why our findings diverge from the existing literature. While not an exhaustive list, we do offer two possible reasons. First, it is possible that while IQ is integral to explaining differences across unrelated persons, perhaps IQ is not as important at explaining differences between siblings/twins. Second, and relatedly, the methodology employed in the current study is highly conservative in that the MZ difference score approach tends to reduce the amount of variation that is left to be explained. This problem is exacerbated by the fact that MZ difference scores studies, including the current one, are often hampered by a lack of statistical power that flows not only from truncated variation, but also from reduced sample size. As a result, it is actually quite common for studies that use MZ difference scores analysis to report null findings, even among variables that are typically significantly correlated when using other types of analytical approaches (e.g., Beaver, 2008). Future research is needed to determine whether the null findings reported here are replicated in other samples that use other measures of IQ and that employ different methodological strategies.

The results of the current study should be viewed with caution in light of two limitations. First, while the Add Health data contain a nationally representative sample of youths, the final analytical sample used in the current study consisted of only MZ twin pairs, which constitutes a small proportion of the overall Add Health sample. While an analysis carried out by Jacobson and Rowe (1998) concluded that the subsample of siblings nested within the Add Health data is not substantively different from the overall sample, future studies would benefit from examining larger and more generalizable samples. Second, the measure of IQ utilized in the current study is a measure of verbal IQ as opposed to a composite index that takes several measures into account. Future studies would benefit from analyzing additional measures of IQ and the distinct role that both genetic and environmental factors play in driving associations between IQ and life outcomes.

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