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How Intelligence Affects Fertility

ROBERT D. RETHERFORD
Population Institute
East-West Center

WILLIAM H. SEWELL
University of Wisconsin

In an earlier study of the reproductive experience of a large, randomly selected cohort of high school seniors who graduated in 1957 in the State of Wisconsin, we found that IQ had a small but statistically significant negative effect on subsequent family size. This negative effect was considerably larger for women than for men. This paper addresses two questions not answered in the earlier study: (1) Why is the effect of IQ on subsequent family size negative? And (2) why is it considerably more negative for women than for men? Path analysis shows that the effects of IQ on subsequent family size are almost entirely indirect through education; thus education provides most of the sought-for explanation. This finding suggests the further hypothesis that, in modern societies, the direction of effect of education on family size may predict the direction of evolution of genotypic IQ. Further research is needed to test the generality of our findings.

In an earlier paper, we reviewed the literature on the relationship between intelligence and fertility and came to the following conclusion:

> "Taken together, [this literature] present[s] a fairly consistent picture: Differential fertility by IQ in the United States appears to have been negative in this century. It probably became less negative during the baby boom (and positive for some samples). It seems to have diverged again in the negative direction after the baby boom."

The reference to the United States occurs because the earlier studies pertain almost exclusively to the United States (Retherford & Sewell, 1988).

The same paper studied the reproductive experience of a large, randomly

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Correspondence and requests for reprints should be sent to Robert Retherford, Population Institute, East-West Center, Honolulu, HI 96848.

selected cohort of high school seniors who graduated in 1957 in the State of Wisconsin, and IQ was found to have a small but statistically significant negative effect on subsequent family size. This negative effect was considerably larger for women than for men. These general findings were not altered when nongraduates (persons who never graduated high school) were incorporated into the analysis.

One of our measures of relationship between IQ and family size was the IQ selection differential, defined as what the generational change in mean IQ would be if, hypothetically, each offspring had the same IQ as the mean of its parents' IQs. This differential was calculated both for graduates in the WLS sample and for the complete age cohort, including both graduates and nongraduates. For graduates, constituting about 75% of the complete cohort, our estimate of the selection differential was 0.5 IQ point decline in a generation, and for the complete cohort it was 0.8 IQ point decline in a generation. Further analysis showed that the contribution of women to the IQ selection differential was more than three times that of men for graduates and almost five times that of men for the complete cohort.

Based on an assumed IQ heritability coefficient of 0.4 and the above estimate of -0.8 for the IQ selection differential, it was estimated, using a simple genetic model, that the generational change in mean genotypic IQ for the complete cohort and its offspring was about one-third of an IQ point decline in a generation. By genotypic IQ is meant the expected value of measured IQ for an individual of a given gene configuration, or genotype, under the hypothetical assumption that the individual was raised in the average environment obtaining in the population.

Although our earlier paper examined the direction and magnitude of effect of IQ on family size, it did not address the questions of (1) why this effect is negative and (2) why it is considerably more negative for women than for men. These questions are addressed in this paper.

HYPOTHESES

Question 1: Why Is the Effect of IQ on Family Size Negative?

We began with the simple hypothesis that brighter persons tend to get more education, and more education tends to reduce family size. This hypothesis was framed in terms of the simple path model shown in Figure 1. In the figure, the negative effect of IQ on family size is hypothesized to be entirely indirect, through education. It is calculated as the product of a positive effect of IQ on education and a negative effect of education on family size.

That the effect of IQ on education tends to be positive is well-established. Relevant earlier studies include those by Bajema (1968), Waller (1971), Sewell and Hauser (1980a), and Duncan (1982). In these studies, the coefficient of correlation between IQ and education, which has the same sign as the IQ coefficient in regressions of education on IQ, ranges from about 0.4 to 0.7. The

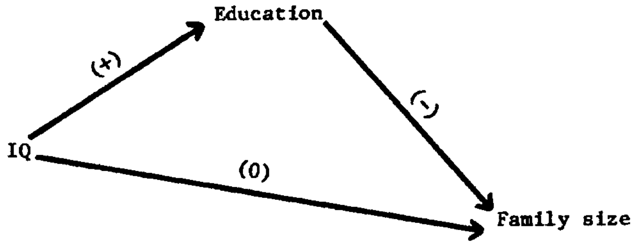

FIG. 1. Hypothesized path model of the effect of IQ on family size.

correlation tends to be higher for men than for women. Jencks et al. (1979:Table 4.3) reviews several additional studies that regressed educational attainment on test score. In these studies, the coefficient of test score in the bivariate regressions ranged from .053 to .128, with most values in the neighborhood of .100. Given that IQ tests are designed to measure the kinds of abilities necessary for academic work, the positive effect of IQ on education is in line with theoretical expectation.

That the effect of education on family size tends to be negative in modern societies is also well-established. The literature on this subject has been reviewed by Cochrane (1979). The reasons for the negative effect of education on family size are reasonably well understood: More education on the part of parents tends to reduce the labor value and raise the cost of children, mainly because parents with more education tend to keep their children in school longer. More education also tends to reduce the old-age security value of children, mainly because education is positively associated with income so that higher savings (some of which may be in the form of insurance and pensions) among the more educated provide a security alternative to children. More educated persons also tend to have more interests and activities outside the family that compete with children for parental resources of time and money. Educated persons also tend to be more knowledgeable about birth control and more effective in practicing it.

In some ways education acts to increase family size. For example, education tends to reduce mortality and therefore increase the number of children who survive to adulthood. Also, the higher income that tends to come with more education increases parental resources for having and rearing children. Theory alone cannot tell us whether the net effect of education on family size will be negative, neutral, or positive. Empirically, however, it is found almost universally in modern societies that the net effect is negative (Cochrane, 1979).

Question 2: Why is the Effect of IQ on Family Size More Negative for Women Than for Men?

We hypothesized that education also explains why the effect of IQ on family size is considerably more negative for women than for men. Our reasoning was, first, for either sex, that the effect of IQ on family size is indirect through education, in line with the previous hypothesis; and, second, that in populations (like Wisconsin) where well-educated women may compete with men for the more prestigious jobs, the effect of education on family size is more negative for women than for men. The effect of education on family size is more negative for women than for men because the possibility of better paying and more interesting jobs outside the home increases the opportunity costs of time needed for childcare, especially for women since they continue to bear the brunt of childbearing and child rearing even when they are highly educated (Cochrane, 1979; Schultz, 1987; United Nations, 1986).

Implications for Estimating the Direction of Evolution of Genotypic IQ

The hypothesis that the effect of IQ on family size is entirely indirect through education is of interest from the standpoint of estimating the direction of evolution of genotypic IQ when data on fertility by IQ are not available. If the hypothesis of an *entirely* indirect effect is true, then, to the extent that the assumptions underlying the path model in Figure 1 are met, the direction of effect of education on family size determines the direction of effect of IQ on family size. This is true because the indirect effect of IQ on family size is calculated as the product of the effect of IQ on education and the effect of education on family size. The effect of IQ on education is always found to be positive in large samples. Therefore, if the effect of education on family size is positive, the indirect effect of IQ on family size must also be positive; if the effect of education on family size is negative, the indirect effect of IQ on family size must also be negative.

According to the above reasoning, the direction of effect of education on family size should predict the direction of effect of IQ on family size. The direction of effect of IQ on family size should in turn predict the direction (though not the rate) of evolution of genotypic IQ. This is so if the direction of evolution of genotypic IQ is determined by the direction of differential reproduction by IQ. Chaining these assumed causal linkages together leads to the further hypothesis that the direction of effect of education on fertility should predict the direction of evolution of genotypic IQ.

If subsequent research confirms this hypothesis, a plausible basis will be available for estimating the direction of evolution of genotypic IQ from data on the educational attainment and fertility of a population. Obviously, such estimates will not be as defensible as those based on longitudinal data on the IQ and subsequent fertility of the individuals constituting the population. But since such data are rarely available, existing data on education and fertility may provide guidance about the direction of evolution of genotypic IQ.

Findings from Previous Studies

We are aware of two previous studies with findings that bear on the hypothesis that the effect of IQ on family size is entirely indirect through education. The first of these, by Udry (1978), analyzed a sample of 1,827 ever-married white women aged 15–44 in low- and high-income census tracts in 16 U.S. cities, who were interviewed in 1974. Fertility was measured by number of children ever born at the time of the survey. IQ was measured by a shortened adaptation of the Peabody Picture Vocabulary Test, which was administered as part of the survey. In the regressions, IQ was coded as high, medium, or low. The number of children ever born predicted by regression, controlling for age, duration of marriage, education, and father's occupation, was found to be 1.89 for low IQ, 1.86 for medium IQ, and 1.71 for high IQ. The fertility difference between the high IQ group and the other two IQ groups was statistically significant. Although the intermediate variables in this analysis include more than just education, the finding that IQ effects do not disappear when other variables are controlled suggests that the effect of IQ on family size is not entirely indirect through education.

There are several reasons, however, why Udry's study is not ideal for testing our hypotheses. First, the study was not based on a measure of completed fertility, since the ages of women ranged from 15 to 44. Statistical controls for age and duration of marriage may not fully remedy this deficiency. Second, IQ was measured at the time of the survey, raising the possibility that education affects IQ as well as vice versa. An adequate test of our path model requires data in a form such that the direction of causation is unambiguously from IQ to education. Third, the coding of IQ in three IQ categories instead of the original metric represents a very crude measurement of IQ. Fourth, the study relied on a short picture vocabulary test instead of a more comprehensive and reliable IQ test. Fifth, the sample is nonrepresentative. It includes high- and low-income census tracts in selected large cities but excludes medium-income census tracts in these cities. It also excludes smaller cities and rural areas, and it excludes never-married women.

The second study, by Olneck and Wolfe (1980), examined the relationship between intelligence and family size using longitudinal data from two samples: the Kalamazoo Sample of Brothers and the National Bureau of Economic Research-Thorndike-Hagan (NBER-T-H) sample of white men. The following discussion of these two samples is recapitulated from Retherford and Sewell (1988).

The Kalamazoo Brothers sample includes 1,200 men, drawn from an original sample of 3,000 males, identified as siblings, for whom sixth-grade test scores from 1928 to 1950 were available in Kalamazoo public school records. Olneck and Wolfe's findings are based on 352 weighted pairs of brothers for whom test scores, age, and self-reported education, earnings, and marital status were available. IQ scores are based on the Terman group test and the Otis test. The scores were adjusted to ensure comparability. The respondents were virtually all white, Protestant, and of nonfarm origins. Their educational and occupational levels are higher than for men of their age when compared with the national sample used in the Occupational Changes in a Generation replication study (Featherman & Hauser, 1977, 1978). The investigators assert that while caution must be used in viewing results from the Kalamazoo sample, there are no obvious biases that would greatly distort the findings of their analysis (Olneck & Wolfe, 1980, p. 244).

The NBER sample comprises 5,000 white men, born between 1917 and 1925, who took the U.S.A. Air Corps Aviation Cadet Qualifying (ACQ) Examination in 1943 and were followed up in a 1969 NBER survey. The sample is relatively homogeneous in measured intelligence and education; all respondents had at least graduated from high school or had high school equivalency and scored at or above the median on the ACQ test. The test score used is based on a pooled composite of a battery of tests and is said to represent general intellectual ability or scholastic aptitude. The measure of fertility derives from the NBER follow-up survey in 1969. It is based on the question, "How many children do you have?" Because of the phrasing of this question and other related questions concerning offspring, it is thought that the respondents reported surviving children currently at home rather than children ever born. Adopted children may also be included in the responses. Never-married persons and individuals who failed to respond to the questions on children, education, or income were excluded. The analysis is based on the 4,826 remaining cases.

According to Olneck and Wolfe (1980, p. 244),

> "The simple correlation between test scores and number of children in both the Kalamazoo and the NBER-TH samples is .06. Thus, in neither sample do we find a gross negative relationship between a measure of ability and number of children. Nor is this finding altered by taking into account the respondent's age, current marital status, educational attainment, income, and, in the Kalamazoo sample, family background. . . . Indeed, in both samples the observed effect of measured ability increases when these variables are included. However, while in both samples the remaining effect is statistically significant, the coefficients are small."

It must be pointed out, however, that results based on a small sample of brothers from Kalamazoo may have limited generalizability regardless of how carefully the analysis was done. The results from the NBER-T-H sample are more impressive but are based on a nonrepresentative sample of ever-married male high school graduates whose measured intelligence was relatively high. Moreover, as has already been pointed out, the measurement of fertility was less than ideal for a study of this kind. Another problem is that in the NBER-T-H sample as in Udry's sample, IQ was measured in adulthood, raising the possibility that education affects IQ as well as vice versa, since IQ is no longer measured at a young age, before differentiation in the degree of educational attainment. Also, both the Kalamazoo and the NBER-T-H samples suffer from being restricted to males; this is a problem because the available evidence indicates that the relationship between fertility and IQ is considerably more negative for females than for males (Retherford & Sewell, 1988). Finally, although both the Kalamazoo and NBER-T-H samples showed a positive association between IQ and fertility, this association has always been found to be negative in large representative samples. (See Retherford and Sewell, 1988, for literature review and further discussion.)

Given the limitations of these studies, it seemed worthwhile to reexamine the relationship between IQ, education, and fertility with our more adequate Wisconsin data, which are among the best available for addressing the questions raised here. Our data also have limitations, which we shall clarify in the course of presenting our analysis.

DATA AND METHODS

The data for our study come from the Wisconsin Longitudinal Study of Social and Psychological Factors in Educational and Occupational Aspirations and Achievements. Henceforth, we shall refer to this study simply as the WLS. It is based on a random sample of 10,317 high school seniors in public, private, and parochial schools in Wisconsin in 1957. The questionnaires covered the students' socioeconomic backgrounds, high school experiences, educational and occupational aspirations and plans, and perceptions of the influence of parents, teachers, and friends on their plans and aspirations. From schools and public sources, additional information was obtained on parents' economic status, the students' measured intelligence and high school grades, and the characteristics of their high schools and communities. Although race was not asked in the WLS, it has been estimated that the sample was about 98% white (Retherford and Sewell, 1988). WLS follow-up surveys of the students were conducted in 1964 and 1975 with response rates of approximately 90%. This paper is based on the 1975 survey (supplemented where necessary with earlier data), which collected detailed retrospective histories relating to family formation and fertility for 4,316 men and 4,782 women. For a detailed discussion of the 1957, 1964, and 1975 samples, nonresponse bias, and data quality, see Sewell and Hauser (1975, 1980b) and Clarridge, Sheehy, & Hauser (1977).

The WLS measures of intelligence and fertility have been discussed in some detail by Retherford and Sewell (1988) and are therefore discussed only briefly here. The IQ measurements are based on scores on the Henmon-Nelson Test of Mental Ability (revised 1954), taken by the members of our sample in the 11th grade. At the time, the Henmon-Nelson test was one of the most widely used group tests of intelligence. The IQ scores are normalized to a mean of 100 and a standard deviation of 15. The Henmon-Nelson IQ scores attempt to measure the kinds of abilities necessary for academic work; they do not measure all aspects of intelligence.

The fertility measurements derive from retrospective histories of family formation that were collected in the 1975 survey. At the time of this survey, respondents were about 36 years old. Our basic measure of fertility is number of children ever born alive to the respondent before the 35th birthday (F_{35}), estimated to represent, on average, about 93% of completed fertility (Retherford & Sewell, 1988). For both men and women, F_{35} is derived from a complete roster of children ever born to ever-married female respondents or fathered by ever-married male respondents. The roster includes the dates of all live births (including those born out of wedlock), the age of the respondent in months at the time of the birth of each child, and the date of each marriage and marital dissolution. Persons never-married at age 35 were assigned a fertility of zero, which is thought to reflect reality closely; in this regard, it is noteworthy that persons still never-married at age 35 had higher than average IQ in the WLS sample.

From the retrospective histories we also constructed several reproductive life cycle variables: progression to parity x by 35th birthday for ever-married persons who attained parity $x-1$ before their 35th birthday, denoted P_x for $x=3,4, \ldots ,7$ (1 if attained parity x, 0 otherwise). By parity is meant number of children ever born. For example, among ever-married women who had at least two children, P_3 is 1 if the woman went on to have a third child before age 35; otherwise P_3 is 0. The value of P_3 predicted by our regressions is interpreted as the probability of going on to have a third child, that is, as a parity progression ratio from two to three children. The reproductive life cycle variables may be viewed as components of overall fertility as measured by F_{35}, although not in any simple additive sense.

Our choice of variables was limited by problems of simultaneity, or two-way causation. Because of the causal form of our model (Figure 1), we chose variables so that causation between IQ and education and between education and fertility would be unambiguously in one direction. Simultaneity between IQ and education, as they are measured in this study, is not a problem. IQ was measured in 11th grade. Therefore education, as measured by completed years of schooling obtained by 1975, could not have caused the 1956 IQ test scores of the members of our sample. But simultaneity between education and fertility is potentially a problem, because fertility at young reproductive ages can affect education (by causing one or both parents to discontinue schooling) as well as the other way around. We attempted to minimize the reverse effects of fertility on education by choosing our fertility measures as cumulative fertility at age 35 and parity progression for parities two and over.

Our analytical strategy was to examine, by sex, the effects of IQ both on F_{35} and on each of the reproductive life cycle variables, with and without a control for education. The regressions with F_{35} as the dependent variable are of the form

$$F_{35} = a + bIQ \tag{1}$$

and

$$F_{35} = c + dIQ + eE \tag{2}$$

where E denotes completed years of education. Our hypothesis is that education will explain the effect of IQ on F_{35}, so that the coefficient d will be reduced to statistical nonsignificance in equation (2).

When the dependent variable is a dummy variable, P_x, representing parity progression from $x-1$ to x, we use logit regression:

$$\text{logit } P_x = a + bIQ \tag{3}$$

$$\text{logit } P_x = c + dIQ + eE \tag{4}$$

where logit P_x is defined as $\ln[P_x/(1-P_x)]$. Otherwise the reasoning is the same as that relating to the ordinary regression equations (1) and (2). As already mentioned, the predicted values of P_x from equations (3) and (4) are interpreted as parity progression ratios.

If the introduction of education into the regressions reduces the coefficient of IQ to statistical nonsignificance for both men and women, we have a strong indication that the sex difference in IQ coefficient is also explained by education. We additionally test this proposition by computing directly the male–female difference in IQ coefficient and deriving probability values (levels of statistical significance) for the difference.

In the research leading to this paper, we examined work-related variables along with education as intermediate variables between IQ and fertility. It turned out, however, that education alone was sufficient to capture the effect of IQ on fertility, as will be seen in the next section.

FINDINGS

The Effects of IQ on Fertility

Principal findings are shown in Tables 1 and 2. The results for the basic regressions of F_{35} on IQ and of F_{35} on IQ and education are also shown in the path diagrams in Figure 2. As recommended by Duncan (1975), the path diagrams show metric coefficients rather than standardized coefficients, since the former are easier to interpret than the latter in this analysis. For example, the coefficient of $-.0058$ for males in Figure 2A means that an increase of one IQ point causes F_{35} to decrease by .0058 child.

Figure 2B shows that the relatively small but statistically significant effect of IQ on F_{35} is almost entirely indirect through education, as hypothesized. This is true for both men and women, although some sex differences are apparent. The effect of IQ on education is more positive for men than for women, whereas the effect of education on F_{35} is considerably more negative for women than for men. Given that many intelligent women in the WLS cohort opted for marriage and children over advanced education, it is not surprising that the effect of IQ on education is more positive for men than for women. We have already discussed

TABLE 1
Regressions of Fertility Variables on IQ and Education

Fertility Variable	Sex	Coefficients of Independent Variables: IQ	Coefficients of Independent Variables: Education	Standard Errors of Coefficients: IQ	Standard Errors of Coefficients: Education	R^2	N
F_{35}	M	−.0058 (.00)		.0015		.0036	4316
	F	−.0105 (.00)		.0016		.0088	4782
	M	.0011 (.52)	−.0895 (.00)	.0017	.0103	.0206	4316
	F	.0009 (.58)	−.2406 (.00)	.0017	.0139	.0674	4782
P_3	M	−.0084 (.00)		.0024		.0023	3218
	F	−.0102 (.00)		.0025		.0031	3815
	M	.0001 (.96)	−.1141 (.00)	.0027	.0172	.0121	3218
	F	.0004 (.90)	−.2373 (.00)	.0027	.0230	.0253	3815
P_4	M	−.0032 (.32)		.0032		.0000	1886
	F	−.0093 (.00)		.0028		.0025	2607
	M	.0011 (.76)	−.0642 (.01)	.0036	.0244	.0015	1886
	F	−.0030 (.31)	−.1924 (.00)	.0030	.0317	.0125	2607
P_5	M	−.0023 (.66)		.0051		.0000	829
	F	−.0111 (.01)		.0041		.0029	1343
	M	−.0046 (.43)	.0349 (.39)	.0057	.0404	.0000	829
	F	−.0074 (.09)	−.1689 (.00)	.0043	.0555	.0072	1343
P_6	M	−.0111 (.23)		.0092		.0000	274
	F	.0050 (.45)		.0065		.0000	554
	M	−.0051 (.62)	−.0915 (.22)	.0104	.0749	.0000	274
	F	.0043 (.52)	.0394 (.67)	.0067	.0935	.0000	554
P_7	M	.0578 (.00)		.0203		.0756	81
	F	−.0050 (.65)		.0108		.0000	215
	M	.0584 (.01)	−.0102 (.94)	.0220	.1425	.0557	81
	F	.0026 (.82)	−.5699 (.03)	.0112	.2588	.0137	215

Note. F_{35} is the number of children ever born alive before the respondent's 35th birthday. P_x is 1 if the respondent had at least x children before the 35th birthday, 0 otherwise; each P_x regression is done just for ever-married persons with at least $x - 1$ children.

The regressions for F_{35} are OLS regressions. The remaining regressions for P_x, $x = 3, 4, \ldots, 7$ are logit regressions. Entries in the table are regression coefficients, with two-sided probability values (levels of statistical significance) indicated in parentheses. Probability values are computed relative to the null hypothesis of no IQ effects.

earlier why one might expect the effect of education on fertility to be more negative for women than for men.

Table 1 presents the basic regressions. Table 2 translates the ordinary and logit regression coefficients in Table 1 into more readable form by considering the change in each fertility variable generated by a 30-point increase in IQ, from 85 to 115. An increase of 30 points is equivalent to an increase of two standard deviations, spanning approximately the middle two-thirds of the IQ distribution.

In Table 1, the coefficient of IQ measures the effect of a one-point change in IQ on the fertility variable or the logit of the fertility variable. In Table 2, entries in the "difference" columns measure the effect of a 30-point increase in IQ on

TABLE 2
Predicted Effect of a 30-point Increase in IQ, from 85 to 115, on Fertility Variables, Based on Fitted Regressions

Fertility Variable	Sex	Unadjusted Values of Fertility Variables: IQ 85	Unadjusted: IQ 115	Unadjusted: Difference	Adjusted Values of Fertility Variables: IQ 85	Adjusted: IQ 115	Adjusted: Difference
F_{35}	M	2.41	2.23	−.17	(2.34)	(2.37)	(.03)
	F	2.85	2.53	−.32	(2.57)	(2.60)	(.03)
P_3	M	.618	.557	−.061	(.593)	(.594)	(.001)
	F	.717	.651	−.066	(.659)	(.661)	(.003)
P_4	M	(.452)	(.428)	(−.024)	(.435)	(.443)	(.008)
	F	.551	.481	−.070	(.491)	(.468)	(−.022)
P_5	M	(.337)	(.322)	(−.015)	(.346)	(.315)	(−.030)
	F	.450	.369	−.081	(.397)	(.345)	(−.052)
P_6	M	(.328)	(.259)	(−.069)	(.307)	(.275)	(−.032)
	F	(.374)	(.409)	(.035)	(.385)	(.416)	(.031)
P_7	M	.152	.503	.351	.150	.505	.355
	F	(.349)	(.316)	(−.033)	(.204)	(.216)	(.013)

Source: Same regressions as those reported in Table 1.

Note. Effects are defined here as the differences in the "Difference" column. Adjusted values of the fertility variables are calculated by setting E = 13.38, the mean number of years of education in the entire sample. Parentheses around an entry indicate that the estimate is based on a coefficient of IQ that is not statistically significant (i.e., $p > .05$). Discrepancies among the 85, 115, and "Difference" columns are due to rounding errors.

the fertility variable. The unadjusted values of each fertility variable in Table 2 are calculated from the simple regressions (1) or (3). The adjusted values of each fertility variable are calculated from regressions (2) or (4) that include education, with education held constant by setting E at its mean value of 13.38 in the entire sample of both sexes.

In Table 1, statistical significance is indicated by the probability values shown in parentheses after the coefficients. In Table 2, parentheses around an entry indicate that the estimate is based on a coefficient of IQ that is not statistically significant at the 5% level (i.e., $p>.05$). Table 1 also shows estimated standard errors of the coefficients, R^2 values, and sample *N*'s indicating sample size. In the case of the logit regressions, the R^2 statistic is similar to the square of the multiple correlation coefficient in ordinary least squares regression (Harrell, 1983).

In Table 2, we see that a 30-point increase in IQ generates an unadjusted decline in our overall fertility measure, F_{35}, of .17 of a child for men and .32 of a child for women. Both effects are highly statistically significant, as shown in Table 1. By this measure, the negative effect of IQ on F_{35} is almost two times larger for women than for men. When education is introduced as a control,

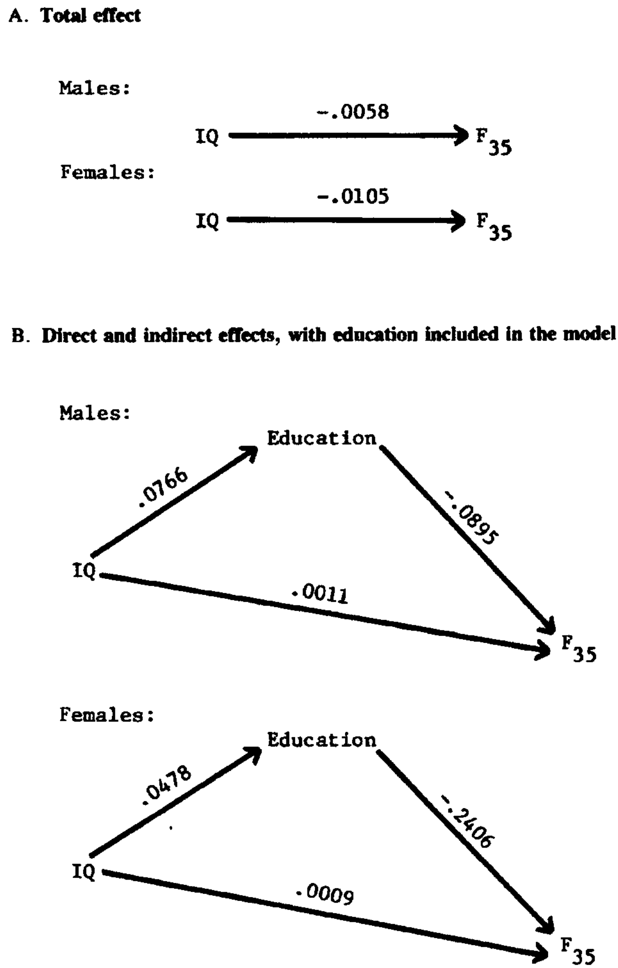

FIG. 2. Path models of the effect of IQ on F_{35}.

Note. Path coefficients are metric, not standardized. All coefficients are statistically significant except the direct effects of .0011 for males and .0009 for females in Panel B.

however, the adjusted effect becomes statistically nonsignificant for both men and women. Thus we interpret the effect of IQ on F_{35} to be indirect through education, or, in other words, education explains (in the sense of mediating) the effect of IQ on F_{35}, as hypothesized.

The variable P_3 represents transition from parity 2 to parity 3 (1 if the transition occurs by the 35th birthday, 0 otherwise). Table 2 shows, for the IQs specified, that the unadjusted parity progression ratio for this transition ranges from 55% for men with IQ 115 to 72% for women with IQ 85. The effect of a 30-point increase in IQ on progression to parity 3 is to reduce the probability of progression by 6–7 percentage points. When education is introduced as a control, this effect is reduced to statistical nonsignificance.

In the case of progression to parity 4, the unadjusted effect of a 30-point increase in IQ is statistically nonsignificant for men. For women, the effect, which is statistically significant, is to reduce the probability of progression by about 7 percentage points. When education is introduced as a control, this latter effect is reduced to statistical nonsignificance. The results for progression to parity 5 are very similar to those for progression to parity 4. In the case of progression to parity 6, both unadjusted and adjusted effects are statistically nonsignificant. This is also true for progression to parity 7 in the case of women. For men, however, the results for progression to parity 7 are anomalous; a 30-point increase in IQ causes a major increase of 35 percentage points in the probability of progression. This large effect remains when education is controlled, and it is highly statistically significant. We are unable to explain this result. In our judgment, the result for men for progression to parity 7 is a quirk of our sample and has no theoretical significance. It also has very little substantive significance in terms of effect on F_{35}, since the parity progression probabilities for parity 7 for men are based on only 81 cases, as shown in Table 1.

On the whole, Tables 1 and 2 and Figure 2 show that education accounts almost entirely for the negative effect of IQ on fertility, as hypothesized. This result must be interpreted cautiously, however, because we assume that the relationship between F_{35} and IQ is linear, whereas in reality it is somewhat nonlinear, as shown by plots of F_{35} by IQ decile in our earlier paper. The plots indicate that, for females, F_{35} is slightly lower in the first decile than in the second, and, for males, F_{35} has a secondary peak in the ninth decile (Retherford & Sewell, 1988).

Although these departures from linearity are not great, it seemed prudent in the present analysis to test whether respecification of the IQ variable as a set of nine dummy variables to represent the 10 IQ deciles made any difference in the results presented here. We conducted this test just for the regressions of F_{35} on IQ and of F_{35} on IQ and education. The respecification makes virtually no difference in the results. IQ again has statistically significant negative effects on F_{35}, but these effects are reduced to statistical nonsignificance when education is included in the regressions. The only exception is the coefficient of the dummy variable representing the ninth IQ decile for males, which remains positive and significant at $p = .02$ after education is controlled. This exception occurs because of the relatively high fertility of males in the ninth IQ decile, which appears to be another quirk of our sample.

Sex Differences in the Effect of IQ on Fertility

The reduction of IQ effects to statistical nonsignificance for each sex separately when education is controlled, as found for F_{35} and most of the reproductive life cycle variables in Tables 1 and 2, strongly suggests that education also explains the sex difference in the effect of IQ on fertility. As mentioned earlier, the sex difference in IQ coefficient can also be computed, and the statistical significance of this difference can be tested directly. This is done in Table 3.

We first examine the sex difference in the effect of IQ on our summary measure of fertility, F_{35}. Without a control for education, the sex difference in IQ coefficient is significant at $p = .03$. With education controlled, the difference is statistically nonsignificant, at $p = .95$. This is consistent with the earlier finding in Table 1 that the effect of education on F_{35} is considerably more negative (by a factor of 3) for women than for men.

The findings for parity progression are similar. In every case except P_7, the sex difference in IQ coefficients is statistically nonsignificant to start with and becomes even less significant when education is controlled. P_7 is anomalous. The sex difference in IQ coefficients is very large and highly statistically significant, both before and after education is controlled; as mentioned earlier, the sex difference in IQ coefficient of P_7 appears to reflect a quirk of our sample that we think has little theoretical or practical significance. In sum, education almost completely accounts for the more negative effect of IQ on fertility for women than for men, as hypothesized.

TABLE 3
Male–female Differences in Coefficients of Independent Variables in Sex-specific Regressions of Fertility Variables on IQ and Education

Fertility Variable	Male–female Difference in Coefficient of Independent Variable		Standard Error of Sex Difference		Probability Value of Sex Difference	
	IQ	Education	IQ	Education	IQ	Education
F_{35}	−.0048		.0022		.03	
	−.0001	−.1511	.0024	.0173	.95	.00
P_3	−.0018		.0035		.60	
	.0002	−.1232	.0039	.0287	.96	.00
P_4	−.0061		.0043		.15	
	−.0042	−.1282	.0047	.0400	.38	.00
P_5	−.0088		.0065		.18	
	−.0028	−.2038	.0072	.0686	.70	.00
P_6	.0160		.0113		.16	
	.0094	.1309	.0124	.1198	.45	.28
P_7	−.0628		.0230		.01	
	−.0558	−.5598	.0246	.2955	.02	.06

Source: Calculated from the regressions in Table 1.

SUMMARY AND DISCUSSION

The effects of IQ on fertility as measured in our Wisconsin sample of high school graduates are explained almost completely by education, as hypothesized. In the context of our simple path models, education explains both the negative effect of IQ on fertility and its more negative effect for women than for men.

In our sample, IQ affects fertility indirectly through its intermediate effect on education, so that the direction of effect of education on fertility predicts the direction of effect of IQ on fertility. (This does not mean, of course, that education is a good proxy for IQ. In the Wisconsin sample, IQ and education are correlated at .42, indicating that education explains only 18% of the variance in IQ). However, the sample excludes nongraduates, who constitute 25% of the complete cohort, so it is not certain that a similar result would have been obtained had it been possible to include nongraduates in the analysis. (A similar result is nevertheless likely, in our judgment, because all evidence suggests that nongraduates in the Wisconsin cohort had both lower intelligence and higher fertility than the graduates; see Retherford & Sewell, 1988). Adding to this uncertainty are two other studies, which, while not based on large representative samples, nevertheless suggest that IQ may sometimes have residual effects on fertility even after education is statistically controlled (Olneck & Wolfe, 1980; Udry, 1978).

Were it generally true that the direction of effect of education on fertility predicted the direction of effect of IQ on fertility, as in our Wisconsin sample, then the direction of effect of education on fertility could be used to predict the direction of evolution of genotypic IQ. The Wisconsin data suggest that the direction of effect of education on fertility may furnish a plausible basis for predicting the direction of evolution of genotypic IQ, but firmer conclusions must await further research based on more complete data from large representative samples in other populations.

Ideally in such research, the sample should be representative of all educational levels, fertility should not be truncated at age 35, and surviving children should be used in place of births. Our sample omits the approximately 25% of the complete Wisconsin age cohort who were not high school graduates. It also omits the approximately 7% of lifetime fertility that, on average, occurred at ages 35 and over for this cohort. Our measure of reproduction is number of children ever born instead of number of surviving children, since the WLS did not collect information on survivorship of respondents' children. Regarding survivorship, the ever-born children of our respondents, at the time the latter reached their 35th birthday, were born, on average, 8.5 years earlier. The expected proportion of children surviving from birth to age 8.5 is approximately 97.9%, as calculated from Wisconsin life tables for 1969–1971 (National Center for Health Statistics, 1975), suggesting that the omission of dead children has little impact on our results.

Despite these limitations, our data are among the best currently available for addressing the questions raised in this paper. Major new data collection is necessary to address these questions more adequately. What appears to be needed are longitudinal studies, based on large, nationally representative samples, in which comparable IQ measurements as well as detailed demographic and socioeconomic characteristics of both parents and children are obtained.

REFERENCES

Bajema, C.J. (1968). Relation of fertility to occupational status, IQ, educational attainment, and size of family of origin: a follow-up study of a male Kalamazoo public school population. *Eugenics Quarterly, 15,* 198–203.

Clarridge, B.R., Sheehy, L.L., & Hauser, T.S. (1977). Tracing members of a panel: a 17-year follow-up. In K.F. Schuessler (Ed.), *Sociological methodology 1978.* San Francisco: Jossey-Bass.

Cochrane, S.H. (1979). *Fertility and education: What do we really know?* World Bank Staff Occasional Papers, No. 26. Baltimore: Johns Hopkins University Press.

Duncan, O.D. (1975). *Introduction to structural equation models.* New York: Academic.

Duncan, O.D. (1982). Ability and achievement. *Social Biology, 29,* 208–220.

Featherman, D.L., & Hauser, R.M. (1977). *The process of stratification: Trends and analyses.* New York: Academic.

Featherman, D.L., & Hauser, R.M. (1978). *Opportunity and change.* New York: Academic.

Harrell, F.E. (1983). The LOGIST procedure. In *SUGI supplemental library user's guide, 1983 edition* (pp. 181–202). Cary, NC: SAS Institute.

Jencks, C., Bartlett, S., Corcoran, M., Crouse, J., Eaglesfied, D., Jackson, G., McClelland, K., Mueser, P., Olneck, M., Schwartz, J., Ward, S., & Williams, J. (1979). *Who gets ahead? The determinants of economic success in America.* New York: Basic Books.

Olneck, M.R., & Wolfe, B.L. (1980). Intelligence and family size: another look. *Review of Economics and Statistics, 62,* 241–247.

National Center for Health Statistics. (1975). *U.S. decennial life tables for 1969–71. Vol. II, state life tables: Wisconsin.* DHEW Publication No. (HRA) 75-1151. Washington, DC: National Center for Health Statistics.

Retherford, R.D., & Sewell, W.H. (1988). Intelligence and Family Size Reconsidered. *Social Biology, 35,* 1–40.

Schultz, T.P. (1987). The value and allocation of time in high-income countries: implications for fertility. In K. Davis, M.S. Bernstam, & R. Ricardo-Campbell (Eds.), *Below-replacement fertility in industrial societies. Population and development review* (supplement to Vol. 12, pp. 87–108).

Sewell, W.H., & Hauser, R.M. (1975). *Education, occupation, and earnings: Achievement in the early career.* New York: Academic.

Sewell, W.H., & Hauser, R.M. (1980a). Sex, schooling, and occupational status. *American Journal of Sociology, 86,* 551–583.

Sewell, W.H., & Hauser, R.M. (1980b). The Wisconsin Longitudinal Study of Social and Psychological Factors in Aspirations and Achievements. In A.C. Kerckhoff (Ed.), *Research in sociology of education and socialization,* Vol. 1. Greenwich CT: JAI.

Udry, J.R. (1978). Differential fertility by intelligence: the role of birth planning. *Social Biology, 25,* 10–14.

United Nations. (1968). *Education and fertility: Selected findings from the world fertility survey data*. New York: United Nations, Department of International Economic and Social Affairs, Population Division.

Waller, J.H. (1971). Achievement and social mobility: relationships among IQ score, education, and occupation in two generations. *Social Biology, 18*, 252–259.